TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DHT-1-19-75-520-4F		

4. Title and Subtitle
Interactive Graphics Roadway Design System-
System Design

5. Report Date
September, 1983

6. Performing Organization Code

7. Author(s)
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8. Performing Organization Report No.
DHT-1-19-75-520-4F

9. Performing Organization Name and Address
State Department of Highways & Public Transportation
11th and Brazos
Austin, Texas 78701

10. Work Unit No.

11. Contract or Grant No.
DOT-FH-11-8910

12. Sponsoring Agency Name and Address
State Department of Highways & Public Transportation
Transportation Planning Division
P.O. Box 5051
Austin, Texas 78763

13. Type of Report and Period Covered
Final

14. Sponsoring Agency Code

15. Supplementary Notes
Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration, under the study title: "Development of an Interactive Graphics Aided Design System."

16. Abstract

This final System Design Report for the first phase of the proposed Interactive Graphics Roadway Design System (IGRDS) defines the functional capabilities and processing structure of IGRDS. IGRDS is based upon the design capabilities of the Roadway Design System. It details the proposed methods of developing a first version of IGRDS to provide advanced interactive capabilities and graphic facilities to roadway designers by linking the basic computational functions of highway design with an interactive graphics system. By basing this first version of IGRDS on existing vendor-supplied IG systems, the expense and need of redeveloping standard graphics capabilities are, at this time, avoided.

The design of the system reflects key concepts in IGRDS development, including maximum portability between various IGDS systems, phased implementation for optimum utilization, retainment of all currently available IGDS facilities, and maintenance of the RDS user-familiar appearance to benefit from prior personnel training. The General Geometry, Horizontal Alignment and Vertical Alignment processes are described with lists of commands and definitions of methods of operation.

This report also discusses future extensions of IGRDS and the need for advancement past the program design phase in order to verify the concepts involved and obtain user feedback from a productive system.

17. Key Words	18. Distribution Statement
Roadway Design System, Automated Mapping System, interactive graphics, roadway design, Interactive Graphics Drafting System.	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	185	

Form DOT F 1700.7 (8-69)

INTERACTIVE GRAPHICS ROADWAY DESIGN SYSTEM
SYSTEM DESIGN

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Research Report 520-4F
Development of an Interactive
Graphics Aided Design System
Research Study 1-19-75-520

Conducted by
Division of Automation
Texas State Department of Highways
and Public Transportation
In cooperation with the
U. S. Department of Transportation
Federal Highway Administration
DOT-FH-11-8910

September, 1983

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

SUMMARY

The following document is the System Design Report for the first phase of the proposed Interactive Graphic Roadway Design System (IGRDS), as generally specified in the General System Design Report as prepared by the Texas State Department of Highways and Public Transportation, dated February, 1983. The System Design Report defines the functional capabilities and the processing structure of IGRDS, a system based upon the integration of the Roadway Design System with a typical vendor-supplied stand-alone Interactive Graphics Drafting Systems.

The System Design is based upon a phased development of IGRDS so that the required development resources and available funds can be matched, and so that interim benefits can be accrued through phased implementation. The proposed method of developing the system is to link together the basic computational functions of highway design and to provide advanced interactive capabilities and graphic facilities to allow the designer to work closely with his computer model of the roadway. The purpose in basing IGRDS upon available off-the-shelf stand-alone IG drafting systems is to save the expense and time of redeveloping standard graphics capabilities. The use of such interactive graphics drafting systems also matches the general trend being followed by the majority of the potential users of IGRDS.

Key concepts in the design of the System are to maximize portability between various IGDS offerings, to provide phased development, to retain as much as possible of the RDS user-familiar appearance to benefit from existing training, and to retain all of the available IGDS facilities. Elements of IGRDS are defined in the report and encompass the use of terrain and ground planimetric survey data in computer form, geometric and roadway design computer facilities and capabilities to graphically view the computer model to aid the designer in viewing and assessing his work. The System Design describes the

means to blend the computer programs and files of the IGDS and RDS systems to achieve an integrated overall process, and allows for the retention of the data forms of both the IGDS and the RDS systems. This allows designers to use the new interactive graphic techniques along with existing data developed through past RDS processes. It also allows for the blending of IGRDS and RDS operations in the manner desired by the user, and as may be required by limitations of availability of interactive graphics equipment in the early days of institution of the process. The General Geometry, Horizontal Alignment and Vertical Alignment processes of IGRDS are described in the Report with lists of commands and definitions of the methods of operation. In excess of 100 commands are included in the Report, with descriptions of their functional steps being provided in block diagram form. The Appendix of the Report contains these command block diagrams.

The Conclusion states the belief that the capability of the defined commands is more extensive than was originally anticipated and provides more than expected benefits, but that even further extensions and benefits are possible. The Conclusion also signals the end of the System Design Phase of the project, confirms the feasibility of the project objectives, and indicates that the detailed program design phase should begin.

Subsequent to the completion of system design of the first phase of IGRDS, the project funds were depleted and the federally funded project terminated. Completion of the system is being pursued under different sponsorship.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

The intention of the design step of the IGRDS Development Project is to prepare a document defining the functional capabilities and processing structure of the Interactive Graphics (IG) system enhancement of RDS. The user facilities of this system were described in the General System Design report, prepared by the Texas State Department of Highways and Public Transportation, February, 1983. It was proposed that IGRDS be created through phased development, a concept which was also employed in the system design. The justification of phased design is based on two factors: the desirability of being able to prove initial concepts before finalizing the design of the entire system, and a recognition of the finite resources available to the project for both design and development. Because of these considerations, the design:

- recognizes the possible need for the System to operate with a portion of the road design processes in an IG mode while others retain their current batch mode.
- was completed and submitted for approval in part so that development of a part could proceed while other parts were still being designed.

As an example of the preparation for the System to run both IG and batch, part one of the design calls for the general geometry, horizontal alignment and vertical alignment processes of RDS to be developed in an IG mode, while the other processes of RDS would be operated in normal batch methods. Procedures are described to allow the designer to work each process in the available mode, or to operate geometry, horizontal alignment or vertical alignment in either IG or batch mode; and to have the ability to have the results of each process available to the others. This capability protects the key concepts of RDS (i.e., processes being integrated and having common data access) throughout the phased development and phased implementation.

CHAPTER 2

SYSTEM OBJECTIVES

The objectives of the Interactive Graphics Roadway Design System (IGRDS) are stated at some length in the previously referenced General System Design document. These objectives were stated in pages II-1 through II-4 of the report. A quotation from which makes a clear statement of the objectives, as follows:

> "To link together the basic components of highway design -- surveying, calculations, and drafting -- in order to minimize the manual intervention currently required to pass data from one function to another by:
>
> 1. Enhancing the existing batch computer system, Roadway Design System (RDS), through the addition of interactive graphics input-output capabilities.
>
> 2. Providing a direct interface with a geographic data base (survey) and a commercial Interactive Graphics Drafting System."

CHAPTER 3

INTERACTIVE GRAPHICS DESIGN SYSTEM REQUIREMENTS

The System design requirements are best defined in two broad categories:

1. Functional

2. Hardware and software

3.1 IGRDS FUNCTIONAL REQUIREMENTS

The detailed functional requirements for IGRDS are spelled out in the referenced General System Design document, pages IV-1 to IV-64. These requirements cover all of the functions currently affected by the RDS System, beginning with route studies, and ending with the calculation of final construction calculations and documentation.

3.2 IGRDS HARDWARE/SOFTWARE REQUIREMENTS

The requirements for interactive graphics design system hardware and software are outlined in the General System Design document, pages III-1 and III-11. An expansion of this discussion follows under the several topics of this section.

3.2.1 Definition of IG Terms and State-of-the-Art

A number of terms are used throughout this document which deserve definition at this time. These terms are as follows:

-IGRDS.. This is the term applied to the subject of this design report, an Interactive Graphics Roadway Design System. This System will perform all of the functions that are currently performed by RDS, but in addition will allow the designer to use interactive methods to communicate with the computer and to take advantage of graphic input and output capabilities as an additional more powerful means to perform this interactive communication.

-IGDS... This term identifies the Interactive Graphics Drafting System that will be used to provide the interactive capabilities and the graphic functions that will be supplied to RDS. The term IGDS is one which is used by a graphics vendor as the name of its interactive graphic drafting system software. This term has been employed as a general name because it does, in fact, explicitly define the functions desired to accomplish the design goals.

-UC..... This term defines the special programming languages which are offered by the various vendors of the IGDS to provide interface programming between their system and application programs which are developed by the user. The UC stands for User Commands. Although this term also is one which has been devised by one specific vendor, it has been elected to be used as a general term because it, too, is descriptive for the functions described in the report.

The current state-of-the-art of graphic offerings can be broken into two basic classes: the stand-alone minicomputer based system, and the large mainframe based system. Of these computer graphic systems, the majority were developed to be drafting rather than design systems. By far, the majority of these interactive graphic drafting systems perform their processes on a stand-alone minicomputer based system. Although there are capabilities offered on large mainframes, the bulk of the users have found that they can process their IG drafting work better in an environment which is separated from the large amount of batch work that is flowing through the mainframe system. In addition, the majority of mainframes in operation today in potential users' organizations do not have good interactive capabilities. It is also apparent that, in the group of users who will be most interested in IGRDS, the current trend is almost exclusively to the stand-alone mini-based IG drafting system. Because of this, the direction of this Design Document has been to fit the current direction of the potential IGRDS users as well as the movement of the general marketplace.

3.2.2 IGRDS System Portability

It is a key and desirable goal that IGRDS be a completely portable system. Portability today has greatly improved over the past, due to the more common offerings of computer vendors in terms of internal computer architecture and almost equal application compilers. However, even though substantial progress has been made in these characteristics of portability, numerous constraints still exist which must be observed by the IGRDS design process. As previously mentioned, the current trend in IG drafting is toward stand-alone minicomputer-based systems. IGRDS is designed to fit into this trend, which means that the design will not be amenable for implementation on a large mainframe. In the IG drafting marketplace, the majority of the most recent offerings for stand-alone processors utilize a 32-bit word computer architecture. Because of this, the IGRDS design is directed toward those stand-alone systems which have this 32-bit architecture. It not only maintains the direction of the IGRDS in the mainstream of IG devices, but it minimizes the amount of conversion that must take place between the RDS programs, which were written for a 32-bit word mainframe, and the IGRDS system hardware. A further constraint applied to the IGRDS design is that the results of IGRDS must interface with the IG drafting capability of the selected vendor system, so that maximum benefits can be realized from the IGRDS design results.

A still further consideration which will affect the initial development is that the IGRDS prototype system must be developed on a particular IG system. More specifically, it must be developed on a system that is in operation at the Texas State Department of Highways and Public Transportation, in order to be able to prove the development and to make it ready for transfer to the FHWA.

From the above, it can be seen that there are constraints upon the desirable goal of complete portability. The feasible goals which this project may obtain are summarized below:

- It will use a stand-alone minicomputer-based interactive graphics drafting system, of which several types exist.
- The computer employed by the stand-alone IG system will be a 32-bit minicomputer, as is offered by several vendors.
- The hardware and software capabilities of the envisioned IG system are as follows:
  - -- Fortran will be used as the programming language, whenever possible, to develop IGRDS interface programs.
  - -- During the system design, RDS program logic will be used to the maximum in order to minimize dependency of the developed system on one particular vendor's IG system. (NOTE: the early implementation phases may not adhere to this process, in order to produce a working system at the earliest possible date; however, the design will clearly lay out the way for a minimum dependent system.)

3.2.3 Hardware Requirements

The CPU hardware requirements for IGRDS will be as specified above. The drafting stations will include one or two CRT displays per station, which displays may be direct-view storage tubes (DVST), raster displays or vector refresh screens. Each of the stations will have a standard alphanumeric keyboard. Lastly, each station will have a screen "picking" device. This may either be a digitizer board, for DVST or raster screens, or it may be a light pen, for vector refresh-type displays.

3.2.4 Software Requirements

The IG system for which IGRDS will be designed must provide a means to interface the application programs of IGRDS with the IG system data files. This provision may either be in the form of a special programming language, or in a Fortran compiler type of language. In addition, the IG system must provide a means whereby the RDS application programs may be interfaced with the standard IGDS system software.

CHAPTER 4

IGRDS DESIGN CONCEPTS

The following design concepts have been employed to guide the planning of IGRDS. For some conditions, these concepts are incompatible or work at cross purposes. For the cases where the design concepts conflict, compromise has been necessary. The guiding concepts follow:

4.1 USABLE IGRDS AT EARLIEST REASONABLE DATE

It is important to produce a working System at an early date in order to:

1. Gain payback
2. Confirm or correct design decisions
3. Demonstrate the feasibility and benefits of IGRDS and gain broadened user support.

To achieve a usable IGRDS, phased development is planned. The first phase to be implemented will provide the minimum number of useful features to achieve an independent system, and will be developed in such a manner as to allow for the addition of new features as they are produced.

4.2 RETAIN RDS APPEARANCE AND OPERATING METHODS

Organizations using RDS have a substantial and valuable existing resource in the form of training and experience of their engineers in the methods, commands and knowledge of the capabilities of RDS. To make the most of this valued resource, IGRDS will be designed, insofar as practicable, to operate in either a similar manner as, or with obvious correlation to RDS procedures. An example of effecting this concept is the naming of IGRDS geometric commands with RDS names, whenever the command exists in RDS, whether or not the actual RDS programs that perform the functions are used.

4.3 USE ALL HELPFUL AVAILABLE FEATURES OF IGDS

All of the features of the IGDS system that are useful to IGRDS will be employed to avoid duplication of software development and to make best use of the resources available for creating IGRDS. This concept allows all features of the IGDS to be used, in addition to the IGRDS commands. Unique features that are not available in some similar form on IG systems, other than the prototype, will not be included in the design as a required part of the IGRDS commands or procedures.

4.4 ACHIEVE MAXIMUM REASONABLE PORTABILITY

The portability of IGRDS between IGDS systems will be emphasized. The design to obtain a highly portable System is qualified with the need to produce a working IGRDS at an early date and with minimum duplication of software development effort. (The earlier discussion of the limited possibilities for portability are considered in this discussion to define the goals of portability.)

CHAPTER 5

DEFINITION OF ELEMENTS OF IGRDS

The System, IGRDS, is a composite of several elements, most of which are design aids in their own right. This section of the design report will identify each of these elements and define, in a general way, the function of each to the whole. Further details of the capabilities of these elements will become apparent during the discussions of the IGRDS process functions in the following section.

5.1 DESCRIPTION OF INDIVIDUAL ELEMENTS

The block diagram of Figure 1 depicts each major element of IGRDS along with program control transfer sequences and data paths between processing programs and data files. Solid lines with arrows indicate transfers of control between processes, while dashed lines indicate data transfers.

IGRDS will perform all of the functions of RDS in an interactive graphics mode that are suitable for such processes, but those RDS functions which are not suitable to this mode will remain "batch" operations. In addition, it is expected that it may not be possible or practical to perform all of the IGRDS functions in an interactive mode, due to a lack of availability of IG terminal equipment. Therefore, Figure 1 depicts the relationship of IGRDS with the batch version of RDS as well as with other supporting programs and devices.

In Figure 1, elements 3 and 4 are completely dependent upon the selected IGDS, and are thus not portable as programs, only concepts. Element 5 represents a series of computer programs, written in Fortran, which are expected to be largely portable, but which will require changes to utilize the IGDS selected by each organization implementing IGRDS, if this system differs from the prototype. Elements 6 and 7 are programs which are expected to be completely portable to every IGDS that has the required capabilites. Elements 11 and 12 are components of the standard batch RDS. The entire set of elements, files and equipment has been named the Interactive Graphics Aided

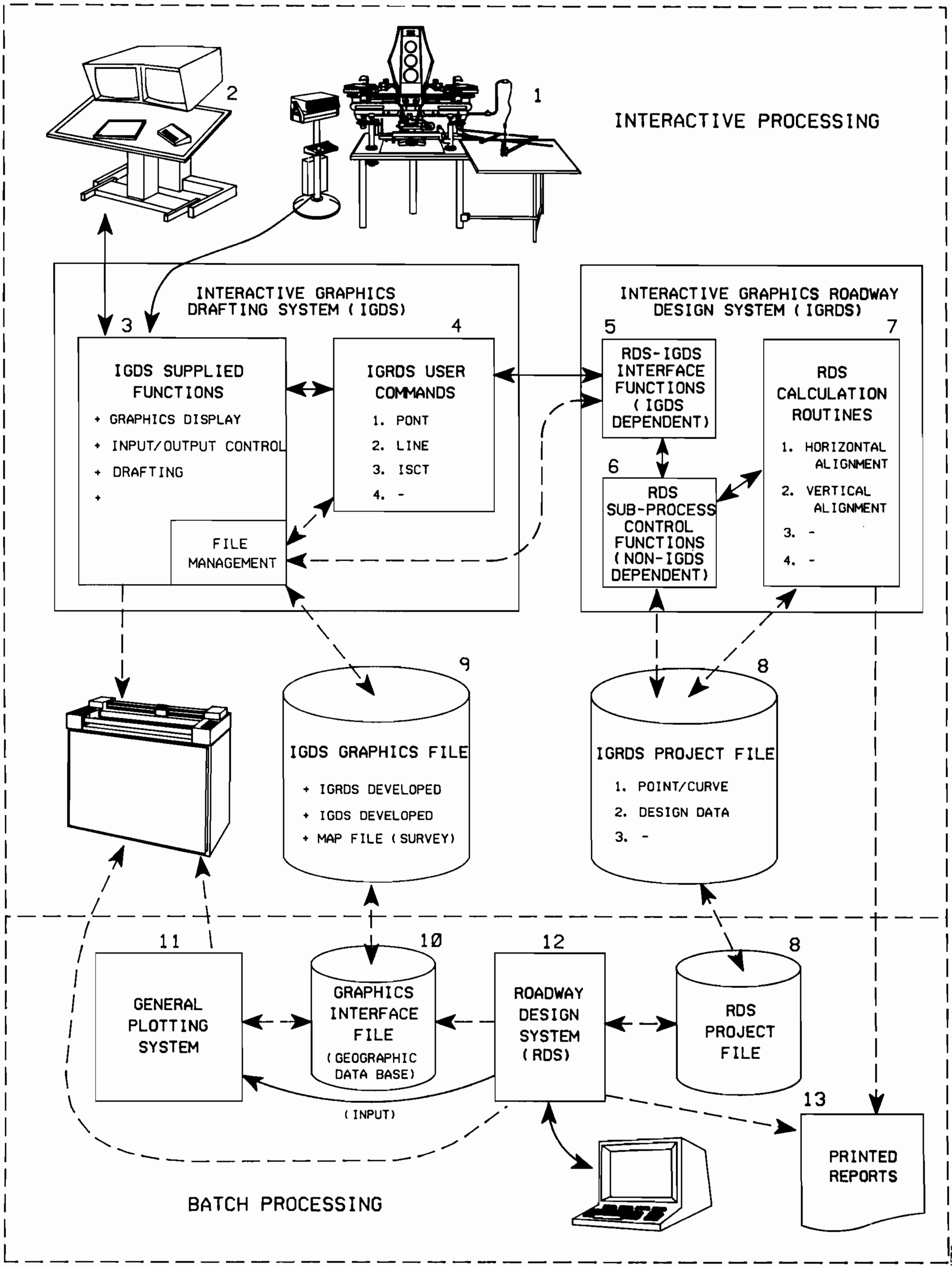


FIGURE I. ELEMENTS OF SYSTEM

Design System (IGADS), the concept of which applies to other applications, such as structural design.

The discussion that follows defines each of the IGADS components and their function in the overall process. The last decimal digit of the number of each discussion refers to a specific number on the block diagram, (i.e., 5.1.1)

5.1.1 Survey Data Acquistion

Although not required for all design sessions using IGRDS, many design tasks will require survey information to be displayed as background graphics, in order to relate the proposed design to the existing conditions in the highway location. This data acquisition function is depicted on the flow chart by the use of a photogrammetic stereoplotter feeding data directly into the Interactive Graphics Drafting System (IGDS). The IGDS can be used to obtain this basic survey data; or an intermediate system, such as the Texas Automated Mapping Systems (TEAMS) could be employed; or the information can be digitized directly from hard copy maps using the capabilities of IGDS. Regardless of the method employed, for some design sessions it is necessary to have the survey data in the IGDS Graphics File for use with IGRDS. Development of this capability is not included in this design document since at least one process, TEAMS -- which was provided earlier as part of this project -- is a system available to assist in this process.

5.1.2 Interactive Graphics Drafting System Station

This will be the interactive input/output, graphics display and finished drawing media for both IGDS and IGRDS. The user will have commands and/or a menu for defining the functions to be performed. The commands and/or menu will be specifically designed to contain the RDS functions of IGRDS along with the calculation, file and display functions of IGDS. The station also provides the output screen(s) for viewing the graphic result of an executed command from either IGRDS or IGDS. Tabular reports from IGRDS will also be displayed on the screen(s) of the station.

DEFINITION OF ELEMENTS OF IGRDS

5.1.3 Interactive Graphics Drafting System

This system will consist of all the functions provided by the commercial system selected by the using organization for drafting, for survey data acquisition (if used) and for IGRDS. The system will specifically provide all input/output control to the drafting station, file management of the IGDS Graphics File and certain geometric calculation capabilites. The commands available will vary with the particular IGDS selected by the user. All of the drafting functions provided by the IGDS will be available to the user when operating IGRDS. All data points, lines and curve elements constructed by the user with the standard IGDS drafting functions and deposited in the IGDS file will be available for use by IGRDS. Further, when producing road plan drawings by IGDS, the user will have available the full range of IGRDS commands to build graphic data structures that can be used for these drawings. An example of this drafting assistance would be the display and plotting of ditch lines by IGRDS command.

5.1.4 IGRDS Commands

Those commands or functions which are designed to fit the special roadway design processing of RDS will be defined as IGRDS commands. They will appear to the user as supplements to the standard IGDS drafting commands. The names and mneumonic definitions of these commands will be as closely related to RDS functions as is feasible. In some cases, the names and operation of the IGRDS and RDS commands will be the same. In other cases, due to the difference in operation between a batch and an interactive environment, a range of differences may occur from slight to no correlation at all.

The IGRDS commands will be initiated by the user through the IGDS terminal keyboard or menu tablet. Because these commands will be accepted and interpreted by IGDS, special software will have to be prepared to perform this function. It is this set of programs that make up System element #4 on the block diagram. After the initial interpretation of the command, there are a variety of supporting steps --

such as user prompting, issuance of error messages and interfacing with (i.e., calling) other programs, either in IGDS or from the IGRDS process, to perform the requested calculations.

These command interpretation programs may be prepared in several ways, depending upon the IGDS.

The command interpretation programs will be unique for every IGDS, and will, thus, have to be specially prepared for each vendor's system. The intention of the design is to minimize the amount of programming assigned to this function and to maximize programming to functions of IGRDS that will be portable between systems.

The prototype IGDS utilizes a unique but simple program language to perform the interpretation and interface function. These special programs are called User Commands. The result of utilizing this language is that these programs will not be portable at all, except to those organizations using the same IGDS as the prototype.

As indicated in the discussion of element #3 above, the IGRDS design commands will be available to aid the drafting process; however, it will be the intent of the System design to provide the capability for the using Department to prohibit modification of the RDS design file during this drafting process.

5.1.5 RDS-IGDS Interface Programs (IGDS Dependent)

Those design functions not provided by IGDS will require the User Command program to branch to IGRDS to perform the needed RDS calculations. This will require the development of new routines to handle the interface functions between RDS routines and a different IGDS than used with the prototype. These routines would have to be highly modified or replaced for each IGDS used with IGRDS; however, the design of the routines will provide the basis for development of the interface programs for another IGDS. The primary function of these programs will be to extract data from the IGDS file, place it into general data storage in preparation for arranging it for input to the

RDS program performing the IGRDS calculation; and to complete similar steps in reverse when returning from IGRDS to IGDS. The IGDS dependent interface programs will also be responsible for the transfer of control between the User Command programs and those interface programs which are not dependent upon the specific IGDS.

5.1.6 RDS Control Functions (Non-IGDS Dependent)

The control of the RDS calculations are different for an interactive graphics environment than for batch. The existing RDS routines that control functions such as input/output and transfer of execution between programs within a process will require modification and, in some cases, replacement for IGRDS. The specific functions performed by these routines will be to:

1. Extract data from general data storage (see #5 above) and organize it for input to the appropriate RDS calculation process.

2. Extract data from RDS storage and place it into general data storage in preparation for transfer of data to IGDS.

3. Control the calling sequence of programs to form an IGRDS process. Many programs that control functions of the RDS batch process will likely not be used by IGRDS due to different data handling methods, or will be used in smaller sequences due to the interactive nature of the process.

This class of routines is believed to require little or no revision for use with different IG systems.

5.1.7 RDS Calculation Routines

Standard RDS routines will be used to perform the roadway design calculations of IGRDS, such as the computation of the station and offset of a point from a horizontal alignment. Although some modifications of the routines may be required, the detail design will minimize these differences and will formulate them in such a way that the routines can retain their compatibility with, or be substituted for, their RDS batch counterparts. Typical differences will arise in error handling and in data file accessing.

5.1.8 RDS and IGRDS Project Files

The IGRDS file will be made up of the same type and nature of data stored in the files of the existing RDS system. The two files shown in Figure 1 could be considered to be the same, except that the method of organization of the data within the files will be different to expedite the responses to the user from IGRDS. The specific difference will be that the RDS file will continue the "paged" organization of the design file while IGRDS will not. These files contain data defining:

1. Point, line, and circle data

2. Horizontal and vertical alignment

3. Data defining templates, cross-sections, etc.

At the user's discretion, either the RDS or the IGRDS file may be used as a master file to produce the other. Upon a command from the user, the then-current paged RDS file will be converted to its unpaged form, by program process, for IGRDS use. In like manner, the IGRDS file may be "paged" for use by RDS. In this way, the user may shift from RDS to IGRDS and back again as the design requirements or IG system availability changes. Although aids will be provided (see Section 6, Geometry), the user will be responsible for determining which of the file forms is up-to-date.

A further discussion of the nature of the IGRDS file in relation to the IGDS file and the methods of data exchange between these two files follows the description of System elements.

5.1.9 IGDS Graphic Files

This file supports the IGDS in its standard drafting process. The file structure is defined by the IGDS used and has all data creation, modification, and extraction supported by programs that are part of and supplied with the IGDS. All graphic data structures displayed on the drafting terminal, or otherwise managed by the user through the IGDS processes, will be stored in this file. Not only will the data in the IGDS file define the graphic image, but it will define the displayed elements in terms of "real world" mathematical terms (i.e., coordinates and mathematical equations of lines and curves). During the various stages of IGRDS operation, this file will contain survey map data, general roadway geometric data, horizontal and vertical alignment data, and roadway surface descriptions as well as various schematic graphics (i.e., drawings with no real physical existence, such as mass haul diagrams) that the user may elect to produce as a result of the IGRDS process and view or otherwise manipulate with the IGDS.

A further discussion of the nature of the IGDS file and its relationship to the IGRDS file, as well as data exchange relationships, follows the description of the System elements.

5.1.10 Graphics Interface File

The purpose of this file is to provide a non-proprietary storage file of graphics data developed using IGDS or IGRDS. It will also provide an intermediate file structure to allow transfer of RDS generated graphics output, such as cross-sections, to IGDS for display on the IGDS Station. This capability will allow for preview of the graphics prior to or in lieu of plotting. It also provides a file structure usable by the General Plotting System (see Section 5.1.11) for plotting of RDS graphics output outside of IGDS.

5.1.11 General Plotting System (GPS)

GPS is a general purpose plotting system that provides the user the ability to produce high quality digital plots on a variety of plotting devices without having to link the devices to application programs, such as RDS. GPS also provides the ability to translate and rotate graphics files for clipping of graphics data sets into individual files and for merging of files (i.e., plan and profile) for plotting together. NOTE: although these functions are also provided by the IGDS, GPS provides the batch users of RDS with additional plotting capabilities and a means to produce graphic data structures for storage into IGDS.

5.1.12 Roadway Design System (RDS)

This will be essentially the same version of RDS supported under the AASHTO Maintenance Contract. Significant system changes but only minor program modifications should be needed to allow it to be used in conjunction with IGRDS. The only known enhancement to RDS is the addition of the ability to produce Graphic Interface File Records.

5.1.13 Printed Reports

The user will have the ability to produce printed reports from IGRDS. These reports will be the same form as RDS. Output from IGRDS would include:

1. Geometric command results that produce useful report information, such as AREA or station/offset commands.

2. Horizontal alignments.

3. Vertical alignment.

The user would have the same report capability as now exists in RDS. Report lines will be produced from IGRDS when a specific command justifies output (i.e., some commands produce "geometric construction" line results which do not provide the user with meaningful information), and the user specifically directs the data to a report. The user will determine which commands should print data by "turning-on" a "print switch" that will cause all commands producing report output to transfer data to the print queue while the "print switch" is on.

It should be noted that the reports will not contain the traditional command audit (i.e., listing of every command and parameter input) currently produced by RDS, since the result of the activity is effectively portrayed as the displayable graphic representation in the IGDS graphics file.

5.2 IGRDS FILE CONCEPTS

The value of defining philosophical ideas such as file concepts and relationships in a design report such as this, is to:

1. Provide a complete understanding of the purpose and function of the design files so that the follow-on detailed design decisions will be made in a correct and consistent manner.

2. Provide a clear idea of the use of these files as a guide for later description of the System operation for users.

5.2.1 Nature and Relationships of IGDS and IGRDS Files

Because the IGDS selected by the user will have a fixed file structure, and because the file structure of RDS is used by the RDS calculation programs and is exactly suited to roadway computational needs, IGRDS will be designed to use both of these files. Each of the two files has both unique and overlapping capabilities.

1. Terminal Display - Almost all IGRDS commands will produce a display for the user. All displays, whether they be of geometric or of alignment calculations, will be produced by the IGDS from the appropriate graphic data structures residing in the IGDS file. Therefore, the IGDS file will be the location for storing all IGRDS display data.

2. General Geometric Calculation - By nature, the IGDS provides many geometric functions which will store their results in the IGDS file. These geometric calculation results define both graphic representations and mathematically real representation of the geometric elements. Each of the geometric elements is stored in the form of points and finite length lines and curves.

The IGRDS file also stores mathematically real representations of geometric elements. These representations, however, are in the form of points, infinite length lines and complete circles. From these data values, graphic data structures can be produced, but it requires additional information. This information is in the form of RDS plot commands which must be applied to the stored data values to define the finite length lines and circular arc segments required for graphics.

For geometric representations, the IGDS file is the natural location to store geometric graphics data structures. The IGDS file is most suitable as the location to hold all geometric construction results since all commands will produce displays which will have the associated data in the IGDS file. Either the IGDS or the IGRDS files could be used as the master storage facility for real representation of the geometric elements; however, since the roadway design steps may take place in both IG and batch mode, the design concept is to consider the IGRDS file as the master storage for all key or control geometrics.

3. Horizontal And Vertical Alignment Calculations - The IGDS file must be used for the terminal display of alignment graphics; therefore, it will hold data to define the alignment graphically. Although the IGDS file could mathematically define the real nature of the main control elements of the alignment, the IGDS capability does not have the means of interpreting the nature of the roadway alignment relationships (i.e., horizontal to vertical alignment to template definition or horizontal stationing and equations).

   The IGRDS file and program logic has been designed to not only store but to interpret all aspects of roadway definition, not only the geometrics of the alignment control, but all of the relationships for which IGDS is not equipped.

IGRDS is also able to interpret this data and produce comprehensive graphic data structures depicting the alignment.

Therefore, the IGRDS file will be the master location to define and store alignment data and the master location from which alignment plots are produced.

Upon consideration of the above and the data control values required in the various data records, the following concepts and relationships are derived and shown in Table 1.

Table 1

Relationship of Files

	IGDS			IGRDS		
	Graphic Definitions		Real	Graphic Definition		Real
	Terminal Display	Plot	Definition	Terminal Display	Plot	Definition
GEOM Pts. Lines Curves	x	x	x	-	x (1)(3)	x (2)
Horiz. Align.	x	x	-	-	x (3)	x
Vert. Align.	x	x	-	-	x (3)	x

DEFINITION OF ELEMENTS OF IGRDS

Table 1 Notes:

1. Plots can be produced from the IGRDS file through the GPS and the GIF file or, if the user desires, through RDS Plot commands.

2. Definition by user, with explicit transfer from IGDS file after IGDS geometric calculations. Transfer primarily for RDS processing, as control for alignment definition or as a result of RDS batch geometry calculation, and transfer from RDS file to IGRDS file.

3. Although plots can be produced from this file, the major plot mode will be through IGDS, where the full drafting features exist.

The general definition of file purpose and function:

1. The IGDS file will be the geometric construction, view and plot file (CVF).

2. The IGRDS file will be the alignment and control geometric file (ACF).

5.2.2 Data Transfer Between Files

The System employs four distinctly defined files. These files, and the conditions for transferring data between them, are depicted in Figure 2. The flow paths shown in the figure are numbered to identify each type of data transfer that will be provided. The description of these data transfer paths is as follows:

1. Data defining alignment control elements (e.g., PI's and curve data) are used to produce input to the IGRDS alignment process. This transfer is made automatically by the System when the user executes an alignment calculation command.

2. Data describing the graphics representation of the alignment calculated by IGRDS, as a result of data transfer #1, is

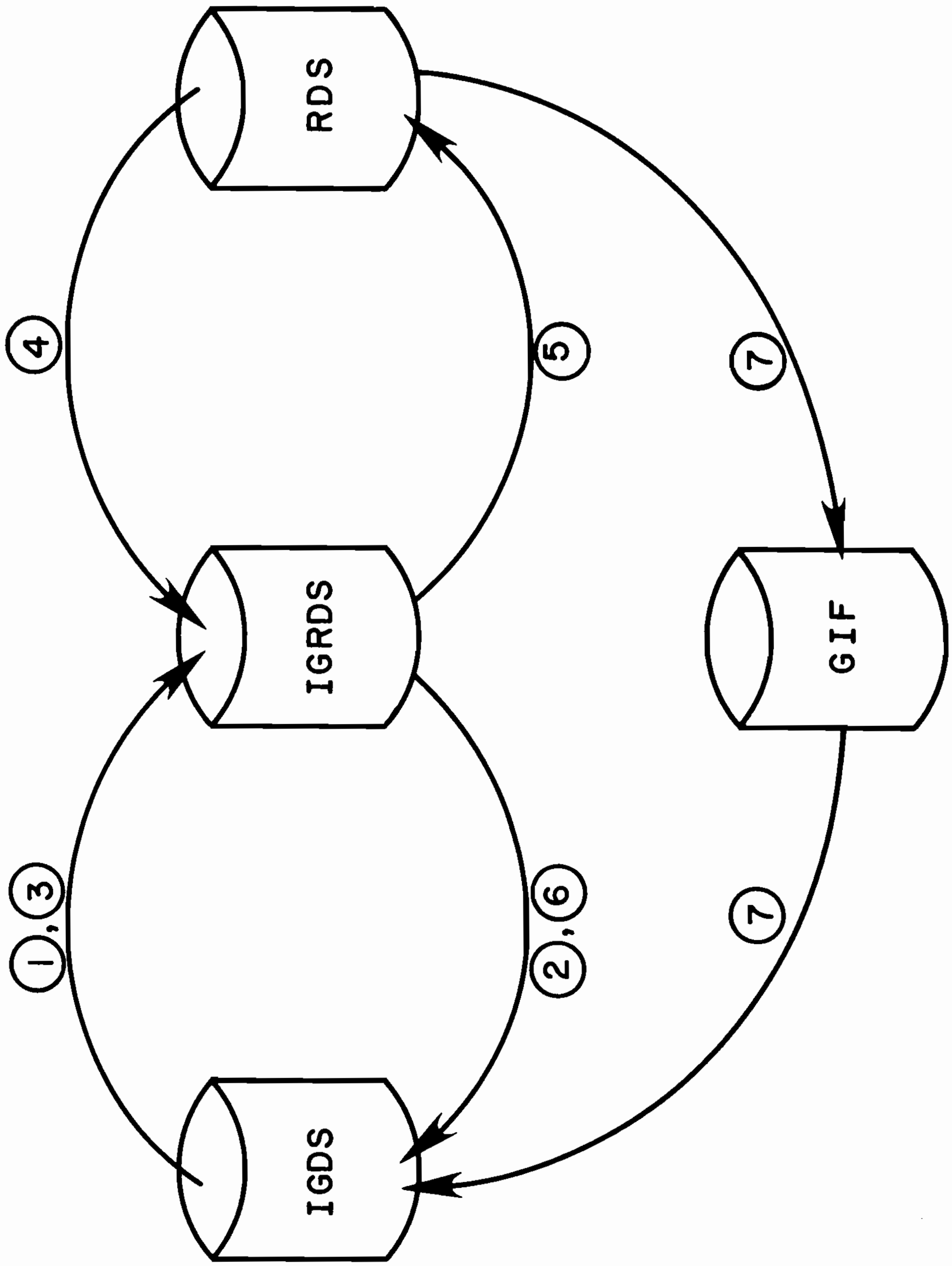


FIGURE 2. SYSTEM FILE RELATIONSHIPS

passed to IGDS for display and/or formal plotting. This transfer is made by the System as a continuation of the process cited in transfer #1 above.

3. Data defining general geometric elements that were developed by IGDS and stored in its file may be transferred to IGRDS by specific command of the user. The effect of this transfer is to copy geometric elements from IGDS to IGRDS, primarily to support computations that are to be made by the batch RDS process. The transfer of geometric data will occur only when:

   - An alignment oriented geometric command is executed by IGRDS programs rather than by IGDS programs.

   - A user specifically designates that a selected geometric command have its results stored in the IGRDS file. This will be accomplished by the user designating an IGRDS store option with a command; or by the user "turning on" a "store switch", which will cause all geometric commands to store their results in the IGRDS file while the "store switch" is on.

4. Data of all types that have been developed in the RDS file by batch processing may be transferred to the IGRDS file for interactive graphics processing. The effect of this transfer will be to "unpage" the "paged" file of RDS in order to reorganize the data for more efficient data accessing for the interactive process.

5. Data of all types that have been developed in the IGRDS file may be transferred to the RDS file for batch processing. The effect of this transfer will be to "page" the "unpaged" file of IGRDS in order to match the processing requirements for RDS.

6. Alignment data that resides in the IGRDS file, but not in the IGDS file, may be transferred by command of the user.

The result will be to store alignment control data (i.e., PI's and curve data) and to produce alignment display data.

7. Geometric data produced by RDS may be transferred from the RDS file to the IGDS file. The representation of the point and curve data in the IGDS file is in the form of discrete points, line segments and curve segments; and the representation of these same geometric elements in the RDS file is in the form of infinite length lines and complete circles. The current method of converting the RDS representation into graphic outputs is to use plot commands. To perform the storage of graphic data structures into the IGDS file from the RDS file, the user will produce these data structures from the RDS geometric elements by the RDS plot commands. The plot commands will produce the necessary discrete points, line segments and circular elements that are necessary for the IGDS file. The transfer can be made from RDS file to IGDS file by the user through the GIF file. This method was selected since such a data path is already established and functioning.

5.2.3 Modes of Interface Between IGDS and IGRDS

A key requirement in the development of IGRDS is the determination of the means of integrating the RDS processes with the IGDS process. The IGDS process must be the initiating and final one of any command, because only through it can the operation become interactive and produce the user display and final plots. Because of this, it is the process that dictates how the integration can take place. Figures 3 through 7 depict the methods that are possible for interfacing RDS and IGDS to achieve the desired integration. There are four methods that will allow the user to achieve results that could be part of the IGRDS operation. While one of these methods is the straightforward use of IGDS, the other three are true interface processes of IGDS and RDS software.

DEFINITION OF ELEMENTS OF IGRDS

Figure 3 shows Mode 1, the standard IGDS process that could be used to perform some geometric calculation features. An experienced IGDS user may elect to work in this mode; however, the IGRDS User's Manual will not emphasize this, as it will not provide all of the aids that the less frequent user -- for which IGRDS is intended -- may require.

Figure 4 depicts Mode 2, a procedure that would provide RDS command names and helpful prompts and error messages to the user. The program capabilities to perform these steps, however, would be those provided by IGDS, without help from RDS programs.

Figure 5 defines Mode 3, a process of interfacing RDS subroutines and new program logic, in both IGDS and standard programming language, to achieve the desired integration. This approach will be used when the selected command procedure is not too complicated and when no IGDS function provides the necessary functions. As an example, this method will be utilized for geometric commands that involve roadway station definitions.

Figure 6 depicts Mode 4, an interface procedure that utilizes RDS subroutines and new logic programmed in both Fortran and the languages of IGDS. This procedure would be used in place of Mode 3, when the RDS process involves a larger number of programs and larger amounts of data, such as alignment calculations. A feature of the procedure of Mode 4 is that the RDS programs would be initiated, but would be placed into hibernation upon a return of the RDS process to IGDS. The hibernating state would allow common blocks to be retained in memory and files to remain open - two procedures that would facilitate execution.

Figure 7 is a composite of Modes 1 to 4, the procedures of Figures 3-6. All of the methods shown will be allowed in IGRDS, although Modes 2 to 4 will be emphasized. The method selected for any command will be based upon the needs of that command.

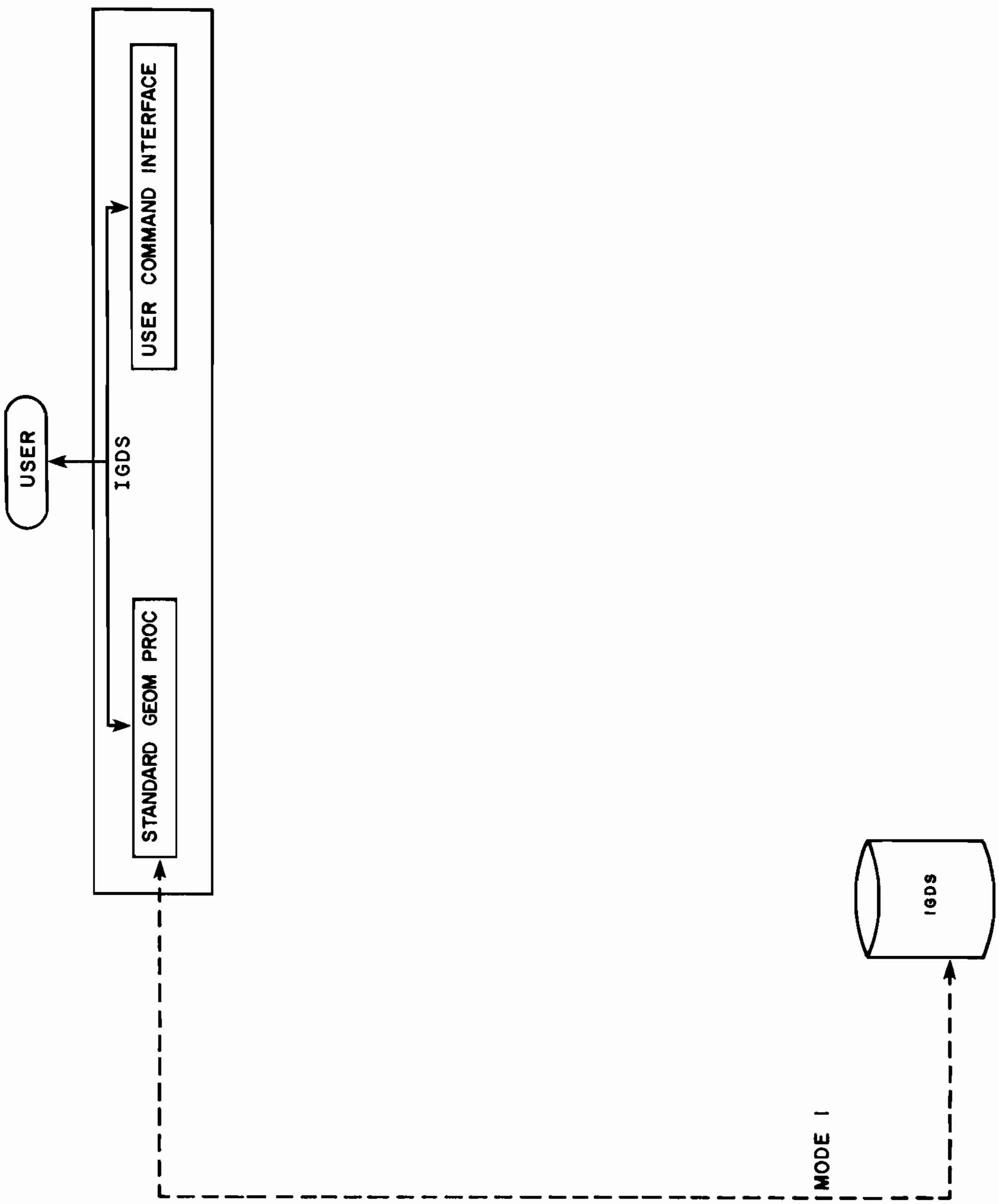


FIGURE 3. IGRDS EXECUTION, MODE I

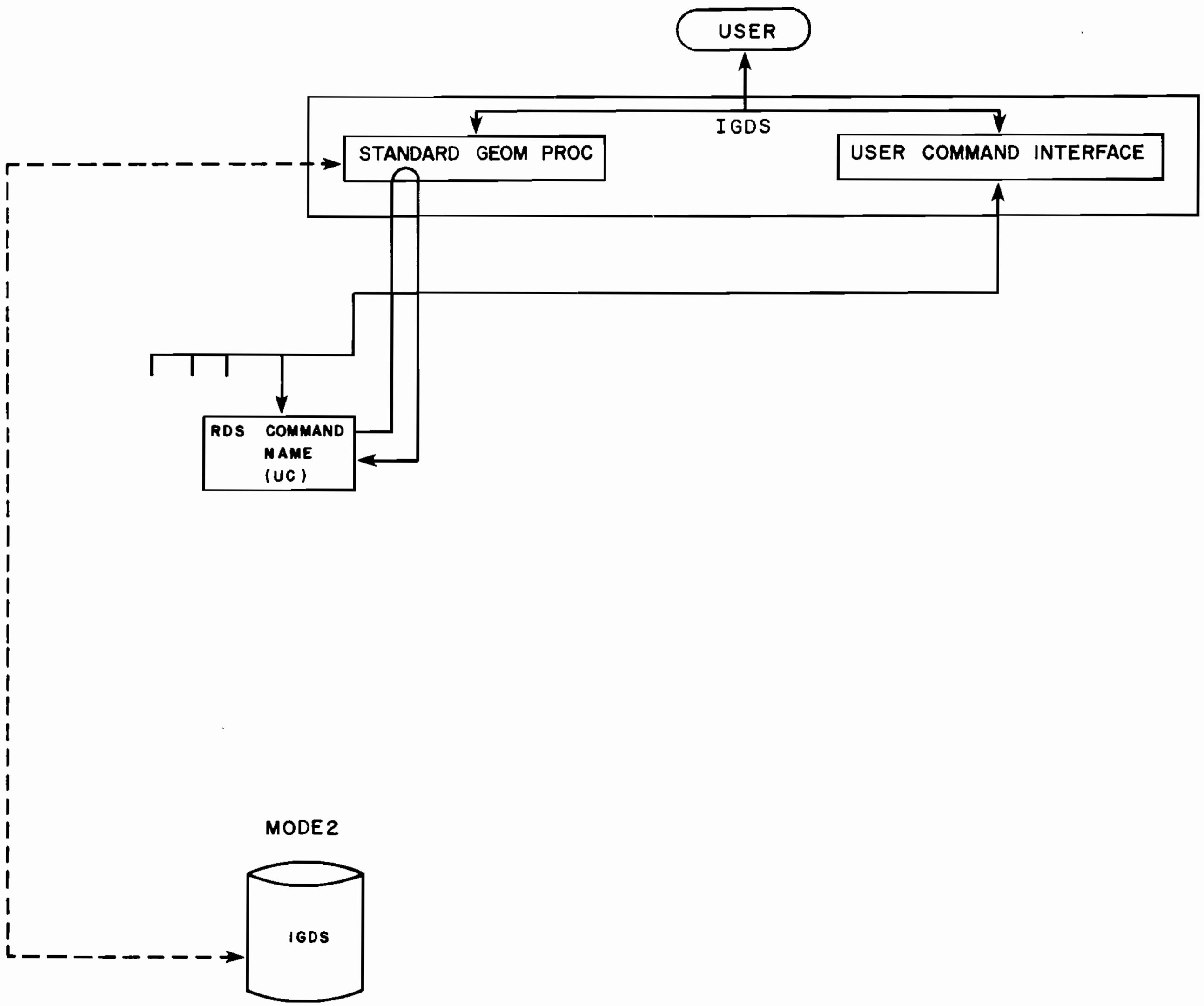


FIGURE 4. IGRDS EXECUTION, MODE 2

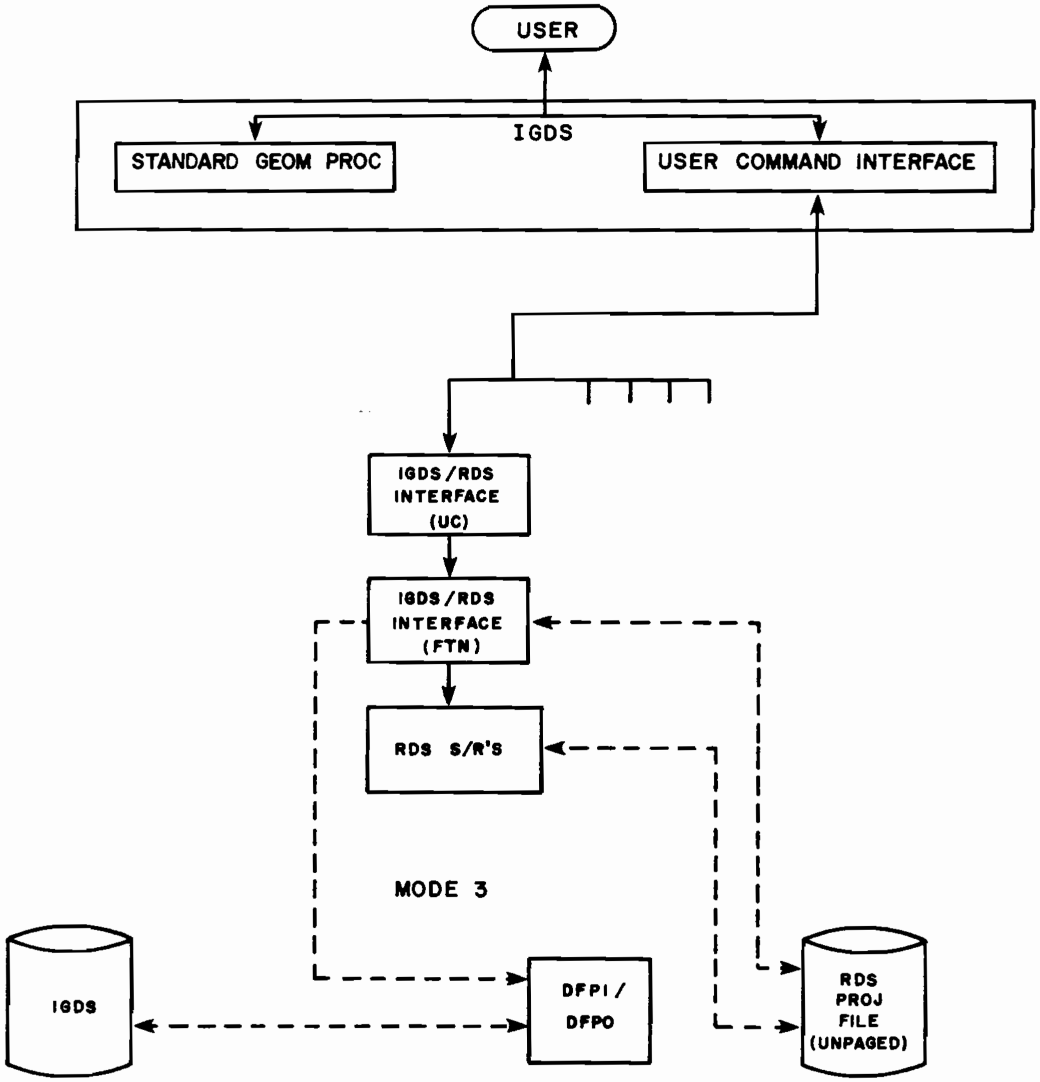


FIGURE 5. IGRDS EXECUTION, MODE 3

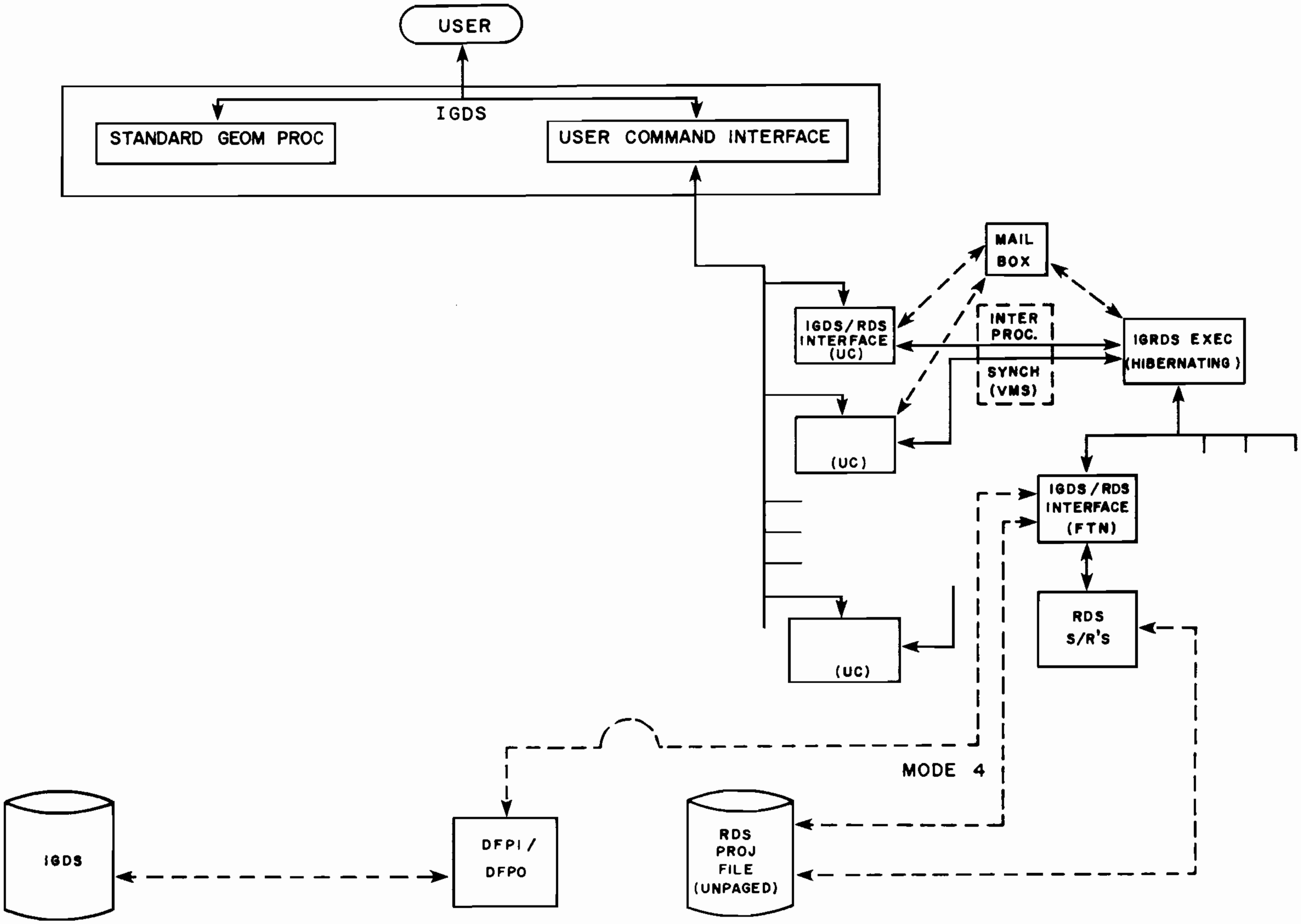


FIGURE 6. IGRDS EXECUTION, MODE 4

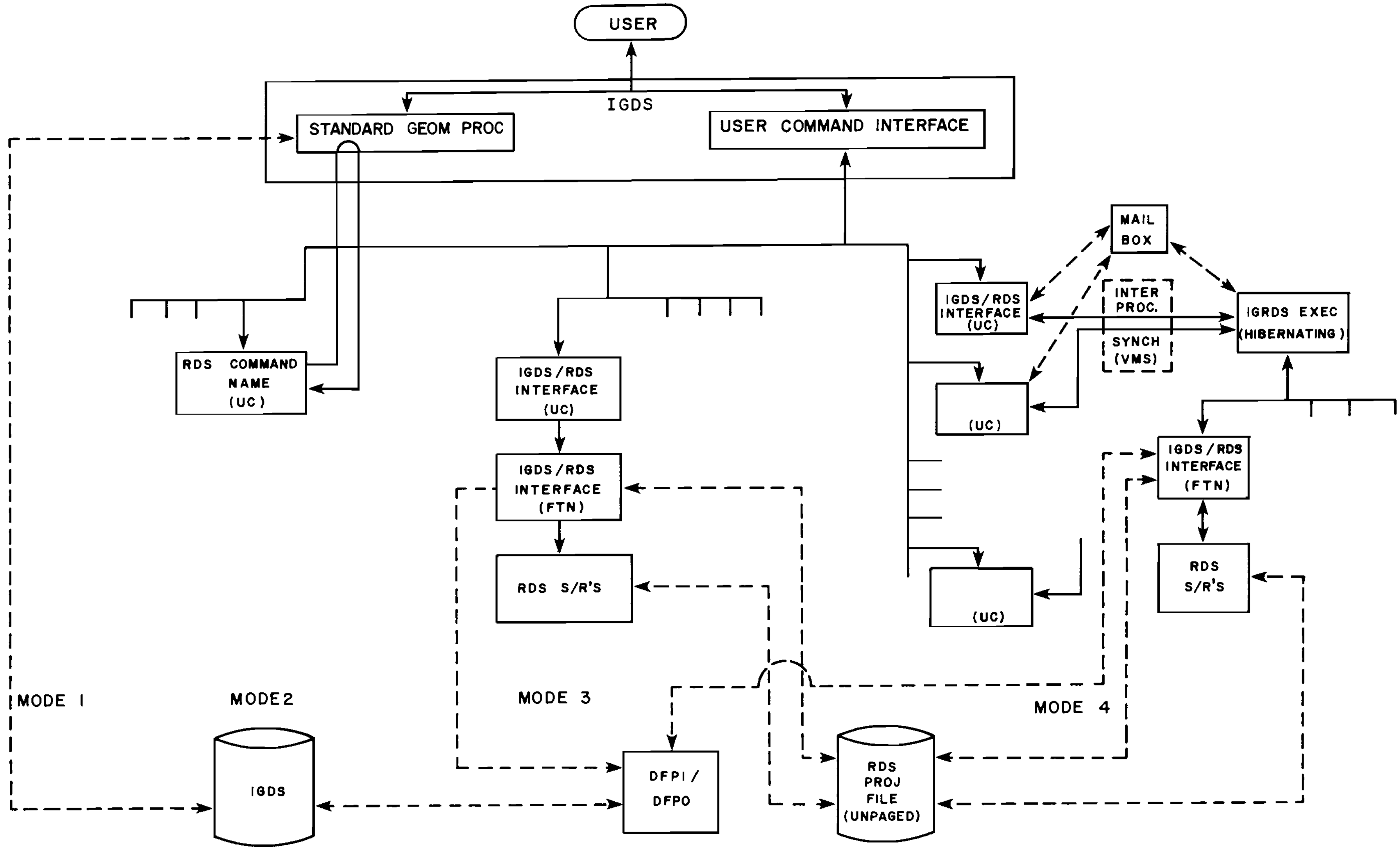


FIGURE 7. IGRDS EXECUTION, MODE I-4

CHAPTER 6

DESCRIPTION OF IGRDS FUNCTIONS

The description of the proposed IGRDS functions will consist of:

1. listings of the commands available to the user.
2. statements related to the contents of System files.
3. listings of the known key elements in the respective files.
4. methods for data transfer between files.
5. general statements of the graphic and printed output forms.
6. functional block diagrams of the design commands.

This system design will form the skeleton upon which the program design will be constructed.

IGRDS is designed to have categories of commands in accordance with the types of processes that may be performed. Figure 8 depicts four processes, each of which has its set of commands. The types of commands in each category are described under individual process headings by means of separate diagrams for each process, tables defining specific IGRDS commands, and block diagrams describing the functional logic of each command.

6.1 GENERAL GEOMETRY

The definition of general geometry commands will be as consistent as possible with that used in RDS; however, due to the differences in the nature of interactive graphics operation from batch operation, the nature of the IGRDS geometric process will differ somewhat from that of RDS. The following will list all of the capabilities available through IGRDS, but will not restate those of RDS. The design has been prepared on the premise that the user will have all existing geometry commands available to him through the current batch version of RDS, and that all data values may be transferred between the two versions.

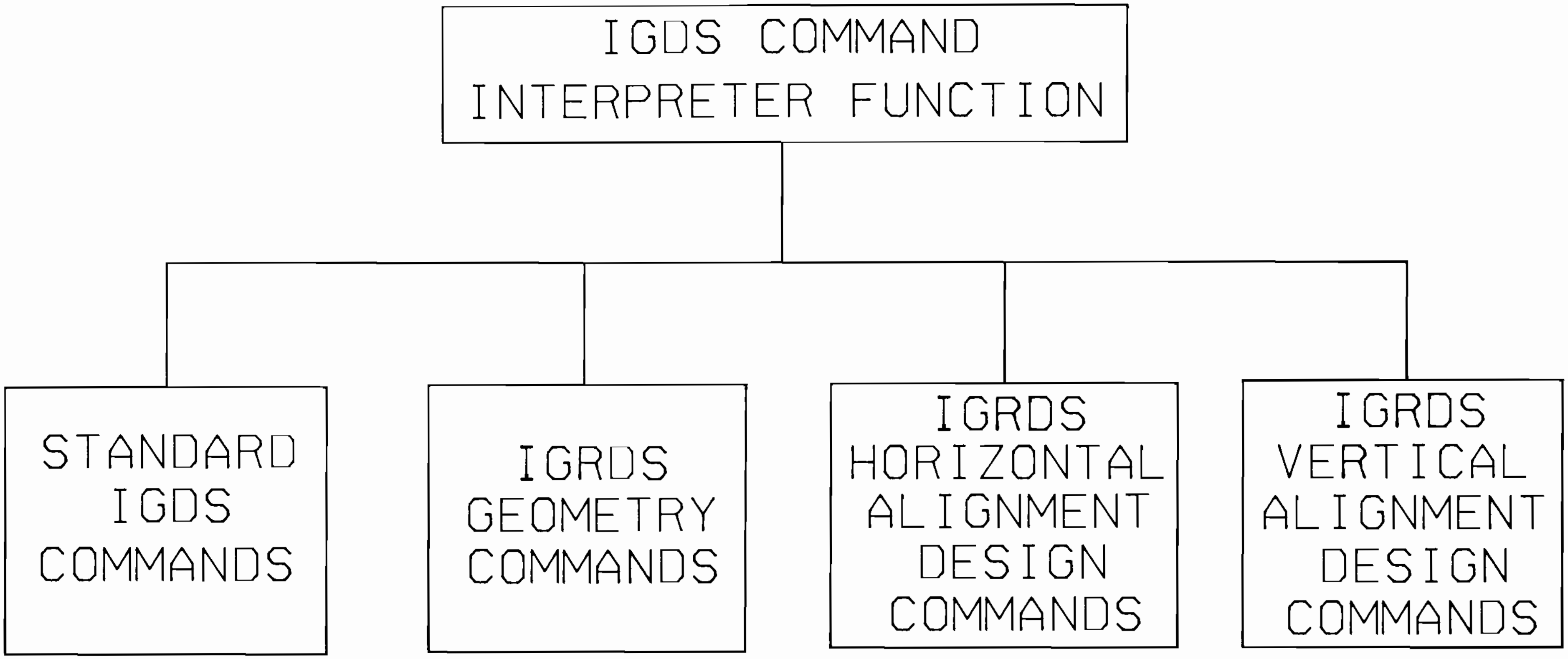


FIGURE 8 CATEGORIES OF IGRDS COMMANDS

DESCRIPTION OF IGRDS FUNCTIONS

6.1.1 General Discussion of Design Process

The objective of the general geometry process is to provide the user with the following aids:

- Commands to create the geometric elements of the following types: points, lines, circular arcs and complex strings (i.e. combinations of lines, circular arcs and spirals).

- Visual and measurable display representation of the created geometric elements.

- Means to control the data storage and print process.

The geometric process will allow the user to make geometric measurements and to create geometric elements which will result in solutions of general geometric problems and to produce horizontal alignment control. These geometric processes may be related to a background terrain display produced from a photogrammetric process and/or by standard IGDS methods. The geometric procedures are planned to allow the designer to measure from the terrain display, but to prevent him from modifying it from within the design process.

The geometric commands allow for the step-by-step build up of geometric results. Each command will produce both a display of the results of the command and storage of these results in the IGDS file. If the user wishes to have geometric elements stored in the IGRDS file for future use, he may accomplish this by setting a command switch that will automatically cause this to happen; he may specifically request this to occur by command or he may, by command, cause a transfer of elements between the IGDS and IGRDS files until all of the same point or string elements are stored in both files. It will be the user's responsibility to cause geometric elements to be stored in the IGRDS file.

Alignment element results produced by the horizontal alignment calculation process may be worked within the geometric process as any other type of geometric element.

6.1.2 Commands and Associated Actions

The general geometric process is made up of approximately 50 commands which have been collected into 7 categories.

6.1.2.1 Discussion of Categories of Commands

The seven categories of geometric commands are shown in Figure 9 and are explained in the following:

Construct Point

A set of commands that provides the user the means to create a point on the IGDS display and in the IGDS file.

Construct Line

A set of commands that provides the user the means to create a line on the IGDS display and in the IGDS file.

Construct Circular Arc

A set of commands that provides the user the means to create a circular arc or full circle on the IGDS display and in the IGDS file.

Construct Element

A set of commands that provides the user the means to create a geometric element that may be either a line or an arc or to create an attached set of connected elements, called a "complex string".

Geometric Calculations

A set of commands that provides the user the means to calculate geometric relationships (i.e. angles, station-offsets, and areas) between elements.

DESCRIPTION OF IGRDS FUNCTIONS

Graphic Display

A set of commands that provides the user the means to produce associated geometric views or to remove geometric elements from the display to reduce clutter.

Management of Geometry File and Printing

A set of commands that provides the user the means to add, delete or replace geometry data values in the IGDS, IGRDS or RDS files and to produce printed output resulting from the geometry process. The commands in this set are broken into three subsets:

Switches - commands that allow the user to control whether or not the data resulting from the geometric command should be printed or stored in the IGRDS data file as a normal part of the geometry commands. While the appropriate switch is set to "on", the print or store function will follow as a natural action to the geometric command without further user action.

Geometry File Management - a set of commands that causes specific geometric elements to be transferred from the IGDS file to the IGRDS file. The Synchronize Command is a special command of this subset that matches the IGDS and IGRDS file and transfers points or complex strings in either direction until each file has the same content for those types of elements.

Geometry Print File Control - a set of commands that allows for organization and control of the geometry print function.

6.1.2.2 Discussion of Characteristics of Individual Commands

Table 2 lists and provides a short description of the geometry commands available through IGRDS (i.e., through the IGDS terminal).

DESCRIPTION OF IGRDS FUNCTIONS

The fifty commands listed are not intended to be the final number available, rather the basic set required to initiate an IGRDS. Table 2 provides an index for each command which is used to make reference to Figure 9, a diagram depicting the categories of geometry commands, and the individual command functional block diagrams contained in the Appendix. Four other columns are included in Table 2, which describe respectively:

1. Command Index - A designation that will uniquely identify each command for this report. The index number will consist of an alpha character defining the command and category, and a unique numeric value within that category.

2. RDS Command - The specific RDS command, or option of a command, that could perform the specified IGRDS function.

3. Print - An indication as to whether the specified functions would produce an RDS geometric report line, if the print switch was turned on. (It should be noted that in the IGRDS environment, where each geometric element is visible as part of the display and exists in the IGDS file, some commands do not require print lines for audit purposes as they do in the RDS environment. Some commands have printing as their only purpose and have been so keyed in the Table. Others have printing as an option to be decided by the user.)

4. IGRDS Store - An indication as to whether, or when, the subject command will cause a storage or modification of the associated data elements in the IGRDS file. Storage or modification of data, if applicable to the command, will occur if the user indicates his desire by means of a "store switch". This switch will be set for all commands activated with the switch set to "on". In addition to storing data in the IGRDS file, the user may cause deletions or updating of data with the same procedure for storing. All of the above IGRDS file modifications will be performed by program processes once the user has indicated the intent.

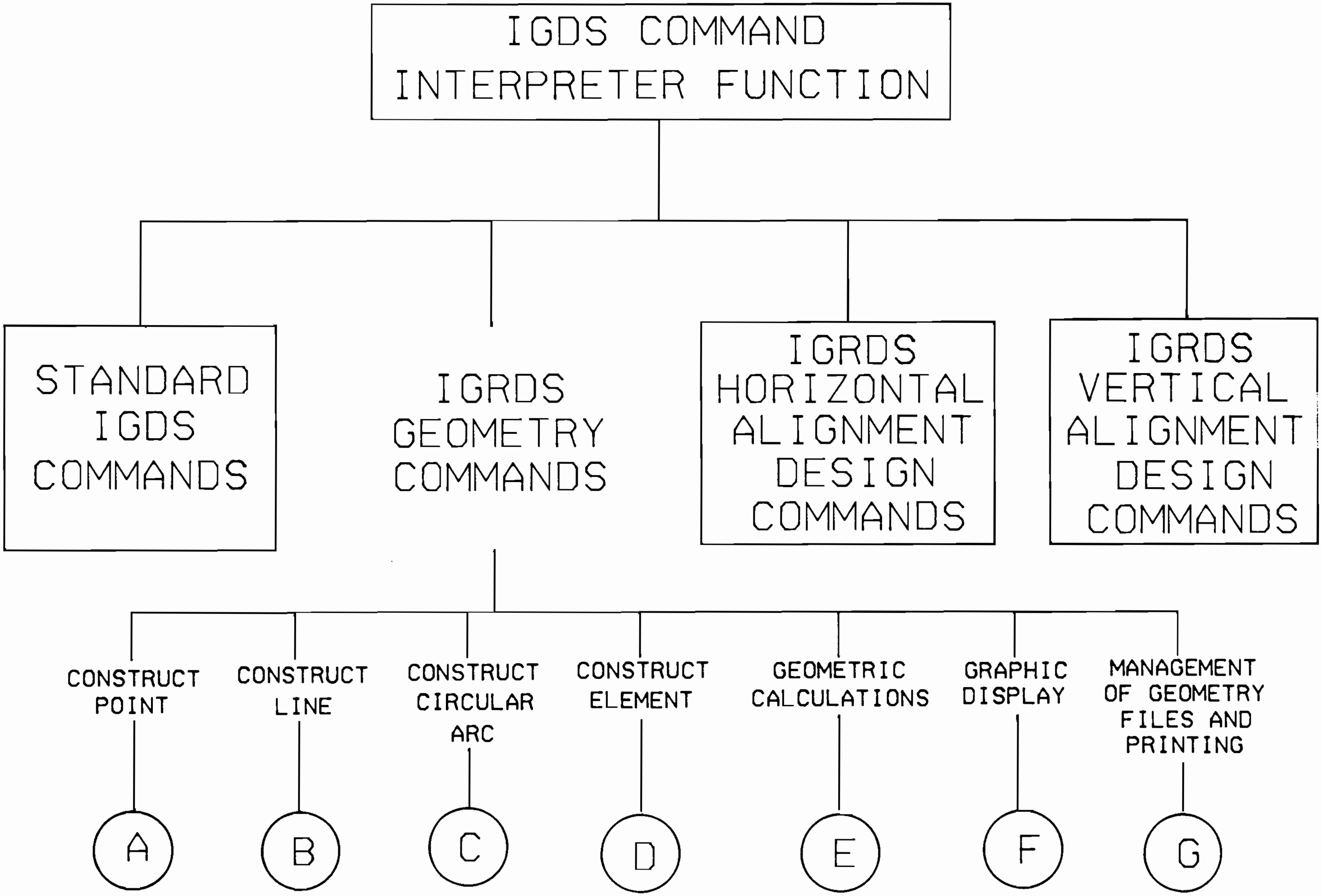


FIGURE 9 TYPES OF IGRDS GEOMETRY COMMANDS

TABLE 2

(Table 2, Page 1)

IGRDS GENERAL GEOMETRIC COMMANDS

Command Indexes	Command Name	Description	RDS Command	Print	IGRDS Store
A1	Construct Point	- by coordinate	PONT 1		0
A2	Construct Point	- intersection two elements	ISCT		0
A3	Construct Point	- intersection complex string and graphic element			0
A4	Construct Point	- on element, a from point on element	TRAY OPT 2		0
A5	Construct Point	- at bearing and distance from existing point	TRAV OPT 1		0
A6	Construct Point	- from two points, at direction angle and distance	TRAV OPT 3		0
A7	Construct Point	- from two points, at deflection angle and distance	TRAV OPT 4		0
A8	Construct Point	- by station and offset	PONT, OPT3		0
A9	Construct Point	- midway between two geomtric elements			0
B1	Construct Line	- between two points	BRDS		0
B2	Construct Line	- perpendicular to line or arc			0
B3	Construct Line	- at skew to line or bearing through point	PERL		0
B4	Construct Line	- tangent to arc, from point off arc	TANG OPT 0 & 0A		0
B5	Construct Line	- tangent to arc, from point on arc	PERL?		0
B6	Construct Line	- tangent to two arcs	TANG OPT 1-4		0
B7	Construct Line	- by station and skew, bearing or azimuth	CURV, OPT6		0
B8	Construct Line	- at station, parallel to other line			0
B9	Construct Line	- mean, through series			0

TABLE 2

(Table 2, Page 2)

IGRDS GENERAL GEOMETRIC COMMANDS

Command Indexes	Command Name	Description	RDS Command	Print	IGRDS Store
B10	Extend Line	- given distance			U
B11	Extend Line	- to point			U
B12	Extend 2 Lines	- to intersection of points			U
C1	Construct Arc	- by center point and radius			O
C2	Construct Arc	- tangent to two lines			O
C3	Construct Arc	- tangent to line			O
C4	Construct Circle	- by center point and radius	CURV, OPT3, 447		
D1	Construct Line or Arc	- parallel to element, through point	PARL OPT 1 & 2		O
D2	Construct Line or Arc	- parallel to element, at offset dimension	PARL OPT 3		O
D3	Construct Line or Arc	- parallel to Horizontal Alignment segment	CURV, OPT5		O
D4	Construct Complex String	- parallel to Horizontal Alignment			O
E1	Calculate Bearing and Distance	- between two points	BRDS	O	P
E2	Calculate Angle	- between two lines	ANGL, OPT1	O	P
E3	Calculate Angle	- between three points	ANGLE, OPT2	O	P
E4	Calculate Station and Offset	- of point	YPNT	O	P
E5	Calculate Station, Offset, and Elevation	- of point	TPNT	O	P
E6	Calculate Area and Dimension	- of existing shape		O	P
E7	Calculate Area and Dimension	- of shape defined by points	AREA	O	P
E8	Calculate Closure and Area	- of deed description	RWTR	O	P

TABLE 2

(Table 2, Page 3)

IGRDS GENERAL GEOMETRIC COMMANDS

Command Indexes	Command Name	Description	RDS Command	Print	IGRDS Store
F1	Display Grid Ticks		TICK		
F2	Contour Roadway Surface		CONT		R
G1	Set Print Switch				
G2	Set Point Store Switch				
G3	Set Complex String Store Switch				
G4	Store Point in IGRDS File				S
G5	Store Complex String in IGRDS File				S
G6	Synchronize IGDS & IGRDS Files			O	U
G7	Delete-Geometric Element				O
G8	Partial Delete-Geometric Element				D
G9	Place Comment in Geometry Print Output		CMNT	Y	
G10	Page Eject in Geometric Print Output		EJCT	Y	
G11	Skip Line(s) in Geometric Print Output		SKIP	Y	

LEGEND:

S = Store
Y = Yes
D = Delete
U = Update
R = Retrieve
P = Yes, If Print
O = Optional

6.1.3 Methods of Implementing Commands

Table 2 lists RDS commands for many of the geometric commands that can perform a desired function. The development plan expects that for the prototype IGRDS most of the geometric functions having IGDS counterparts would use the IGDS capabilities. This approach will yield a functioning prototype IGRDS at the earliest date and at least cost. RDS programs would be used to implement the geometric commands when RDS printing or IGRDS storage is required, or when IGRDS is moved from the prototype IGDS to another that does not have these computational capabilities.

From the above, it is apparent that the IGRDS geometry commands will be implemented with a combination of IGDS capabilities and RDS programs. Figures 3-7 (see Section 5.2.3) show and explain four modes available for implementing IGRDS for the various needs of the IGRDS functions. The geometry process of IGRDS will use Modes 2 and 3, with Mode 1 being available for the IGDS experienced user. Mode 1 is the utilization of native IGDS construction, display and store commands. Any such command may be employed to establish geometric points, lines or curves which, in turn, may be used to fulfill any of the IGRDS needs for geometric or alignment element creation or manipulation. Mode 2 involves the use of a User Command program to call an IGDS function. The purpose in using the UC program is only to provide a familar command definition (i.e., RDS oriented command definition) for the user. Mode 3 would be employed when RDS programs are used to perform the geometric calculation, or to print and store in the IGRDS file. The steps of Mode 3 would include:

1. The use of a User Command program to call an IGDS/RDS interface program.

2. The execution of the IGDS/RDS interface program to access the IGDS file and to call the RDS program.

3. The calculation of the desired geometry by RDS programs and the accessing of the IGRDS file.

6.1.4 Nature, Key Elements and Management Methods of Files

Two files are involved in the geometry process of IGRDS: the IGDS, and the IGRDS files (see Figure 2).

1. IGDS File

   Since all geometry commands will result in a graphic display of the appropriate elements at the user terminal, the graphics, and also real description of the elements, will be placed in the IGDS file. The natural record format and organization of the IGDS will be maintained, except for additional values added to the record for IGRDS. At this level of system design, the only item positively known to be added will be a geometric element number of the type used by RDS for each point, circle or line that has similar definition to that of the RDS file. The purpose of this number will be to allow for correlation of elements between the two files, and between the files and the reports.

2. IGRDS File

   The IGRDS file will receive or have its geometric data modified only when one of the following is true:

   - The involved command appropriately produces IGRDS data values and the user indicates that he wishes to have the data stored in IGRDS.
   - The user specifically initiates a command which will either transfer element data from the IGDS file to the IGRDS file or will cause some modification of the data of the IGRDS file.
   - The user causes an eligible geometric command to print.
   - The user causes a conversion of an RDS file to an IGRDS file, replacing the previous IGRDS file.

Since the IGRDS file will be accessed by RDS programs and may be initiated by an unpaging of the RDS file, the record layout and organization of geometric data will be the same as the RDS file for the Phase 1 implementation. At this time, it is recommended that the IGRDS and RDS files be upgraded in the future to accept the following new geometric elements:

- Line Segments
- Circular Arc Segments
- Complex Strings

6.1.5 General Definition of Graphic and Printed Output

The geometric process of IGRDS will have display and plotted graphic outputs and printed outputs. These two classes of results are described as the following:

1. Graphic Output

   A CRT screen view will be produced at the IGDS terminal showing the result of each displayable command. These displays will be produced by the standard IGDS processes as a result of depositing the effect of the command into the IGDS file. The user may take advantage of any natural IGDS graphics function to change views, zoom, window, annotate, etc., to combine these actions with IGRDS, thus, producing a display view to fit the person's needs. The user will have the option of producing the displays with geometric element numbers attached as labels, as well as what would be considered the normal manner, without numbers.

   Plotted output of geometric elements may be obtained in either of two ways:

   - An IGDS file representing the desired plot may be plotted by normal IGDS procedures.

- An IGRDS file may be transferred into RDS file form and plotted with existing RDS plot commands. The plot output will be produced either by standard RDS commands or by GPS.

2. Printed Output

Printed reports will be produced by IGRDS as a result of execution of commands generating printable results with the user controlled print switch set to on. Each printable command will have the same report format as for RDS and will be output in the same manner as for RDS. Graphic displays will show the RDS geometric element ID that is in the geometric element file and is shown on the printed report to allow the designer to correlate displays and reports.

6.2 HORIZONTAL ALIGNMENT

Although the design calculations of IGRDS and RDS are the same, the commands to initiate horizontal alignment calculations are not comparable. The difference is solely due to the lack of similarity of operational conditions between interactive graphics and batch. As is true for the geometry process, the horizontal alignment capabilities of IGRDS will have all of the natural functions of the IGDS and the geometry functions just defined for the IGRDS available to support it, as well as all of the facilities of the batch version of RDS. Because the geometric functions of IGDS were not developed with roadway engineering as an objective, the horizontal alignment process of IGRDS will be much more dependent upon the subroutines of RDS.

6.2.1 General Discussion of Design Process

The objective of the horizontal alignment design process is to provide the user with the following aids:

- Visual and measurable reference of the character of the terrain (i.e., planimetric and topographic map displays).

- Commands to define the horizontal alignment with visual feedback of these definitions, short of full calculations, to determine the probable effect of design decisions.

- Capabilities to calculate horizontal alignment data and to display the results.

- Commands to provide graphic display attribute information to aid in visual interpretation.

A single horizontal alignment will be calculated at a time; however, other alignments may be displayed simultaneously on the screen to provide the user with orientation and relationships of the alignments.

As a means of providing visual and measurable reference between the alignment and the terrain, the user may display the mapping that has been produced in the IGDS file. The procedures for entering this data into and displaying it from the IGDS file will be functions of IGDS, and will have no special capabilities provided from IGRDS. The horizontal alignment design commands are planned to be used in conjunction with a background terrain display and the geometry commands described in the preceding sections. The geometry commands will provide the means to measure from the displayed background terrain and to place, and otherwise construct the horizontal alignment PI's.

The PI's will be stored in the IGDS file, along with user entered PI curve and spiral data, and will be displayed with an identifying symbol. At the user's request, tangent lines may be displayed between PI's to provide a general view of the alignment. The PI point data, stored in the IGDS file, will be the input values to the RDS alignment calculation program. At the user's command, the RDS alignment calculation process will be executed. The result will be the alignment reports, currently produced by RDS, which will be displayed on the user's terminal and printed as hardcopy. In addition to the reports, a display of the calculated alignment will be produced on the terminal. Commands will allow the user to place or delete annotations and station tick marks or associated lines representing crown, ditch or catch.

Calculations with relation to the alignments may be performed by geometric commands.

6.2.2 Commands and Associated Functions

The Horizontal Alignment Design Process is made up of approximately seventeen commands which have been collected into four categories.

6.2.2.1 Discussion of Categories of Commands

The Horizontal Alignment Commands are classified into the four categories shown in Figure 10 and are explained in the following:

Define Active Roadway

- A single command that signals to the system the particular alignment that is subject to the user's design in the subsequent calculating processes.

Establish and Update PI's

- A set of commands to define the basic control elements of the horizontal alignment. These commands provide the user with the means to place, add, move, revise, delete and otherwise modify the location and data associated with the PI's controlling the horizontal alignment.

Calculate and Display or Delete Horizontal Alignments

- A command that causes a calculation process to be performed in similar manner and with similar results as is now done by RDS, with the resulting horizontal alignment to be displayed on the user's terminal.

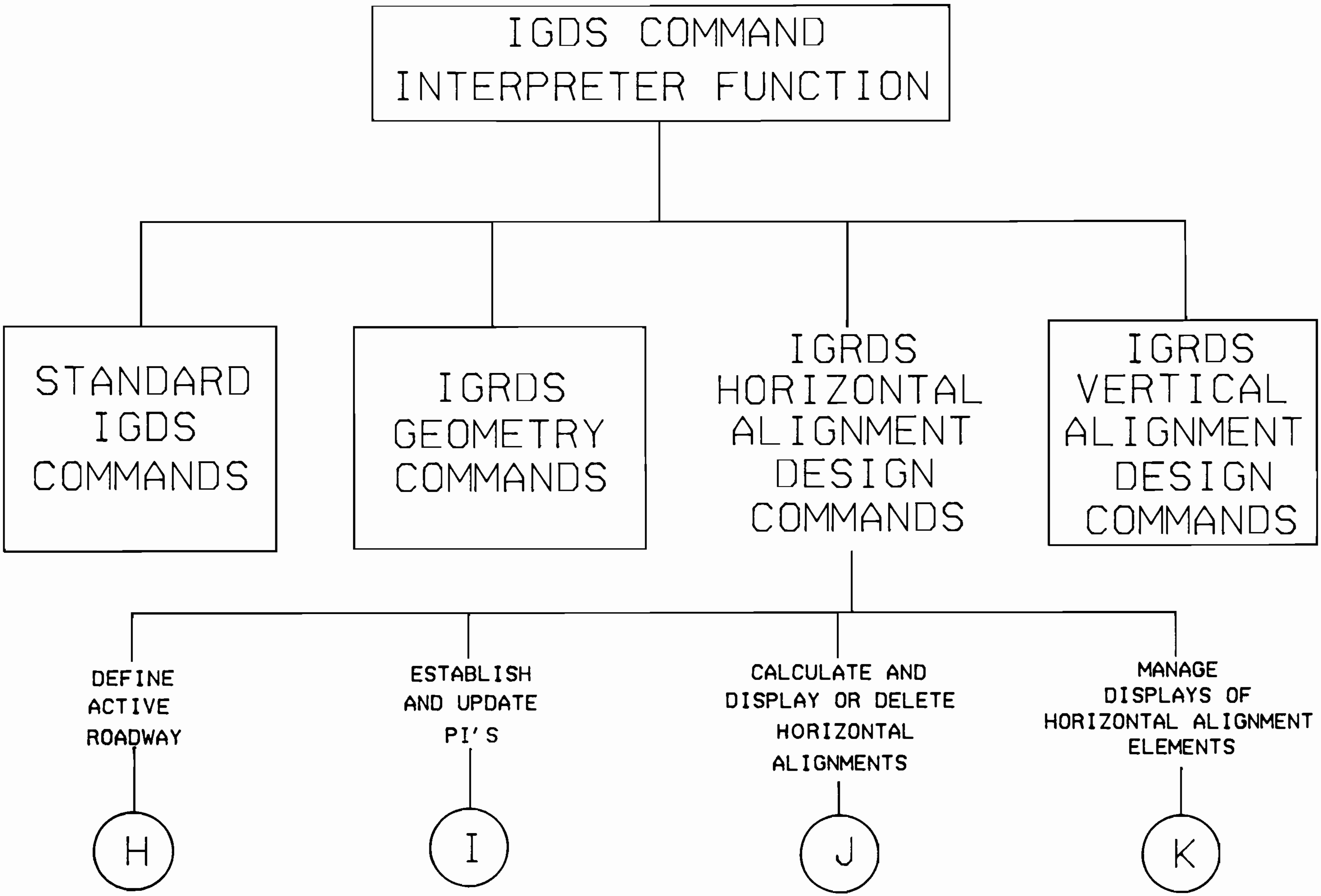


FIGURE 10 TYPES OF IGRDS HORIZONTAL ALIGNMENT COMMANDS

Manage Displays of Horizontal Alignment Elements

- A category of commands that allow the user to display or remove labels, symbols, and subsidiary graphic elements (i.e., tangent lines to horizontal curves, station ticks, station labels, PI numbers) which may, at various times, be considered to be enhancing or cluttering the display.

6.2.2.2 Discussion of Characteristics of Individual Commands

Table 3 lists and provides a short description of the horizontal alignment commands available through IGRDS (i.e., through the IGDS terminal). The seventeen commands listed are not intended to be the final number available, rather the basic set required to initiate an IGRDS. Table 3 provides an index to each command, which is used to make reference to the general process description block diagram shown in the Appendix. Just as for the geometry process, four other columns are included in Table 3 and describe, respectively:

1. Command Index - A designation that will uniquely identify each command for this report. The index number will consist of an alpha character defining the command category and a unique numeric value within that category.

2. RDS Commands - The specific RDS command, or option of a command, that could perform the specified IGRDS function. It can be noted that the majority of these commands deal with data and display manipulation rather than deal with computational procedures; and, thus, most of these commands do not have direct hereditary links to RDS.

3. Print - An indication as to whether the specified functions would produce an RDS report. For horizontal alignment, only the calculation and display command produces a report. The report would be the same as that now output from RDS, and would be displayed on the screen and printed in hardcopy.

TABLE 3

IGRDS HORIZONTAL ALIGNMENT COMMANDS

Command Indexes	Command Name	Description	RDS Command	Print	IGRDS Store
H1	Define Active Roadway		HA		
I1	Add Horizontal Alignment PI	- in sequence			S (No)
I2	Add Horizontal Alignment PI	- before or after existing Horizontal Alignment PI			
I3	Revise Horizontal Alignment PI	- location			U (No)
I4	Delete	- Horizontal Alignment PI			D (No)
I5	Revise Horizontal Alignment PI	- Data			
I6	Resequence Horizontal Alignment PI Numbers				
J1	Calculate and Display Horizontal Alignment		HA	Y	S
J2	Delete	- Horizontal Alignment			D
K1	Display	- Horizontal Alignment Tangents			
K2	Display	- Horizontal Alignment			
K3	Display	- Horizontal Alignment Annotation	HA		
K4	Display	- Station File Lines (Crown, Ditch, Catch)	STAF		R
K5	Delete Display	- Horizontal Alignment Tangents			
K6	Delete Display	- Horizontal Alignment			
K7	Delete Display	- Horizontal Alignment Annotation			
K8	Delete Display	- Station File Lines (Crown, Ditch, Catch)			

LEGEND:

S = Store
Y = Yes
D = Delete
U = Update
R = Retrieve
P = Yes, If Print
O = Optional

4. IGRDS Store - This key provides an indication of the effect of each command on the IGRDS file. These commands affect the IGRDS file in these ways:

   - The calculation command transfers PI and curve data values alignment calculation. As part of the calculation, IGRDS will store the alignment data in its file, replacing any previously existing data for the alignment being processed. This is essentially the same procedure as occurs with batch RDS.

   - An alignment display command will extract data from the IGRDS file, without modification to the file, and generate an IGDS file which will cause the desired display to be produced.

   - Alignment data stored in the IGRDS file may be deleted by an IGRDS command.

6.2.3 Methods of Implementing Commands

Figures 3-7 (see Section 5.2.3) depict four modes by which RDS programs may be interfaced with IGDS. All four of these modes will be available for the horizontal alignment process. Mode 1, the native IGDS command capability, may only be employed by the user to delete alignment control data (i.e., PI and curve information) or terminal display elements. Although this will be possible, the IGRDS User's Manual will advise the user not to take this approach since he will not receive all of the aid that the IGRDS commands will provide. None of the native IGDS commands will have any effect on the IGRDS file. Mode 2 involves the use of a User Command program to prompt a user and to call IGDS functions. This mode is likely to be employed by IGRDS to establish and update horizontal alignment control data or elements of an alignment display (e.g., tangents, ditch lines, etc.). Mode 3 may be used to produce an alignment display, when calculations are not required. Mode 4 is most likely to be employed to perform the horizontal alignment calculations and the resulting displays.

6.2.4 Nature, Key Elements and Management Methods of Files

Two files are involved in the horizontal alignment process of IGRDS: the IGDS and the IGRDS files (see Figure 7, Section 5.2.3).

1. IGDS File

   The IGDS file will provide the storage function for the creation and retention of horizontal alignment control data (i.e., PI and curve information) which will be the input to the RDS calculation and alignment storage step, and for the display and plotting of alignments and associated elements. This can be likened to storage of alignment input data and graphic display data structures. IGDS records that define points (i.e., in the terms of the prototype IGDS, "point cells") will be used to identify alignment PI's, and will have PI attribute data added to them. At least the following PI point attributes will be added to the records:

   - Point Record Type (i.e., alignment PI)
   - Alignment Identification
   - PI Number
   - Station
   - Radius
   - Spiral Length In
   - Spiral Length Out

Additional data may be added during detail design. The PI point records for an alignment are analogous to the RDS RD05 input cards. IGDS/RDS interface programs (see Figure 7, Section 5.2.3) will extract these records and create input for the RDS alignment calculation programs modified for IGRDS.

Upon completion of the calculation process of IGRDS, the alignment data will be passed back to the IGDS file in the form of a graphics data structure. This data structure will result from RDS plot program logic, and will have the form of a line string made up of lines and circular arcs (i.e., a "complex string", in the terms of the prototype IGDS). The records defining this complex string will have attribute data added to them. The attribute data will define the function and name of each element of the string, and will be in the form of data fields added to the complex string element records. At least the following attributes will be added to the records:

- Alignment Number
- Alignment Element Type (i.e., tangent, curve, spiral, etc.)
- Element Name (e.g., tangent PT3 to PC4, curve PI4, etc.)

These complex strings will be stored in IGDS. They may be used with other geometric or alignment calculations, since their elements are valid geometric elements for both IGDS and IGRDS.

2. IGRDS Files

The IGRDS file will be the real horizontal alignment model file. It will have the same record description as does RDS. The alignment data will be entered into the IGRDS file either from an IGRDS command initiated by the user from the IGDS, or from a user initiated transfer operation from a batch RDS file.

6.2.5 General Definition of Graphic and Printed Output

Just as for the geometric process, IGRDS will have display and plotted graphic outputs and printed outputs. The description of the methods of obtaining graphic and printed output for the geometric process will hold true for the horizontal alignment process with the following elaborations:

DESCRIPTION OF IGRDS FUNCTIONS

1. The user will have the option to display or not display alignment components such as: tangent lines from PC to PI and PT to PI; crown ditch and catch lines; and station ticks and labels.

2. Printed reports of the alignment calculation will be displayed on the terminal and printed as hard copy.

6.3 VERTICAL ALIGNMENT

Even though the vertical alignment design calculations of IGRDS and RDS are the same, the commands to initiate vertical alignment calculations, as was true for horizontal alignment, are not comparable. The difference is due to the dissimilar operating concepts between interactive graphics and batch. As is true for both the geometry and the horizontal alignment processes, the vertical alignment capabilities of IGRDS will have available to support it all of the natural functions of the IGDS, the functions previously defined for the IGRDS, as well as all of the facilities of the batch version of RDS. The native IGDS functions, however, will be of even lesser value to vertical alignment than for horizontal alignment, due to the even greater dissimilarities between IGDS geometry and roadway vertical alignment calculations.

6.3.1 General Discussion of Design Process

The objective of the vertical alignment design process is to provide the user with the following aids:

- Visual and measurable reference of the horizontal and vertical character of the alignment (i.e., measured along the centerline of the horizontal alignment).

- Dual scale view of alignment (i.e., different vertical and horizontal scales) as is commonly used in the manual design process.

- Facility to guide the user in the placement of profile elements on the view screen.

- Commands to define the vertical alignment with visual feedback of these definitions, short of full calculations, to determine probable effect of design decisions.

- Capabilities to calculate vertical alignment data and to display the results.

- Commands to provide graphic attribute information to aid in visual interpretation.

- Ability to make measurements from the vertical alignment.

The vertical alignment design will allow only one alignment to be designed at a time, but will allow profiles of other alignments to be simultaneously displayed on the screen to provide the user with orientation of the alignments. As a means of providing visual reference, a line of constant elevation, of the user's choosing, may be displayed on the screen. This reference line would have ticks representing true distance along the centerline of the horizontal alignment being designed. The distance would take into account all equations and would depict stationing with ticks at appropriate locations along the reference lines, also accounting for all station equations. The user would be able to adjust the reference line vertically (i.e., to have the reference line displayed at different elevations) to fit his needs.

For historically justifiable engineering reasons, the vertical alignment would be shown at different scales in the vertical and horizontal direction. To aid the user when placing points in a relative position, rather than at an absolute station and elevation, a background of grid ticks may be displayed by command to show horizontal and vertical position. The horizontal position will be defined by vertical lines of crosses that will be located at station increments, as established by the User Command. Locations of station equations will be recognized and the vertical grid displayed accordingly.

DESCRIPTION OF IGRDS FUNCTIONS

After establishing the reference lines and optionally the background grid, the user will have the facility to produce a profile of the natural ground along the centerline of the horizontal alignment, displayed in relative scale with the reference alignment and vertical scale. With this visual guidance, the user may place VPI's at desired locations and cause tangent lines to be displayed without complete vertical alignment calculation to visually evaluate, in a preliminary sense, the effect of the placement. The VPI location, and associated data, will reside in the IGDS files as input data for calculation. Upon initiation of a calculation command, this data will be extracted from the IGDS file and be formatted into input for the RDS calculation, a vertical alignment calculation will be made as is now done for RDS, and a display of the resulting profile (i.e., tangents and vertical curves) will be produced on the display with the generating data being placed in the IGDS file.

The user will have available a series of display control commands that will allow him to produce supplementary profile display data such as annotation. The displayed profile may be used to make measurements, as an example, for clearance.

6.3.2 Commands and Associated Functions

The vertical alignment design process is made up of approximately twenty-nine specific commands which have been collected into five categories.

6.3.2.1 Discussion of Categories of Commands

The vertical alignment commands are classified into the five categories shown in Figure 11 and are explained in the following:

- Manage Background Display Aids

  - A set of commands that does not have a counterpart in either general geometry or horizontal alignment of IGRDS. Its most analogous functions would be those provided by IGDS in producing the planimetric and topographic displays, produced by

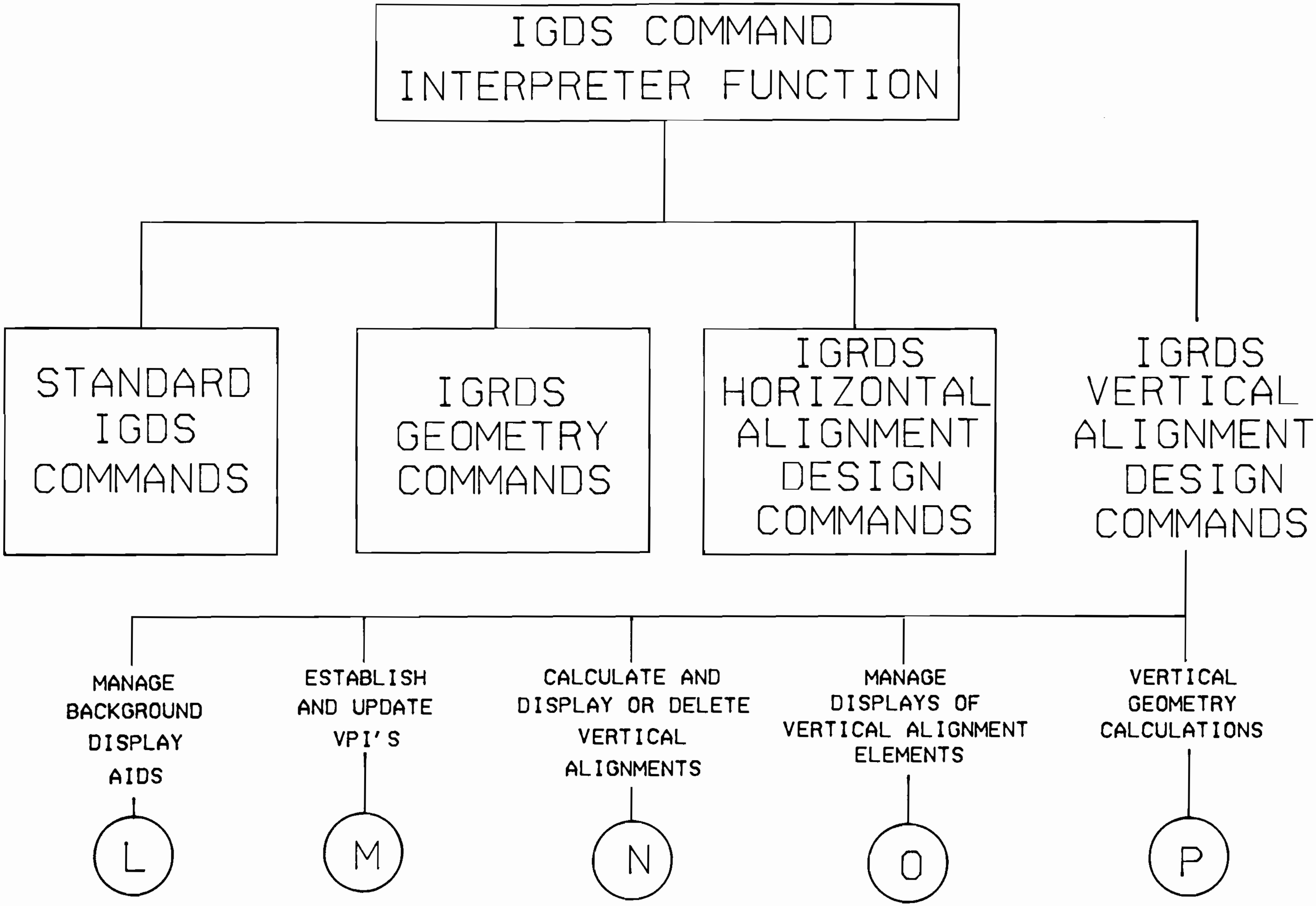


FIGURE 11 TYPES OF IGRDS VERTICAL ALIGNMENT COMMANDS

photogrammetry, to orient the user for the general geometry and horizontal alignment process.

This category of commands provides the user the means to make those vertical alignment design decisions that are dependent upon the ground profile and the stationed alignment. The commands provide the visual and measurement frame of reference that the user will need to determine how to place VPI's, grade lines and vertical curves to both initially establish a realistic first alignment definition and then to refine it based upon the resulting calculation.

The aids provided would be:

- A reference line providing a base elevation and visual representation of stationing along the alignment.
- Screen grid ticks to allow horizontal and vertical orientation for the user.
- A natural ground profile line along the alignment centerline.

A further description of these aids is in Section 6.3.2.2.

- Establish and Update VPI's
  - A set of commands that is similar to the category of commands with the same name for horizontal alignment. These commands provide the user with the means to place, add move, revise, delete and otherwise modify the location and data associated with the VPI's controlling the vertical alignment.
- Calculate and Display or Delete Vertical Alignments
  - A command that will cause a calculation process to be performed, in the same manner as is now done by RDS, and the resulting vertical alignment to be displayed on the user terminal.

- Manage Displays of Vertical Alignment Elements

  - A category of commands that will allow the user to display or remove labels, symbols, and subsidiary graphic elements (i.e., tangent lines to vertical curves) which may at various times be considered to enhance or clutter the display.

- Vertical Geometry Calculations

  - A category of commands that will allow the user to perform miscellaneous calculations and produce appropriate displays related to grade or profile control points along the alignment which determine grade line position.

6.3.2.2 Discussion of Characteristics of Individual Commands

Table 4 lists and provides a short description of the vertical alignment commands available through IGRDS (i.e., through the IGDS terminal). The twenty-nine commands listed are not intended to be the final number of commands available but rather a basic set to initiate IGRDS. Table 4 provides a number to each command, which is used to make reference to both Figure 11 (Categories of IGRDS Vertical Alignment Commands) and the individual process description block diagram shown in the Appendix. Just as for the general geometry and horizontal alignment processes, four other columns are included in Table 4, which columns describe respectively:

1. Command Index - A designation that will uniquely identify each command for this report. The index number will consist of an alpha character defining the command category and a unique numeric value within that category.

2. RDS Commands - The specific RDS command, or option of a command, that could perform the specified IGRDS function. It can be noted that the majority of the IGRDS vertical alignment design commands deal with data and display manipulation rather than with computational procedures which are currently performed by a designer prior to entering data into batch

TABLE 4

(Table 4, Page 1)

IGRDS VERTICAL ALIGNMENT COMMANDS

Command Indexes	Command Name	Description	RDS Command	Print	IGRDS Store
L1	Display	- Terrain Profile	PROFILE PLOT		
L2	Display	- Profile Reference Line			
L3	Display	- Profile Reference Grid			
L4	Delete	- Display Terrain Profile			
L5	Delete	- Profile Reference Line			
L6	Delete	- Profile Reference Grid			
L7	Move Profile Reference Line				
L8	Return Profile Reference Line to Origin				
M1	Add VPI	- by Station and Elevation, in Sequence	RD10		
M2	Add VPI	- by Station and Grade			Y
M3	Add VPI	- By Station and Elevation, Before or After Existing VPI			
M4	Add VPI	- of Vertical Curve Passing Through Critical Point			
M5	Revise VPI	- Location			U
M6	Revise VPI	- Data			
M7	Move VPI	- on Tangent			
M8	Delete	- VPI			D
M9	Resequence VPI Numbers				
N1	Calculate and Display Design Profile				Y
N2	Delete	- Design Profile			U
O1	Display	- Design Profile Tangents			
O2	Display	- Design Profile Alignment	RD10	Y	

TABLE 4

(Table 4, Page 2)

IGRDS VERTICAL ALIGNMENT COMMANDS

Command Indexes	Command Name	Description	RDS Command	Print	IGRDS Store
03	Display	- Design Profile Annotation			
04	Delete Display	- Design Profile			
05	Delete Display	- Design Profile Tangents			
06	Delete Display	- Design Profile Annotation			
07	Display	- Profile(s) for Plan and Profile Sheet	PROF PLOT		
P1	Calculate Station and Profile Elevation of Point			O	P
P2	Construct Vertical Point by Station and Elevation				O
P3	Calculate	- Tangent Grade Between Two Points			

LEGEND:

S = Store
Y = Yes
D = Delete
U = Update
R = Retrieve
P = Yes, If Print
O = Optional

RDS; and, thus, only a few of these commands have a direct hereditary link to RDS.

3. Print - An indication as to whether the specified functions would produce an RDS report. For vertical alignment, only a very few of these commands produce a report. When printed, the reports would be the same as those now output from RDS and would be displayed on the screen and printed in hard-copy.

4. IGRDS Store - An indication of the effect of each command on the IGRDS file. The store commands would affect the IGRDS file in the following ways:

   - The calculation command transfers VPI and curve data values from the IGDS file to IGRDS in a form to allow for an alignment calculation. As part of the calculation, IGRDS will store the alignment data in its file, replacing any previously existing data for the alignment being processed. This is essentially the same procedure as occurs with batch RDS.

   - An alignment display command will extract data from the IGRDS file, without modification to the file, and generate an IGDS file which will cause the desired display to be produced.

     Alignment data stored in the IGRDS file may be deleted by an IGRDS command.

6.3.3 Methods of Implementing Commands

Figures 3-7 (see Section 5.2.3) depict four modes by which RDS programs may be interfaced with IGDS. All four of these modes will be available for the vertical alignment process. Mode 1, the native IGDS command capability, may only be employed by the user to delete any alignment control data (i.e., VPI and vertical curve information) or terminal display elements. Although this will be possible, the IGRDS User's Manual will advise the user not to take this approach since he will not receive all of the aid that the IGRDS commands will provide. None of the native IGDS commands will have any affect on the IGRDS file. Mode 2 involves the use of a User Command program to prompt a user and to call IGDS functions. This mode may be employed by IGRDS to establish and update vertical alignment control data or elements of an alignment display (e.g., tangents, grids or annotations). Mode 3 may be used to produce a vertical alignment display, when calculations are not required. Mode 4 is most likely to be employed to perform the vertical alignment calculations and the resulting displays.

6.3.4 Nature, Key Elements and Management Methods of Files

Just as for the horizontal alignment process, two files are involved in the vertical alignment design process of IGRDS: the IGDS and the IGRDS files (see Figure 7, Section 5.2.3).

1. IGDS File

   The IGDS file will provide the storage function for the creation and retention of vertical alignment control data (i.e., VPI and curve information) which will be the input to the RDS calculation and alignment storage step, and for the display and plotting of alignments and associated elements. This can be likened to storage of vertical alignment input data and graphic display data structures. IGDS records that define points (i.e., in the terms of the prototype IGDS, "point cells") will be used to identify alignment VPI's and will have VPI attribute data added to them. At least, the following VPI point attributes will be added to the records:

   - Point Record Type (i.e., alignment PI)

   - Alignment Identification

   - VPI Number

- Station
- First Vertical Curve Length
- Second Vertical Curve Length
- Elevation Correction

Additional data may be added during detail design. The VPI point records for a vertical alignment are analogous to the RDS RD10 input cards. IGDS/RDS interface programs (see Figure 7, Section 5.2.3) will extract these records and create input for the RDS alignment calculation programs, modified for IGRDS.

Upon completion of the calculation process of IGRDS, the vertical alignment data will be passed back to the IGDS file in the form of a graphics data structure. This data structure will result from RDS plot program logic, and will have the form of a line string made up of lines and parabolic arcs (i.e., a "complex string", in the terms of the prototype IGDS). The records defining this complex string will have attribute data added to them. The attribute data will define the function and name of each element of the string and will be in the form of data fields added to the complex string element records. At least, the following attributes will be added to the records:

- Alignment Number
- Alignment Element Type (i.e., profile tangent, vertical curve, etc.)
- Element Name (e.g., tangent VPT3 to VPC4, curve VPI4, etc.)

These complex strings will be stored in IGDS. They may be used with other vertical alignment calculations (e.g., elevation or clearance), since their elements are valid geometric elements for both IGDS and IGRDS.

2. IGRDS Files

The IGRDS file will be the real vertical alignment model file. It will have the same record description as does RDS. The alignment data will be entered into the IGRDS file either from an IGRDS command initiated by the user from the IGDS, or from a user initiated transfer operation from a batch RDS file.

6.3.5 General Definition of Graphic and Printed Output

Just as for the geometric and horizontal alignment process, IGRDS will have display, plotted graphic outputs, and printed outputs. The description of the methods of obtaining graphic and printed output for the horizontal alignment process will hold true for the vertical alignment process.

CHAPTER 7

CONCLUSION

This Report, except for a small amount of detailed file layout, completes the System Design of the first phase of IGRDS. At this point, the project was prepared to move ahead with detailed program design and development; however, the project funds were depleted and the Federal Project terminated. Completion of the system is being pursued under different sponsorship. The study and design work that was the basis for this Report did verify the feasibility of the proposed development and did not detect any significant, unexpected, or technical obstacles to such development. It did become apparent that there is potential to provide an even greater number of design commands to aid the user than first anticipated. As of this report, a total of 106 commands have been defined. Although it appears that other facilities of significant benefit are feasible, the 106 commands currently defined are more than the minimum necessary for an initial implementation. The implication of this finding is that even greater resources could provide increased benefits; however, it is quite possible, and the system design has been so structured, to develop and implement IGRDS in phases. This phased approach will allow the matching of benefits to funds and the proving of design concepts before "total" implementation takes place.

There was a small amount of detailed file layout that was not included in the Design Report because by far the largest part of the file structure is already established by the RDS and IGDS files. The development project planned to proceed to finalize these last file layouts and to develop program definition for both the existing RDS programs and for those interface programs that are to be newly developed for IGRDS.

Upon completion of IGRDS, designers will have a system available that will both:

- Improve their productivity in roadway engineering and in performing geometric calculations.

- Provide the means to conveniently and visually evaluate the details of the engineering project to better evaluate the engineering, thus achieving better results with fewer errors or changes in construction.

Development is proceeding at a reduced rate since the termination of the federally funded contract. It would be beneficial if the members of the AASHTO RDS Maintenance Contract effort would become involved in the completion of the system and make it available to the highway engineering community as they have for RDS, and/or have the FHWA reinstate their sponsorship.

In the interim, since the termnation of the project, a subset of the General Geometry and Horizontal Alignment functions of IGRDS has been completed and placed into production by the Texas State Department of Highways and Public Transportation for evaluation of the design concepts. The users of the system have shown their acceptance through their utilization of IGRDS for highway design and have identified several enhancements. Development of the remaining segments of the system was continuing at the time this report was finalized.

APPENDIX A: IGRDS COMMANDS

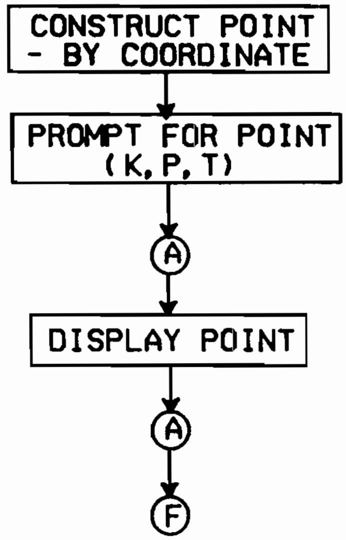
Functional Block Diagrams

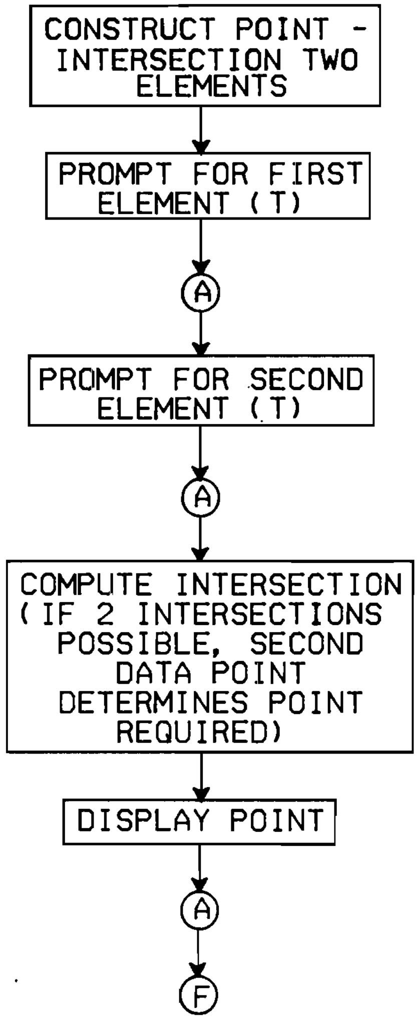
DISCUSSION OF NATURE OF BLOCK DIAGRAMS

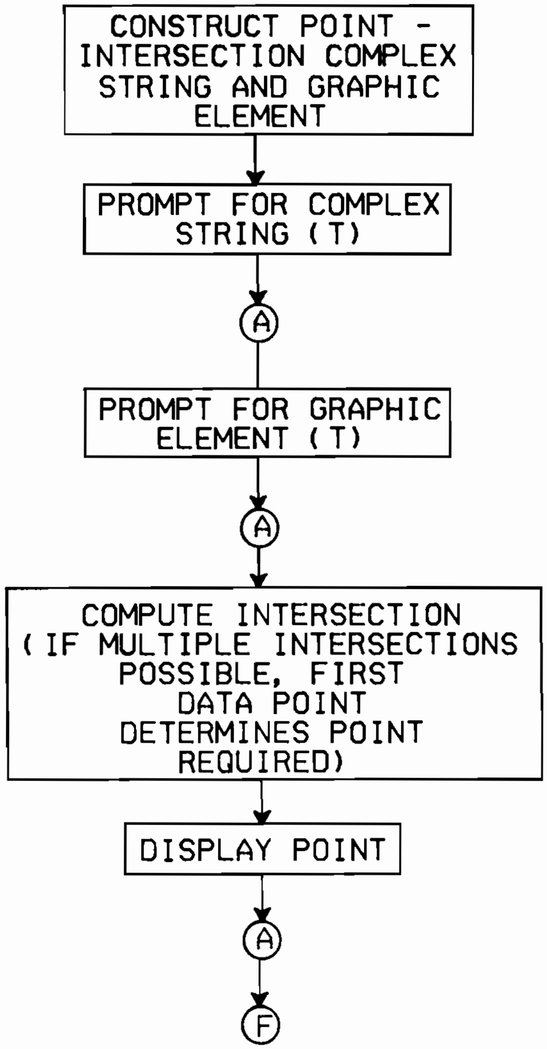
Each of the IGRDS commands is diagramed on the following pages to describe the functional nature of the commands. The command index is a reference key between the tables of the main body of the text and the command block diagram. Each rectangle describes an action, each circle filled with an alphabetic character describes another group of logical steps that has much common usage (this common logic is located in the back of the diagram), and each diamond describes a condition upon which logical branching will depend. A set of "keys" describing various input modes that may be used by the designer is defined in the legend below:

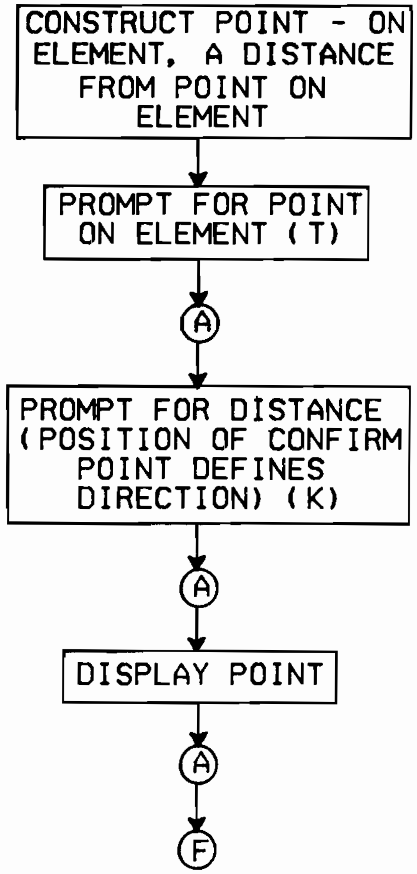
DIAGRAM LEGEND

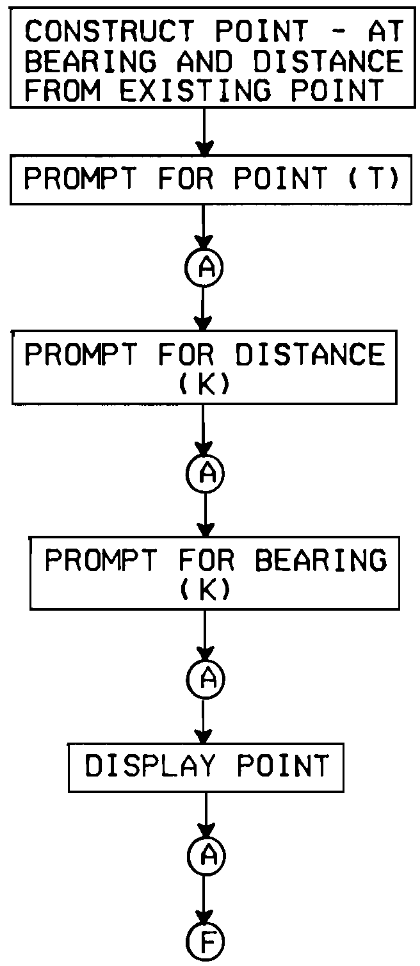
INPUT MODES:
- (K) - Keyboard Entry
- (P) - Data Point by Graphic Cursor
- (T) - Tentative Point, Identify Element or Locate Point on Element
- (R) - Reset or Reject
- (A) - System Assign Parameter

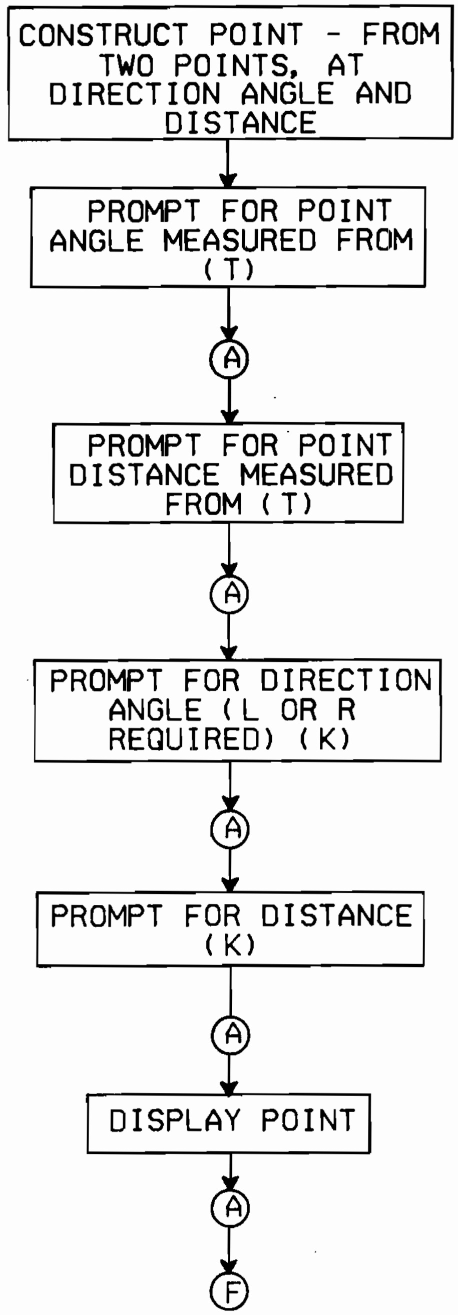

CONSTRUCT POINT
- BY COORDINATE
PROMPT FOR POINT
(K, P, T)
A
DISPLAY POINT
A
F

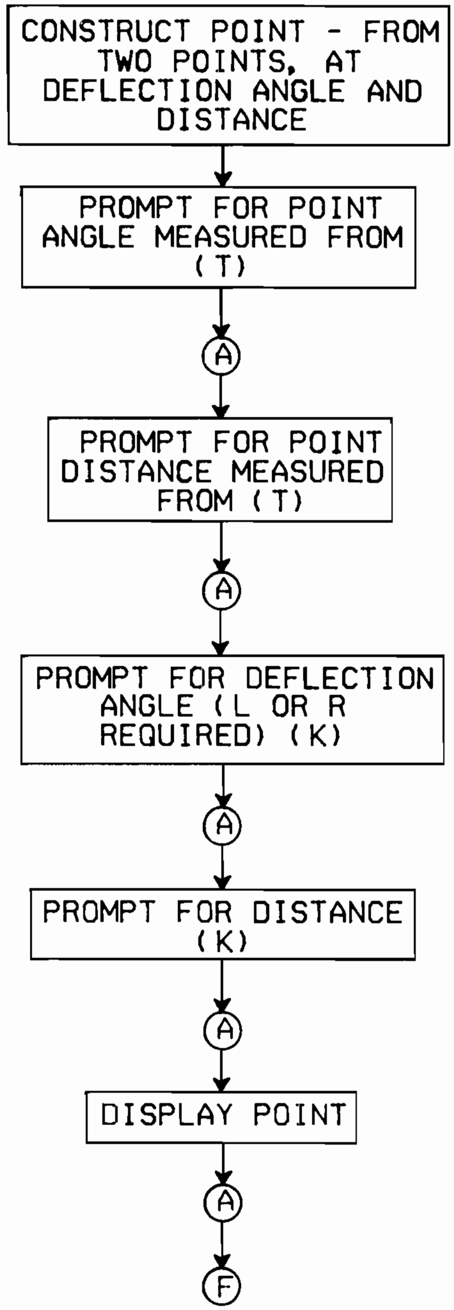

CONSTRUCT POINT - INTERSECTION TWO ELEMENTS
PROMPT FOR FIRST ELEMENT (T)
A
PROMPT FOR SECOND ELEMENT (T)
A
COMPUTE INTERSECTION (IF 2 INTERSECTIONS POSSIBLE, SECOND DATA POINT DETERMINES POINT REQUIRED)
DISPLAY POINT
A
F

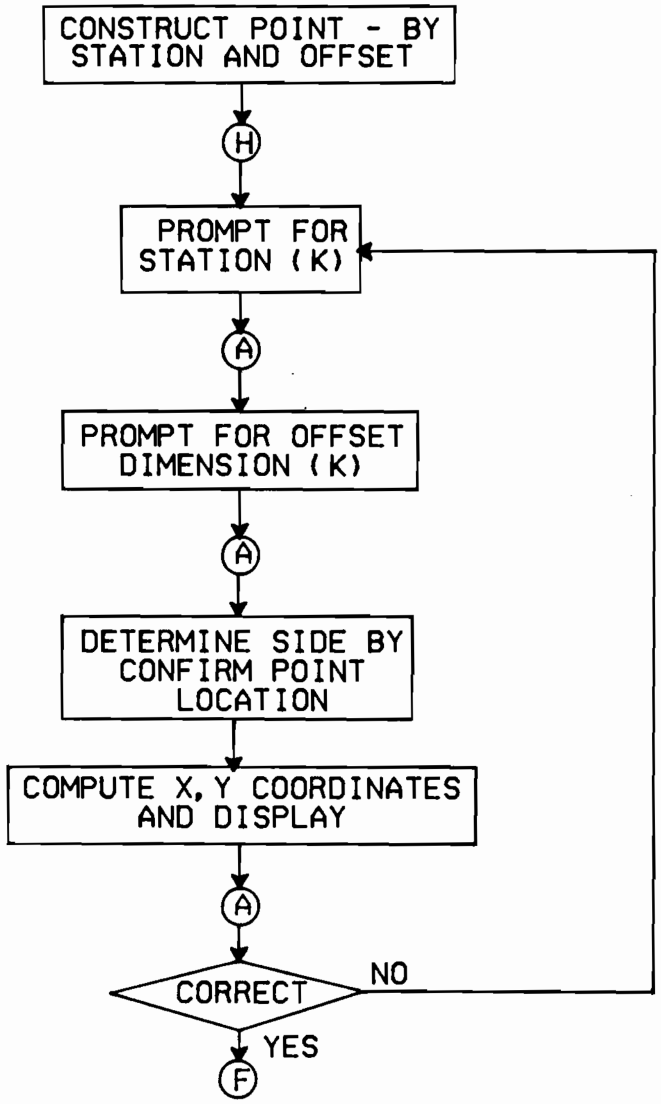

CONSTRUCT POINT - INTERSECTION COMPLEX STRING AND GRAPHIC ELEMENT
PROMPT FOR COMPLEX STRING (T)
A
PROMPT FOR GRAPHIC ELEMENT (T)
A
COMPUTE INTERSECTION (IF MULTIPLE INTERSECTIONS POSSIBLE, FIRST DATA POINT DETERMINES POINT REQUIRED)
DISPLAY POINT
A
F

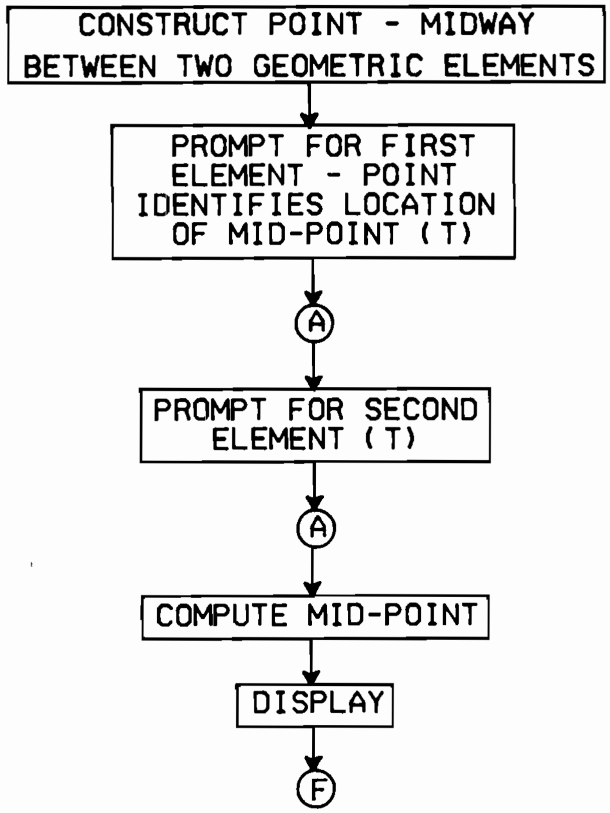

CONSTRUCT POINT - ON ELEMENT, A DISTANCE FROM POINT ON ELEMENT
PROMPT FOR POINT ON ELEMENT (T)
A
PROMPT FOR DISTANCE (POSITION OF CONFIRM POINT DEFINES DIRECTION) (K)
A
DISPLAY POINT
A
F

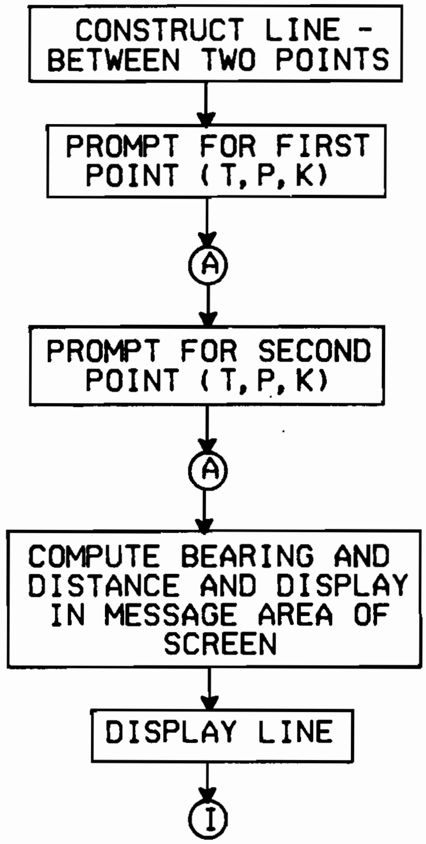

CONSTRUCT POINT - AT BEARING AND DISTANCE FROM EXISTING POINT
PROMPT FOR POINT (T)
A
PROMPT FOR DISTANCE (K)
A
PROMPT FOR BEARING (K)
A
DISPLAY POINT
A
F


CONSTRUCT POINT - FROM TWO POINTS, AT DIRECTION ANGLE AND DISTANCE
PROMPT FOR POINT ANGLE MEASURED FROM (T)
A
PROMPT FOR POINT DISTANCE MEASURED FROM (T)
A
PROMPT FOR DIRECTION ANGLE (L OR R REQUIRED) (K)
A
PROMPT FOR DISTANCE (K)
A
DISPLAY POINT
A
F

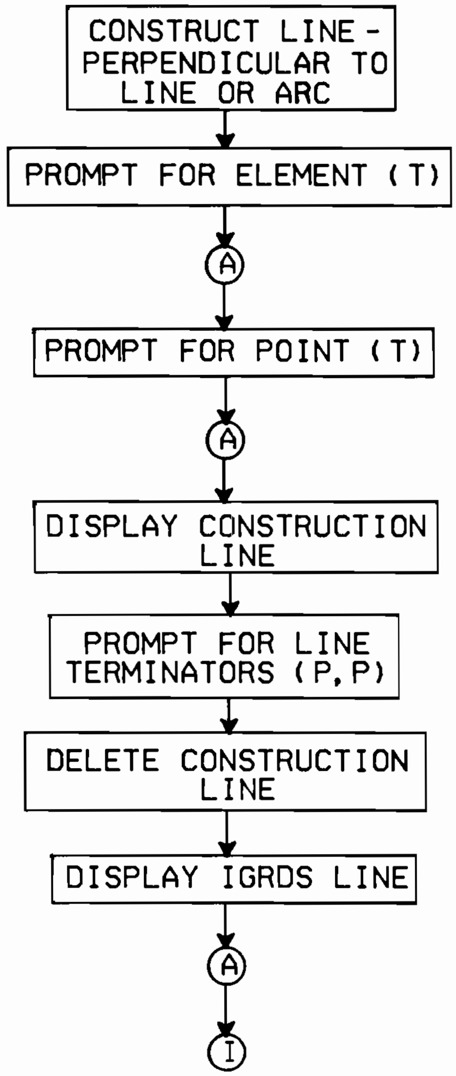

CONSTRUCT POINT - FROM TWO POINTS, AT DEFLECTION ANGLE AND DISTANCE
PROMPT FOR POINT ANGLE MEASURED FROM (T)
A
PROMPT FOR POINT DISTANCE MEASURED FROM (T)
A
PROMPT FOR DEFLECTION ANGLE (L OR R REQUIRED) (K)
A
PROMPT FOR DISTANCE (K)
A
DISPLAY POINT
A
F

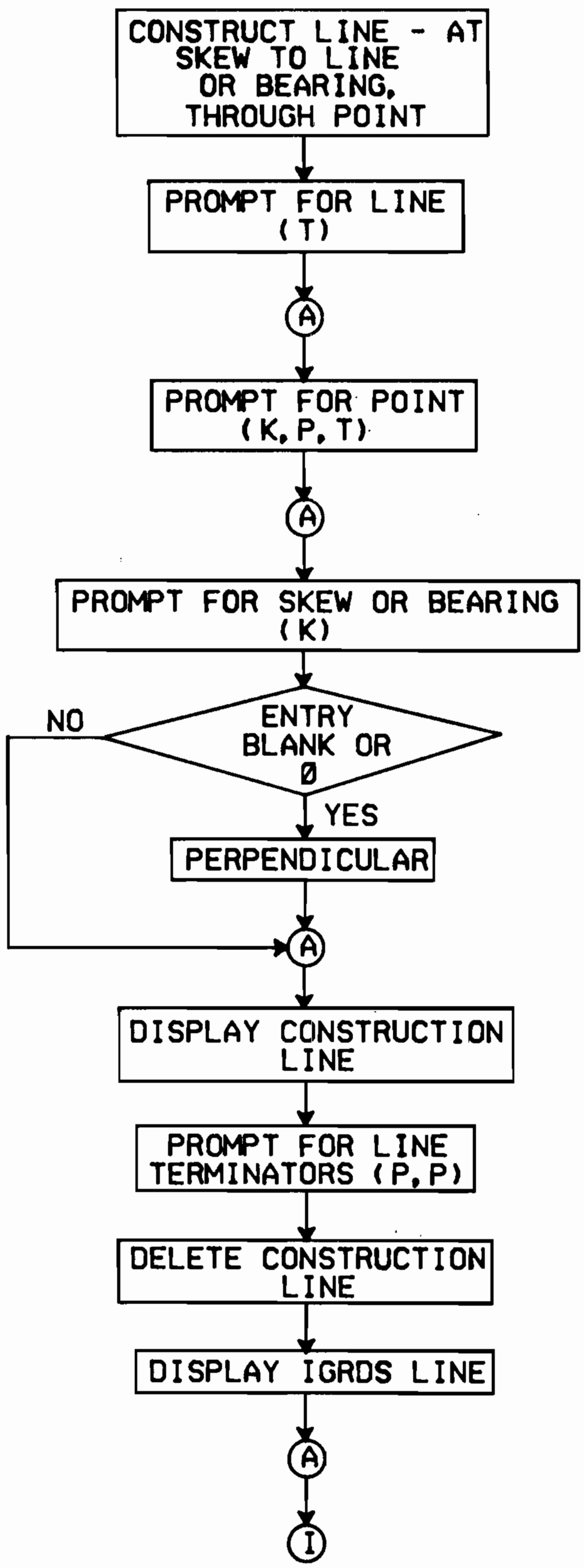

CONSTRUCT POINT - BY STATION AND OFFSET
H
PROMPT FOR STATION (K)
A
PROMPT FOR OFFSET DIMENSION (K)
A
DETERMINE SIDE BY CONFIRM POINT LOCATION
COMPUTE X,Y COORDINATES AND DISPLAY
A
CORRECT
NO
YES
F


CONSTRUCT POINT - MIDWAY BETWEEN TWO GEOMETRIC ELEMENTS
PROMPT FOR FIRST ELEMENT - POINT IDENTIFIES LOCATION OF MID-POINT (T)
A
PROMPT FOR SECOND ELEMENT (T)
A
COMPUTE MID-POINT
DISPLAY
F

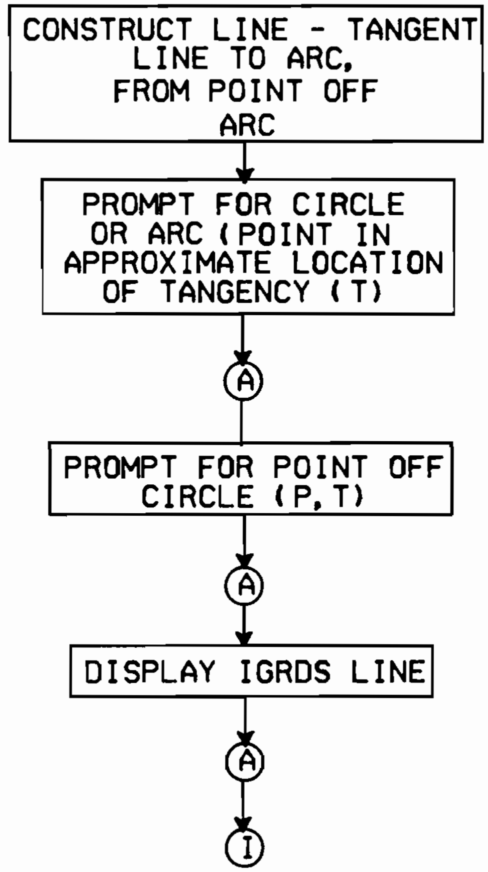


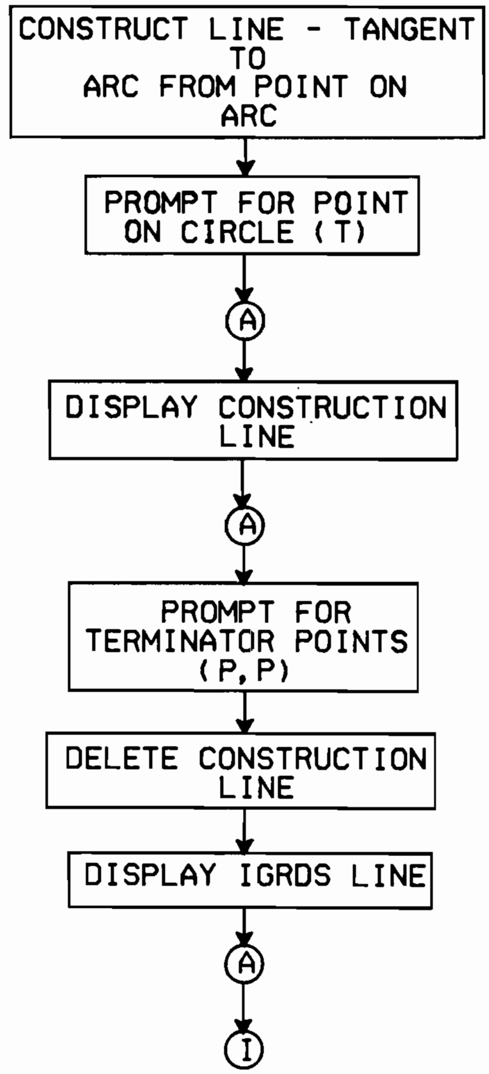
COMMAND INDEX B1

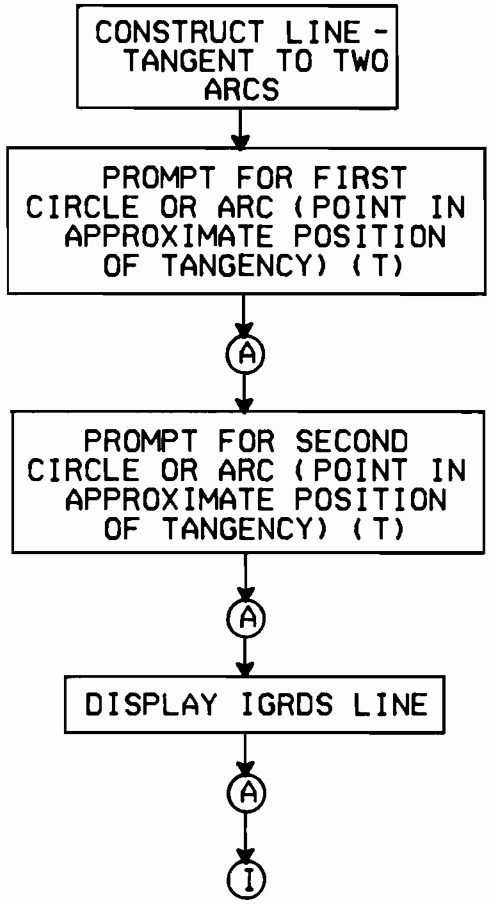

CONSTRUCT LINE - PERPENDICULAR TO LINE OR ARC
PROMPT FOR ELEMENT (T)
A
PROMPT FOR POINT (T)
A
DISPLAY CONSTRUCTION LINE
PROMPT FOR LINE TERMINATORS (P,P)
DELETE CONSTRUCTION LINE
DISPLAY IGRDS LINE
A
I

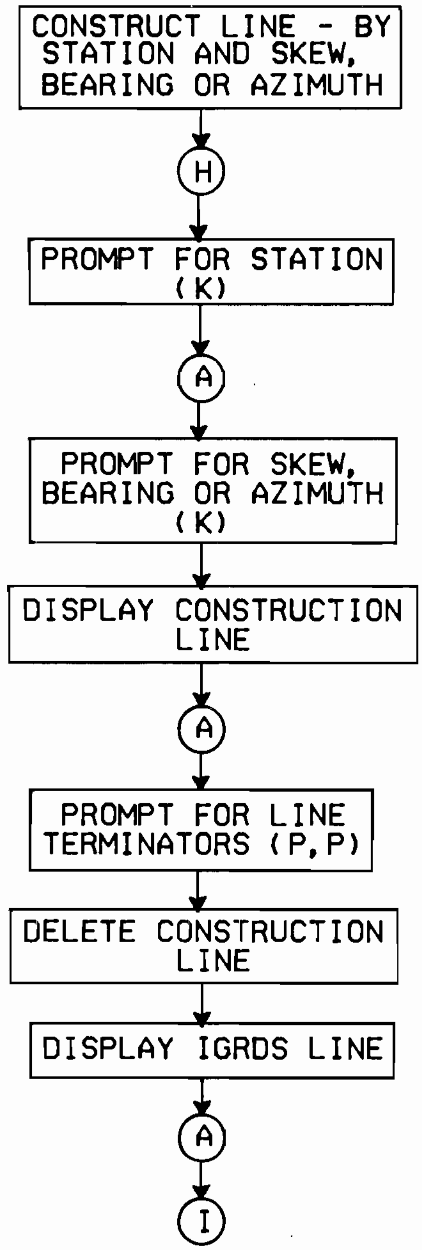


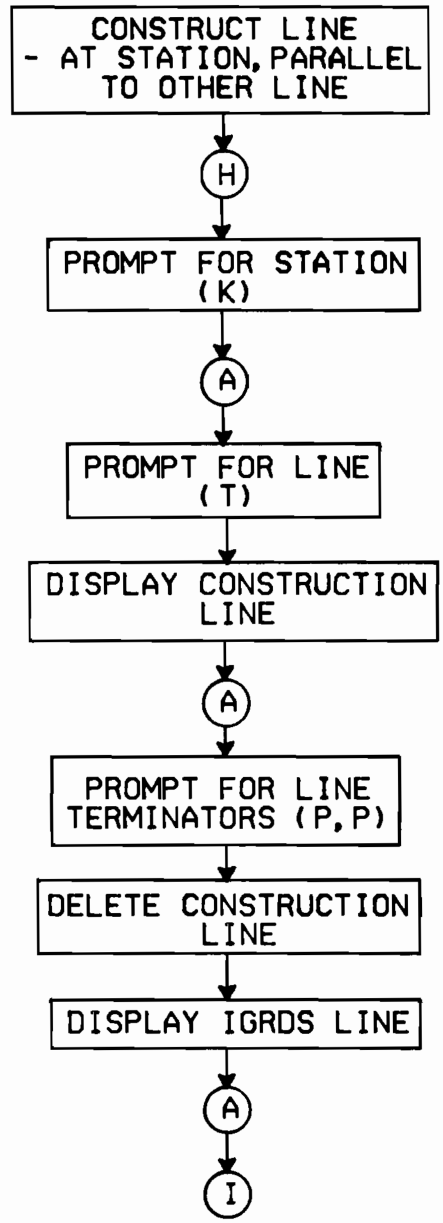
COMMAND INDEX B3

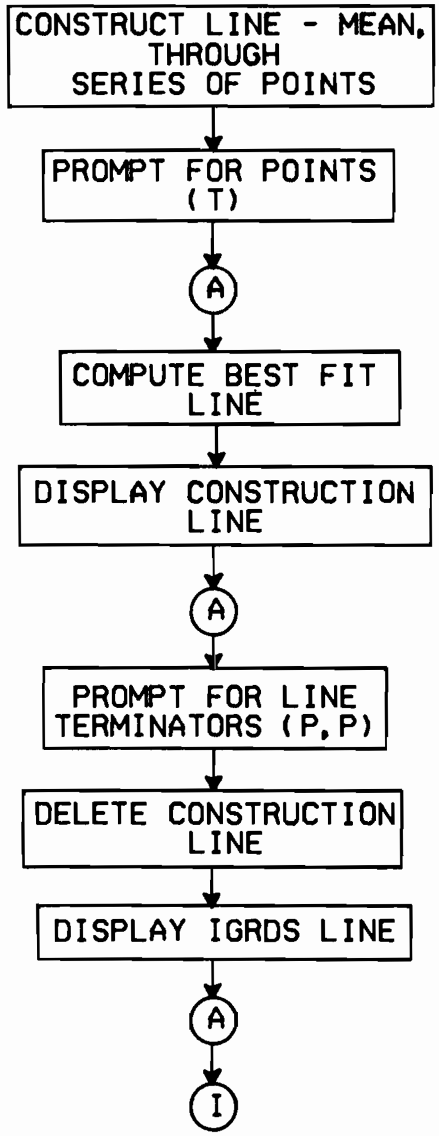

CONSTRUCT LINE - TANGENT LINE TO ARC, FROM POINT OFF ARC
PROMPT FOR CIRCLE OR ARC (POINT IN APPROXIMATE LOCATION OF TANGENCY (T)
A
PROMPT FOR POINT OFF CIRCLE (P, T)
A
DISPLAY IGRDS LINE
A
I

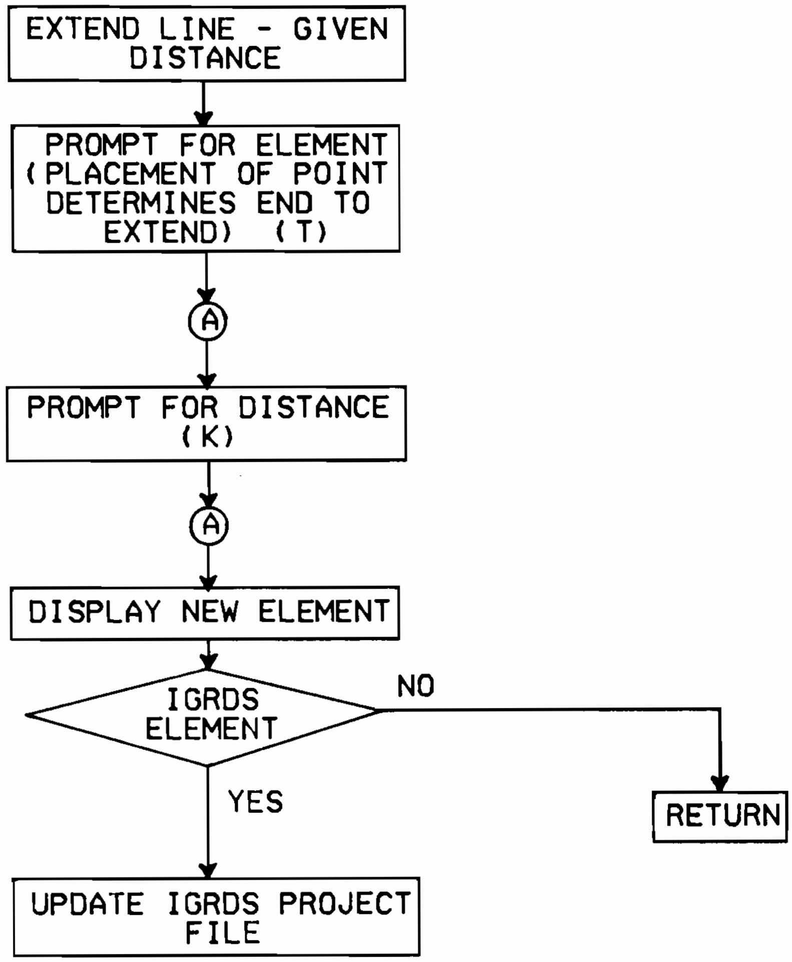

CONSTRUCT LINE - TANGENT TO ARC FROM POINT ON ARC
PROMPT FOR POINT ON CIRCLE (T)
A
DISPLAY CONSTRUCTION LINE
A
PROMPT FOR TERMINATOR POINTS (P,P)
DELETE CONSTRUCTION LINE
DISPLAY IGRDS LINE
A
I

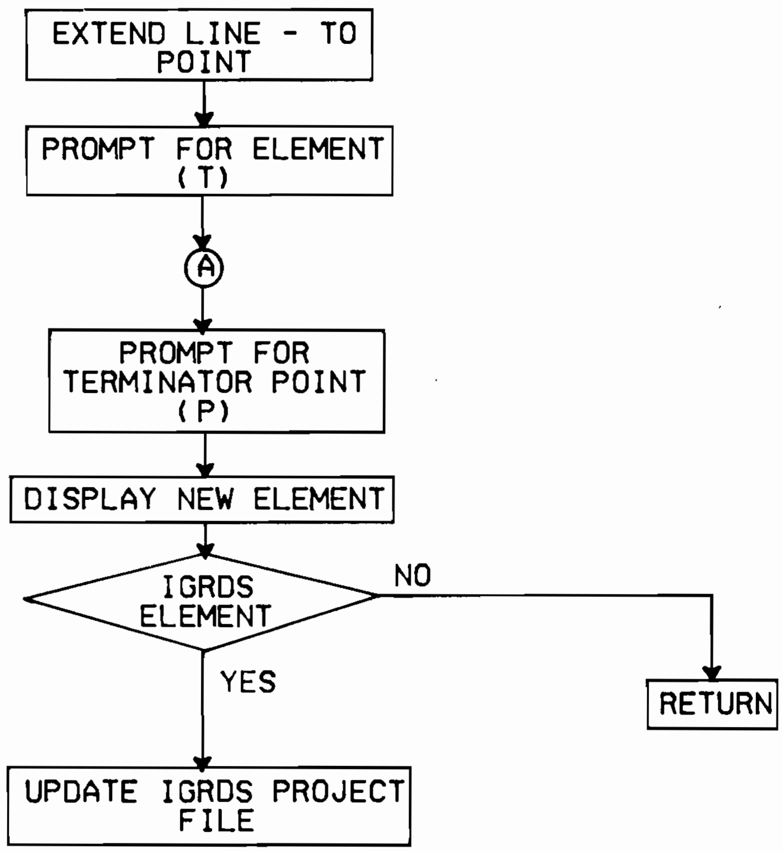

CONSTRUCT LINE - TANGENT TO TWO ARCS
PROMPT FOR FIRST CIRCLE OR ARC (POINT IN APPROXIMATE POSITION OF TANGENCY) (T)
A
PROMPT FOR SECOND CIRCLE OR ARC (POINT IN APPROXIMATE POSITION OF TANGENCY) (T)
A
DISPLAY IGRDS LINE
A
I

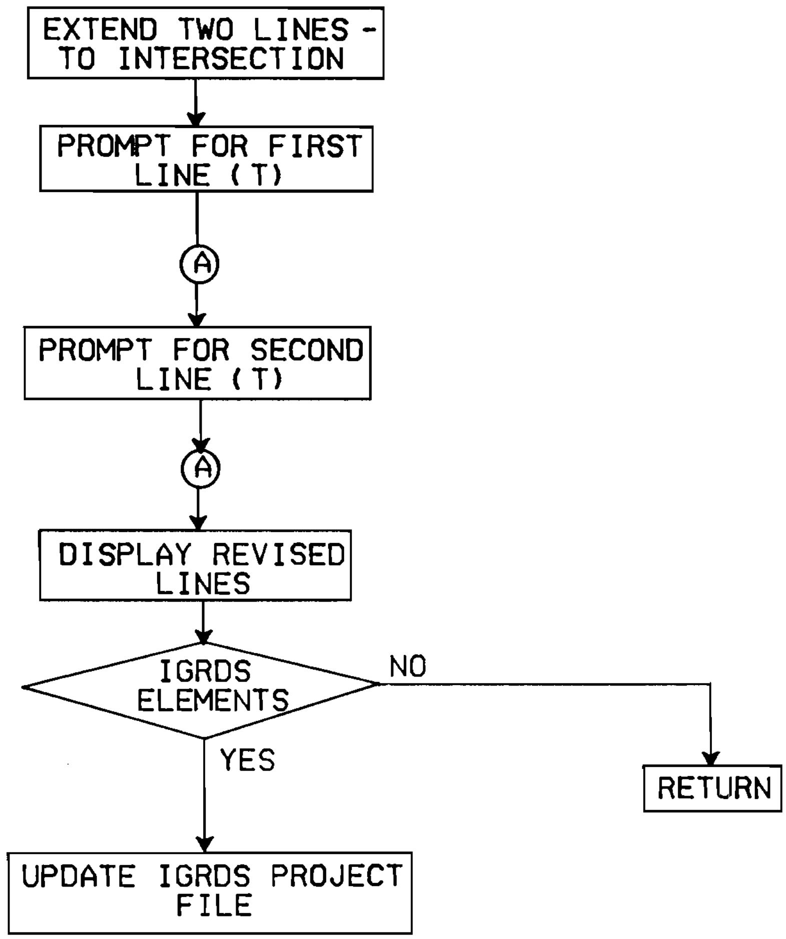

CONSTRUCT LINE - BY STATION AND SKEW, BEARING OR AZIMUTH
H
PROMPT FOR STATION (K)
A
PROMPT FOR SKEW, BEARING OR AZIMUTH (K)
DISPLAY CONSTRUCTION LINE
A
PROMPT FOR LINE TERMINATORS (P,P)
DELETE CONSTRUCTION LINE
DISPLAY IGRDS LINE
A
I

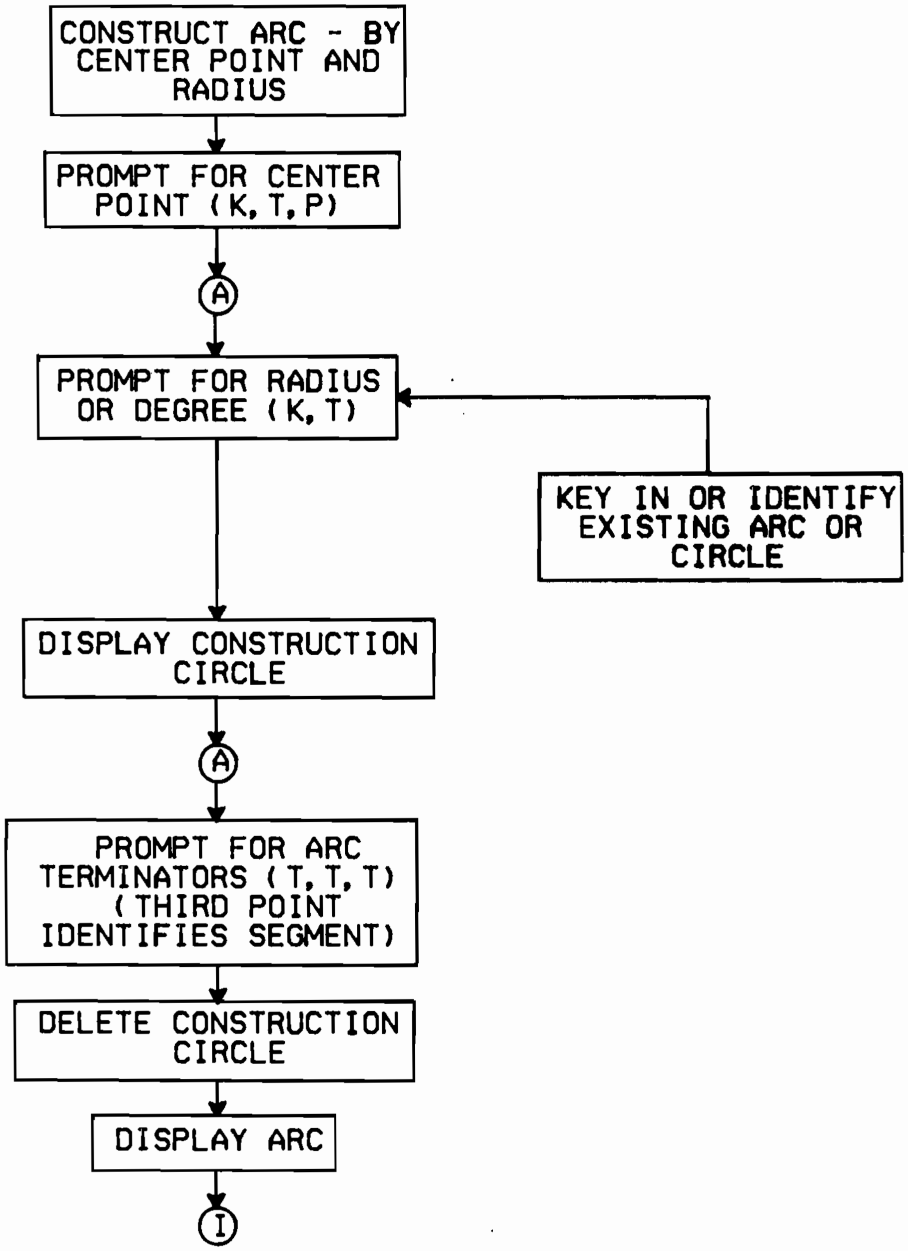

CONSTRUCT LINE
- AT STATION, PARALLEL TO OTHER LINE
H
PROMPT FOR STATION (K)
A
PROMPT FOR LINE (T)
DISPLAY CONSTRUCTION LINE
A
PROMPT FOR LINE TERMINATORS (P, P)
DELETE CONSTRUCTION LINE
DISPLAY IGRDS LINE
A
I

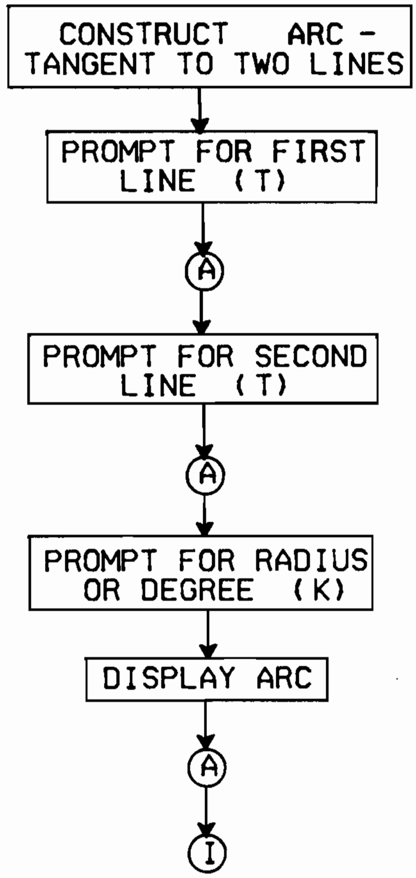

CONSTRUCT LINE - MEAN, THROUGH SERIES OF POINTS
PROMPT FOR POINTS (T)
A
COMPUTE BEST FIT LINE
DISPLAY CONSTRUCTION LINE
A
PROMPT FOR LINE TERMINATORS (P,P)
DELETE CONSTRUCTION LINE
DISPLAY IGRDS LINE
A
I

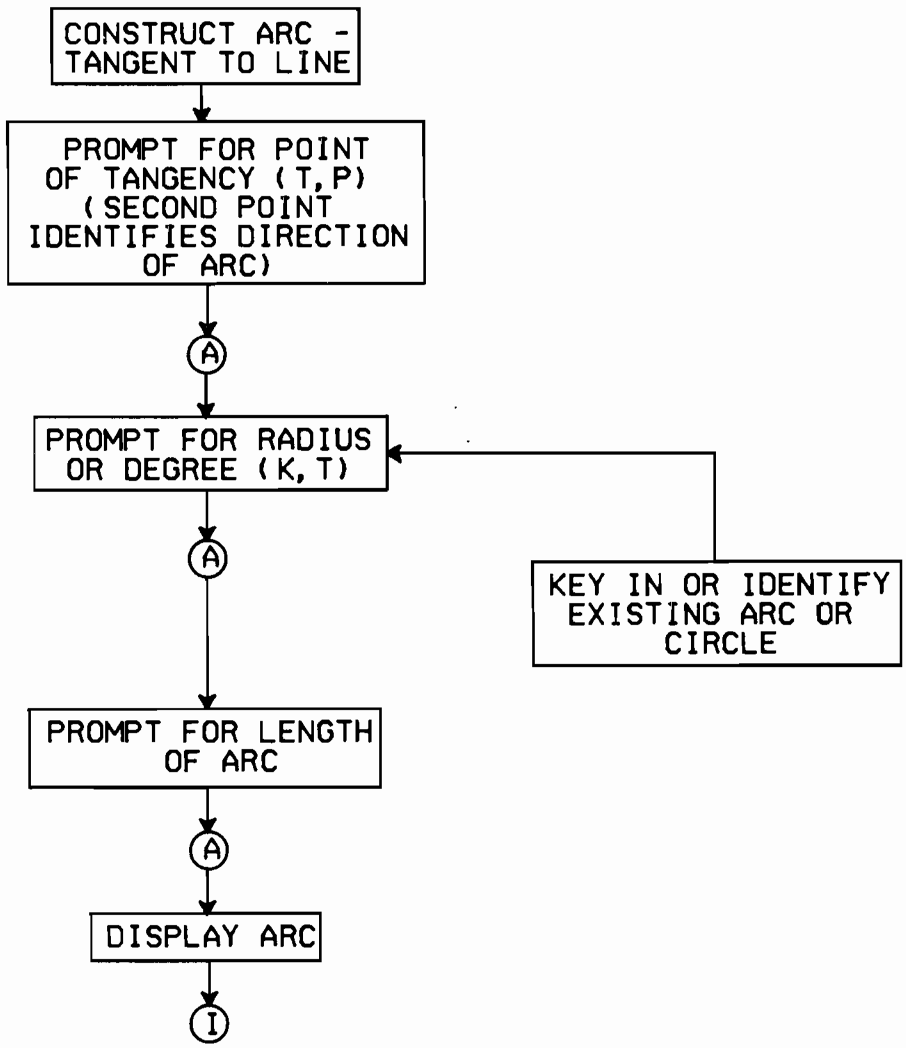

EXTEND LINE - GIVEN DISTANCE
PROMPT FOR ELEMENT (PLACEMENT OF POINT DETERMINES END TO EXTEND) (T)
A
PROMPT FOR DISTANCE (K)
A
DISPLAY NEW ELEMENT
IGRDS ELEMENT
NO
YES
RETURN
UPDATE IGRDS PROJECT FILE

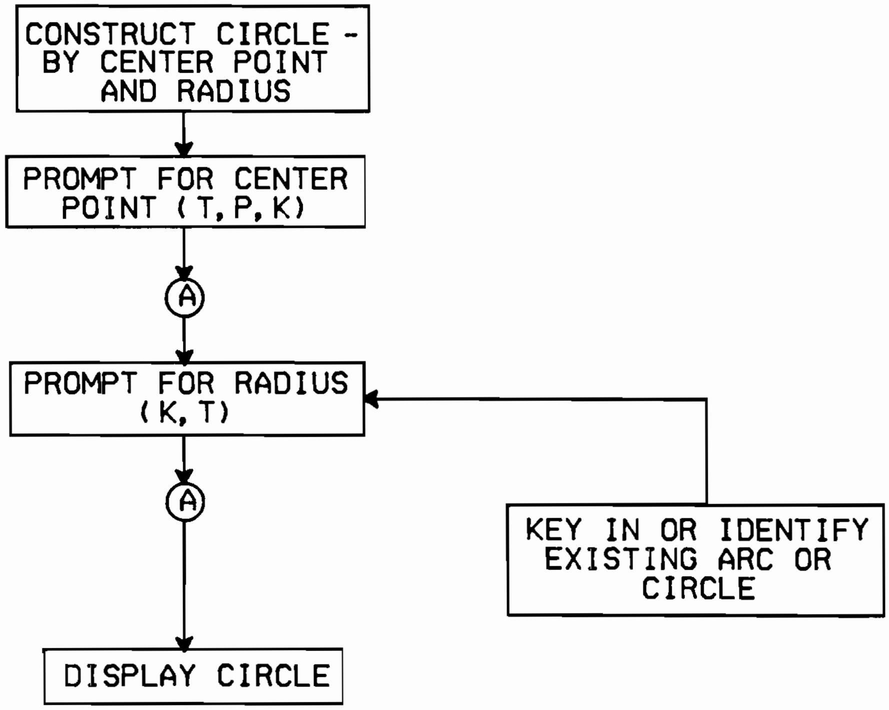

EXTEND LINE - TO POINT
PROMPT FOR ELEMENT (T)
A
PROMPT FOR TERMINATOR POINT (P)
DISPLAY NEW ELEMENT
IGRDS ELEMENT
NO
RETURN
YES
UPDATE IGRDS PROJECT FILE

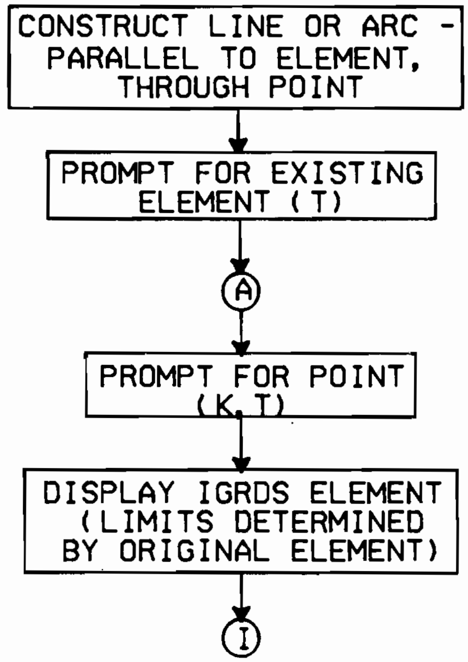

EXTEND TWO LINES - TO INTERSECTION
PROMPT FOR FIRST LINE (T)
A
PROMPT FOR SECOND LINE (T)
A
DISPLAY REVISED LINES
IGRDS ELEMENTS
NO
YES
RETURN
UPDATE IGRDS PROJECT FILE

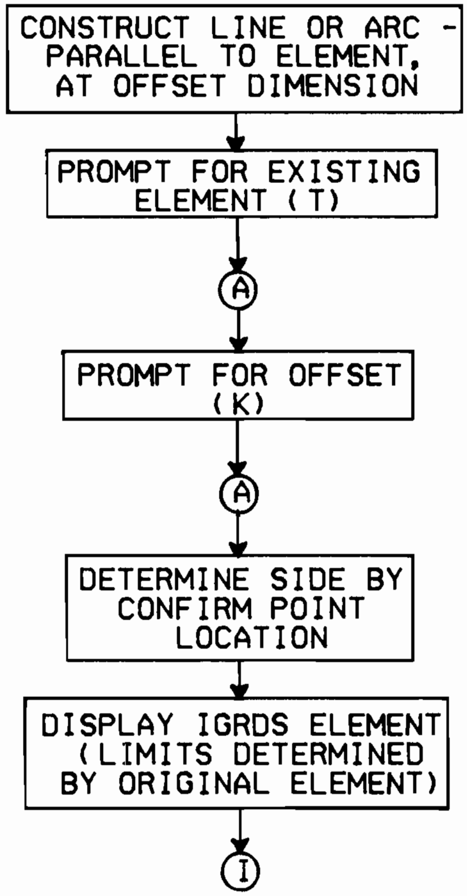

CONSTRUCT ARC - BY CENTER POINT AND RADIUS
PROMPT FOR CENTER POINT (K,T,P)
A
PROMPT FOR RADIUS OR DEGREE (K,T)
KEY IN OR IDENTIFY EXISTING ARC OR CIRCLE
DISPLAY CONSTRUCTION CIRCLE
A
PROMPT FOR ARC TERMINATORS (T,T,T) (THIRD POINT IDENTIFIES SEGMENT)
DELETE CONSTRUCTION CIRCLE
DISPLAY ARC
I

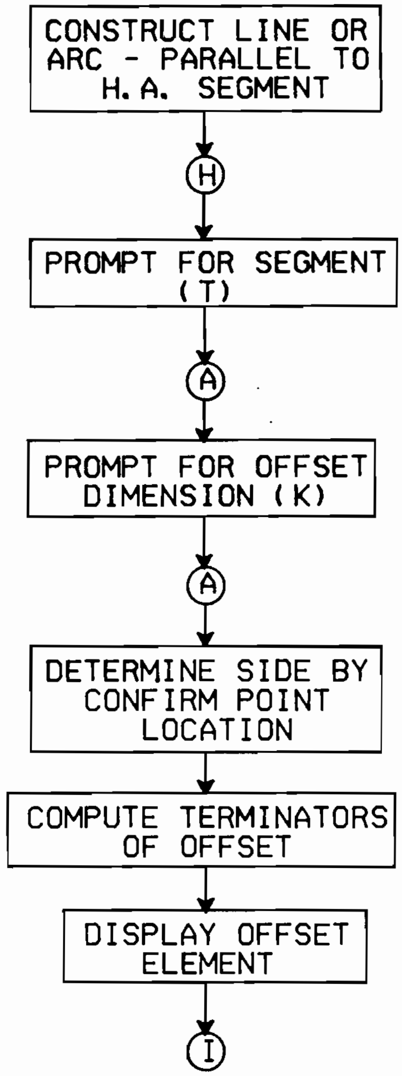

CONSTRUCT ARC - TANGENT TO TWO LINES
PROMPT FOR FIRST LINE (T)
A
PROMPT FOR SECOND LINE (T)
A
PROMPT FOR RADIUS OR DEGREE (K)
DISPLAY ARC
A
I

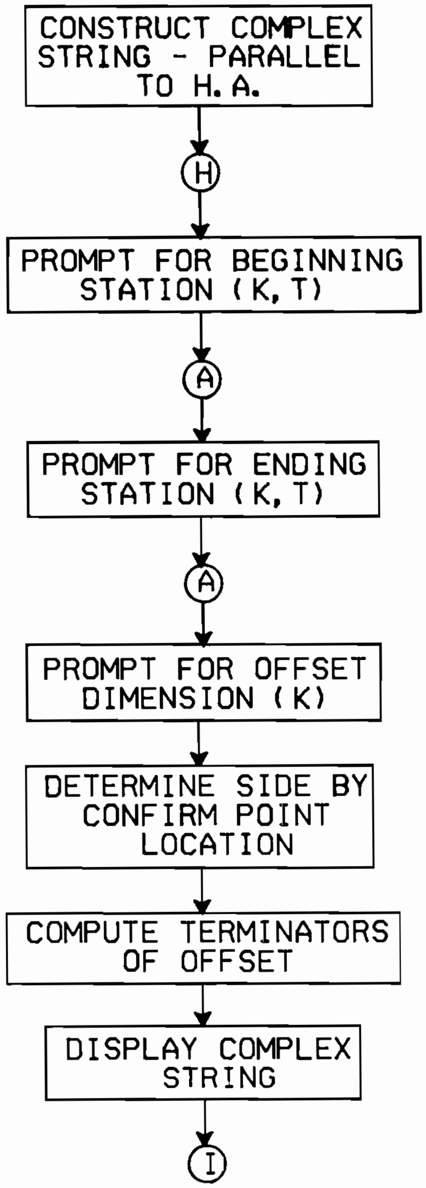

CONSTRUCT ARC - TANGENT TO LINE
PROMPT FOR POINT OF TANGENCY (T,P) (SECOND POINT IDENTIFIES DIRECTION OF ARC)
A
PROMPT FOR RADIUS OR DEGREE (K,T)
A
KEY IN OR IDENTIFY EXISTING ARC OR CIRCLE
PROMPT FOR LENGTH OF ARC
A
DISPLAY ARC
I

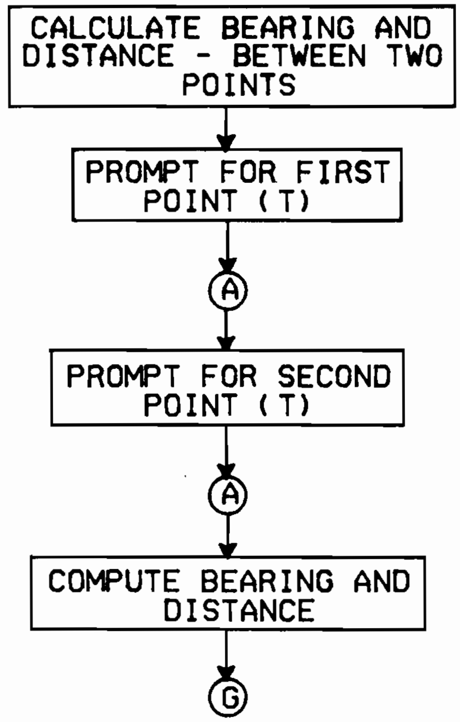

CONSTRUCT CIRCLE - BY CENTER POINT AND RADIUS
PROMPT FOR CENTER POINT (T, P, K)
A
PROMPT FOR RADIUS (K, T)
A
KEY IN OR IDENTIFY EXISTING ARC OR CIRCLE
DISPLAY CIRCLE

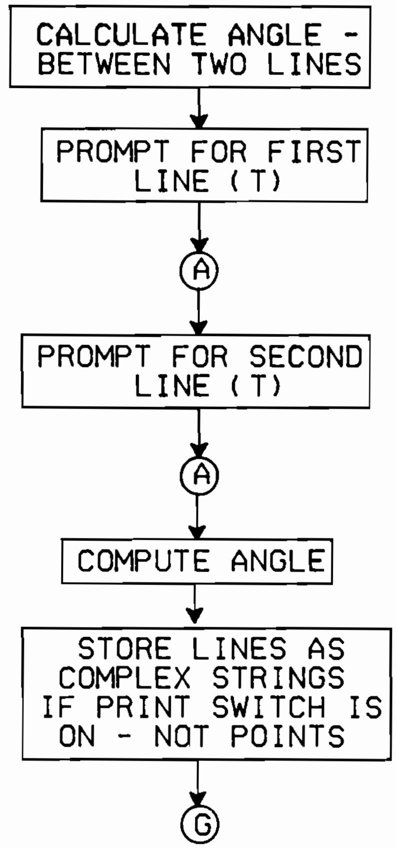

CONSTRUCT LINE OR ARC - PARALLEL TO ELEMENT, THROUGH POINT
PROMPT FOR EXISTING ELEMENT (T)
A
PROMPT FOR POINT (K,T)
DISPLAY IGRDS ELEMENT (LIMITS DETERMINED BY ORIGINAL ELEMENT)
I

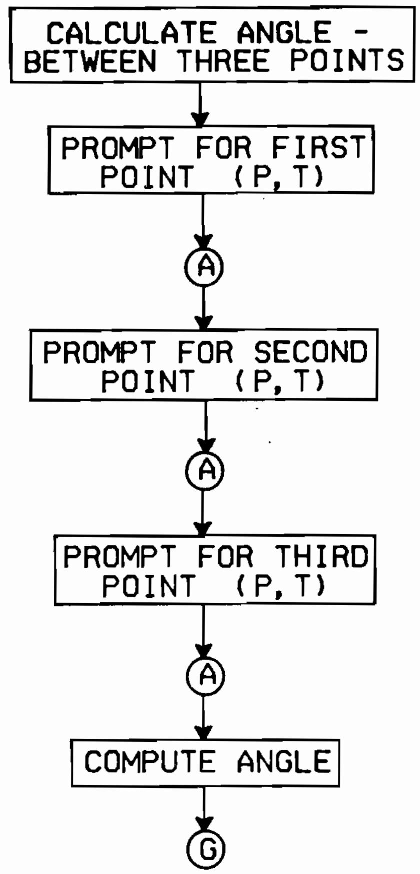

CONSTRUCT LINE OR ARC - PARALLEL TO ELEMENT, AT OFFSET DIMENSION
PROMPT FOR EXISTING ELEMENT (T)
A
PROMPT FOR OFFSET (K)
A
DETERMINE SIDE BY CONFIRM POINT LOCATION
DISPLAY IGRDS ELEMENT (LIMITS DETERMINED BY ORIGINAL ELEMENT)
I

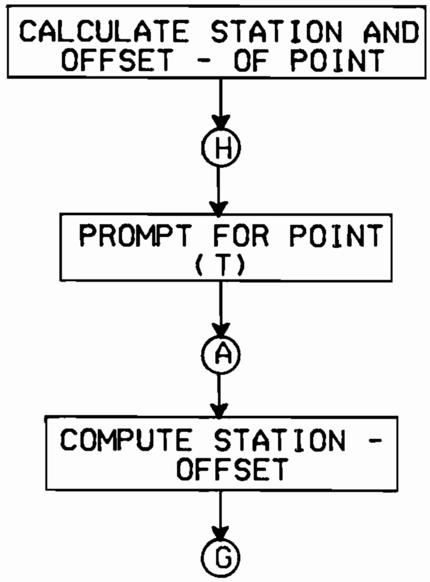

CONSTRUCT LINE OR ARC - PARALLEL TO H.A. SEGMENT
H
PROMPT FOR SEGMENT (T)
A
PROMPT FOR OFFSET DIMENSION (K)
A
DETERMINE SIDE BY CONFIRM POINT LOCATION
COMPUTE TERMINATORS OF OFFSET
DISPLAY OFFSET ELEMENT
I

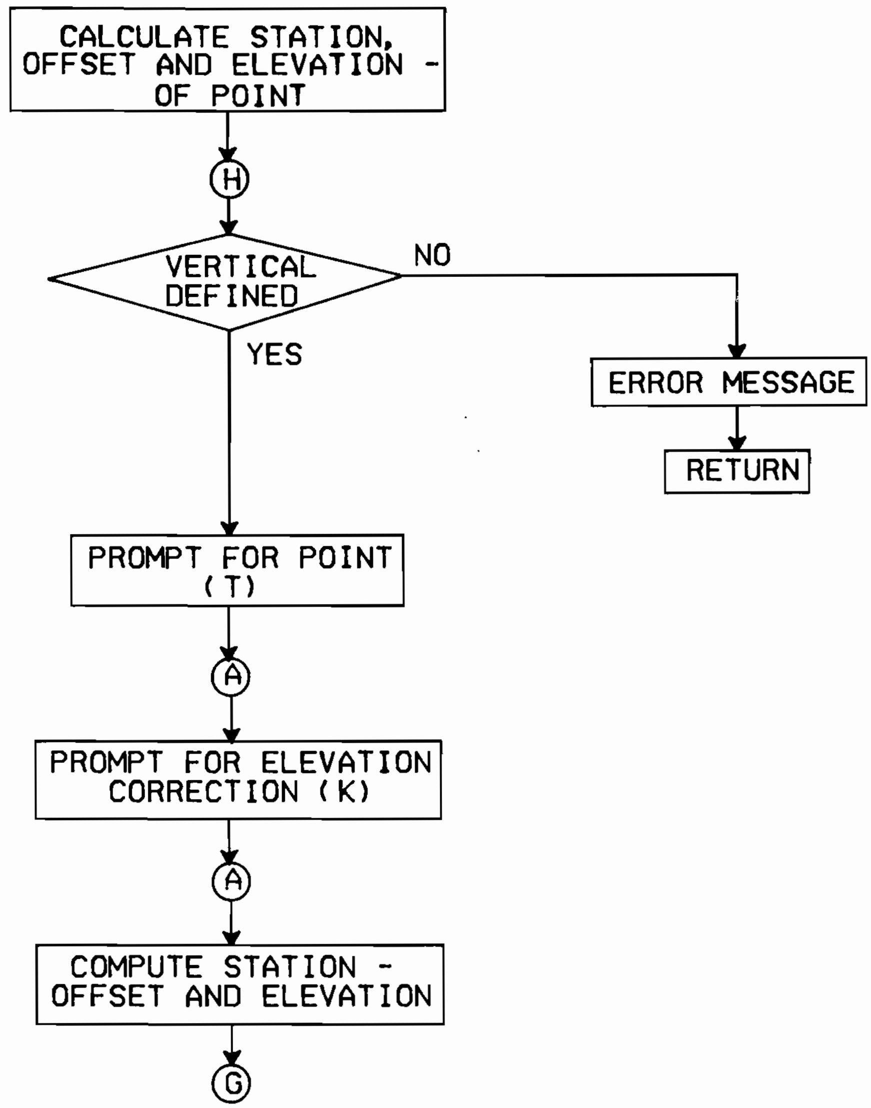

CONSTRUCT COMPLEX STRING - PARALLEL TO H. A.
H
PROMPT FOR BEGINNING STATION (K, T)
A
PROMPT FOR ENDING STATION (K, T)
A
PROMPT FOR OFFSET DIMENSION (K)
DETERMINE SIDE BY CONFIRM POINT LOCATION
COMPUTE TERMINATORS OF OFFSET
DISPLAY COMPLEX STRING
I

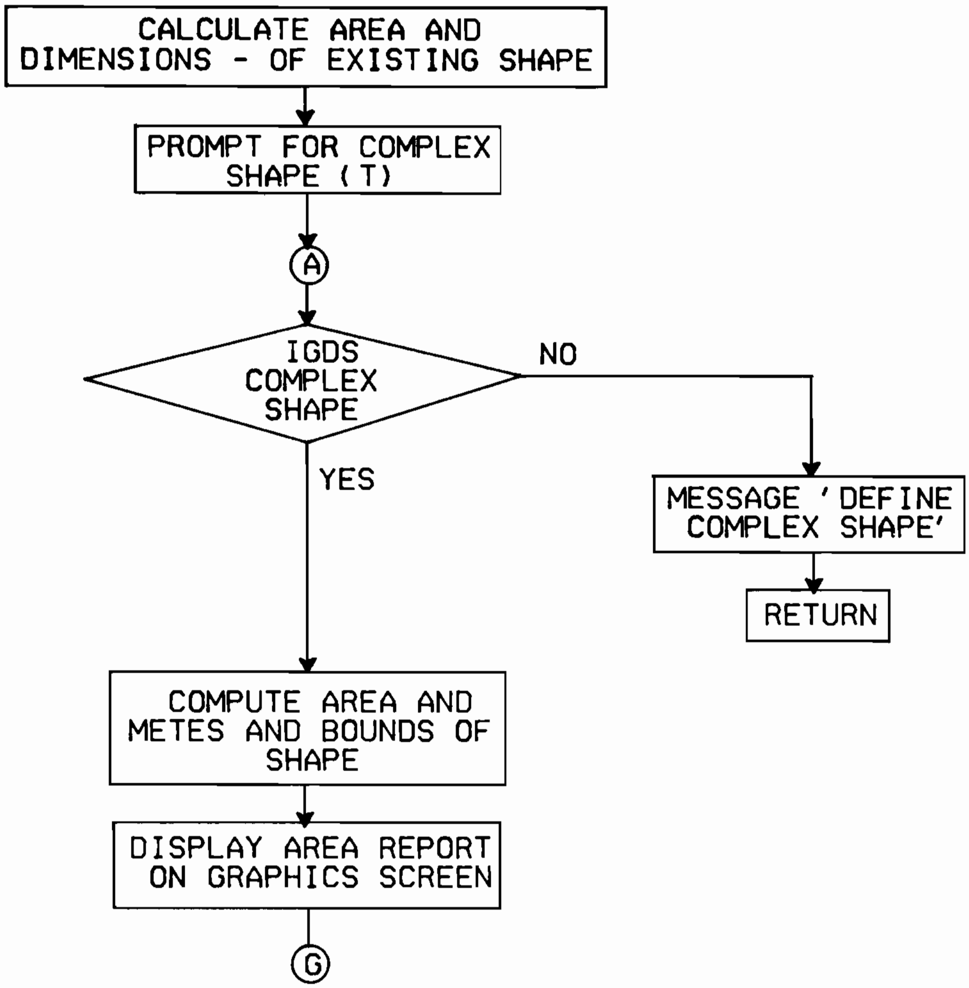

CALCULATE BEARING AND DISTANCE - BETWEEN TWO POINTS
PROMPT FOR FIRST POINT (T)
A
PROMPT FOR SECOND POINT (T)
A
COMPUTE BEARING AND DISTANCE
G

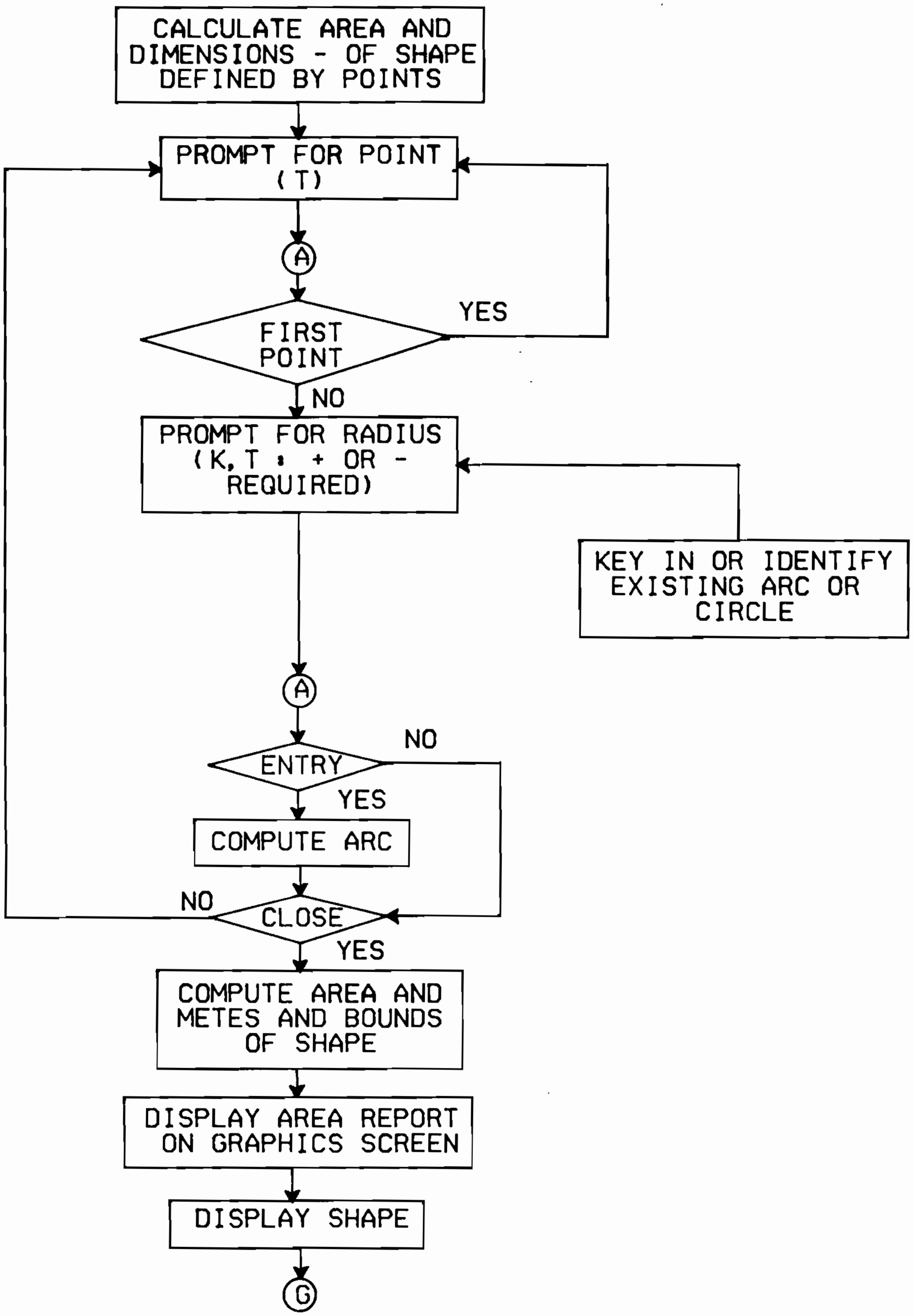

CALCULATE ANGLE - BETWEEN TWO LINES
PROMPT FOR FIRST LINE (T)
A
PROMPT FOR SECOND LINE (T)
A
COMPUTE ANGLE
STORE LINES AS COMPLEX STRINGS IF PRINT SWITCH IS ON - NOT POINTS
G

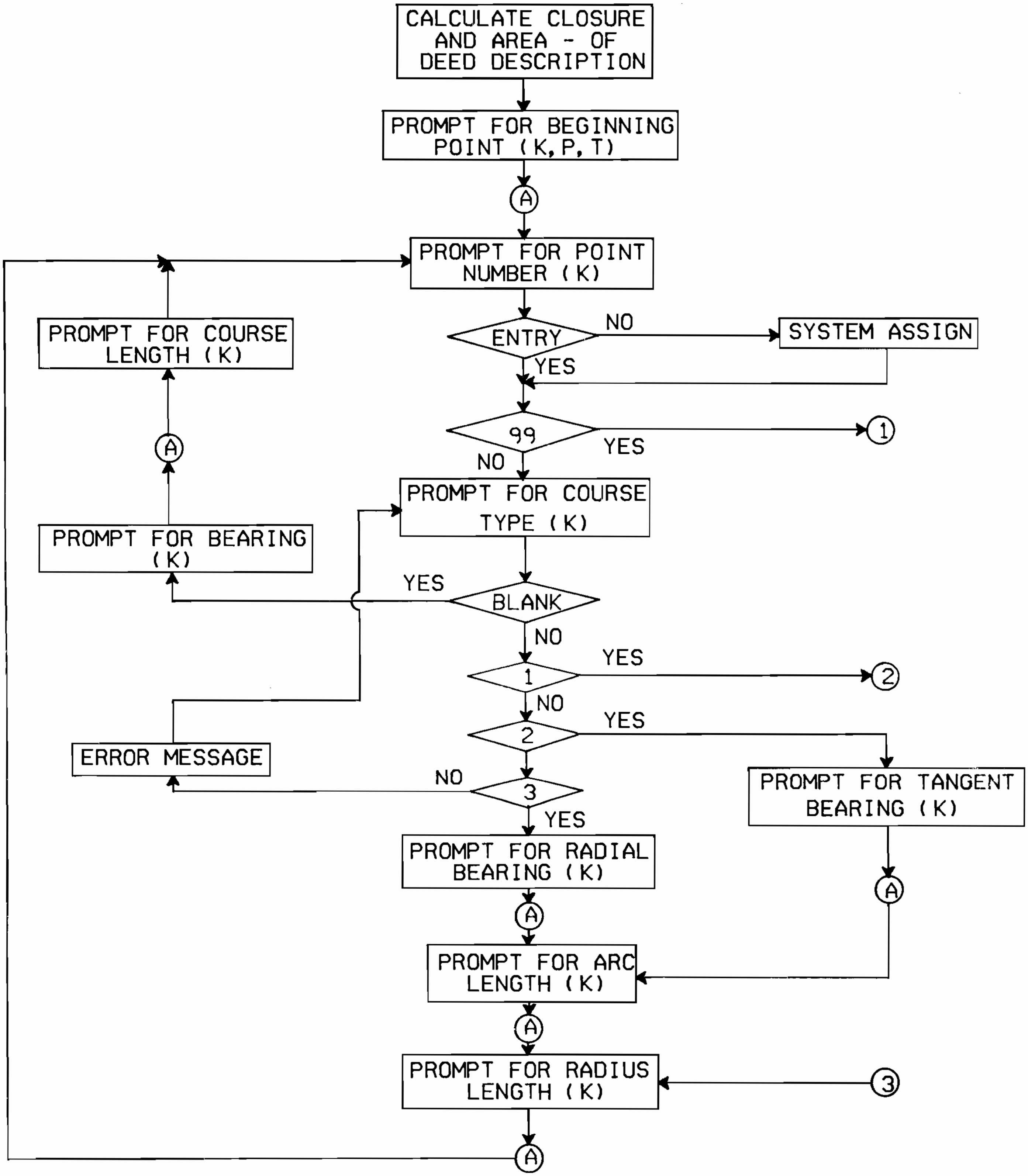

CALCULATE ANGLE - BETWEEN THREE POINTS
PROMPT FOR FIRST POINT (P,T)
A
PROMPT FOR SECOND POINT (P,T)
A
PROMPT FOR THIRD POINT (P,T)
A
COMPUTE ANGLE
G


CALCULATE STATION AND OFFSET - OF POINT
H
PROMPT FOR POINT (T)
A
COMPUTE STATION - OFFSET
G

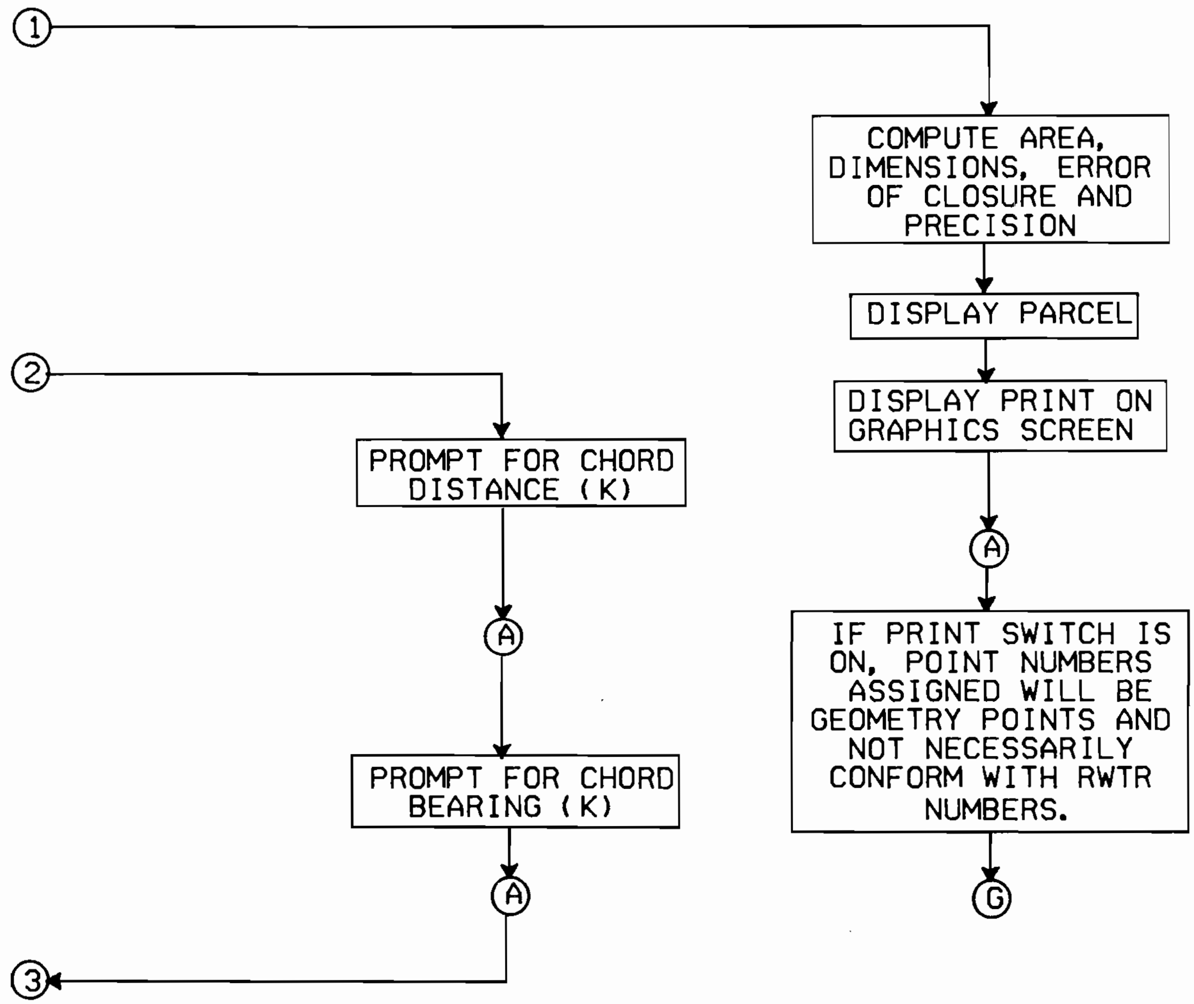

CALCULATE STATION, OFFSET AND ELEVATION - OF POINT
H
VERTICAL DEFINED
NO
YES
ERROR MESSAGE
RETURN
PROMPT FOR POINT (T)
A
PROMPT FOR ELEVATION CORRECTION (K)
A
COMPUTE STATION - OFFSET AND ELEVATION
G

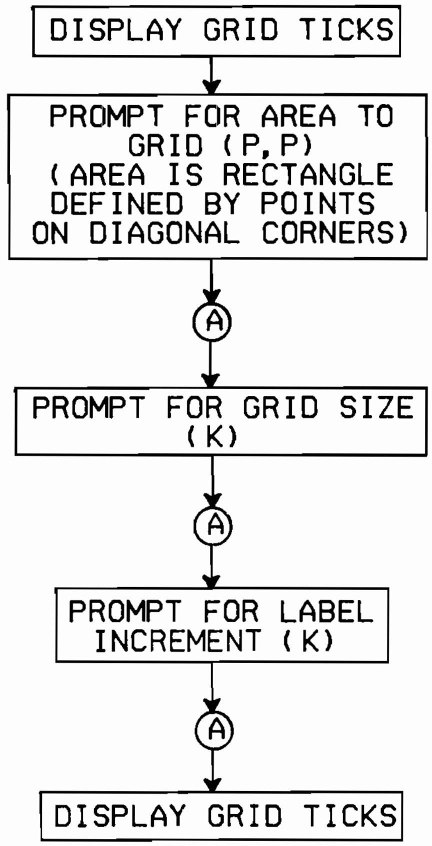

CALCULATE AREA AND DIMENSIONS - OF EXISTING SHAPE
PROMPT FOR COMPLEX SHAPE (T)
A
IGDS COMPLEX SHAPE
NO
YES
MESSAGE 'DEFINE COMPLEX SHAPE'
RETURN
COMPUTE AREA AND METES AND BOUNDS OF SHAPE
DISPLAY AREA REPORT ON GRAPHICS SCREEN
G


CALCULATE AREA AND DIMENSIONS - OF SHAPE DEFINED BY POINTS
PROMPT FOR POINT (T)
A
FIRST POINT
YES
NO
PROMPT FOR RADIUS (K,T : + OR - REQUIRED)
KEY IN OR IDENTIFY EXISTING ARC OR CIRCLE
A
ENTRY
NO
YES
COMPUTE ARC
CLOSE
NO
YES
COMPUTE AREA AND METES AND BOUNDS OF SHAPE
DISPLAY AREA REPORT ON GRAPHICS SCREEN
DISPLAY SHAPE
G

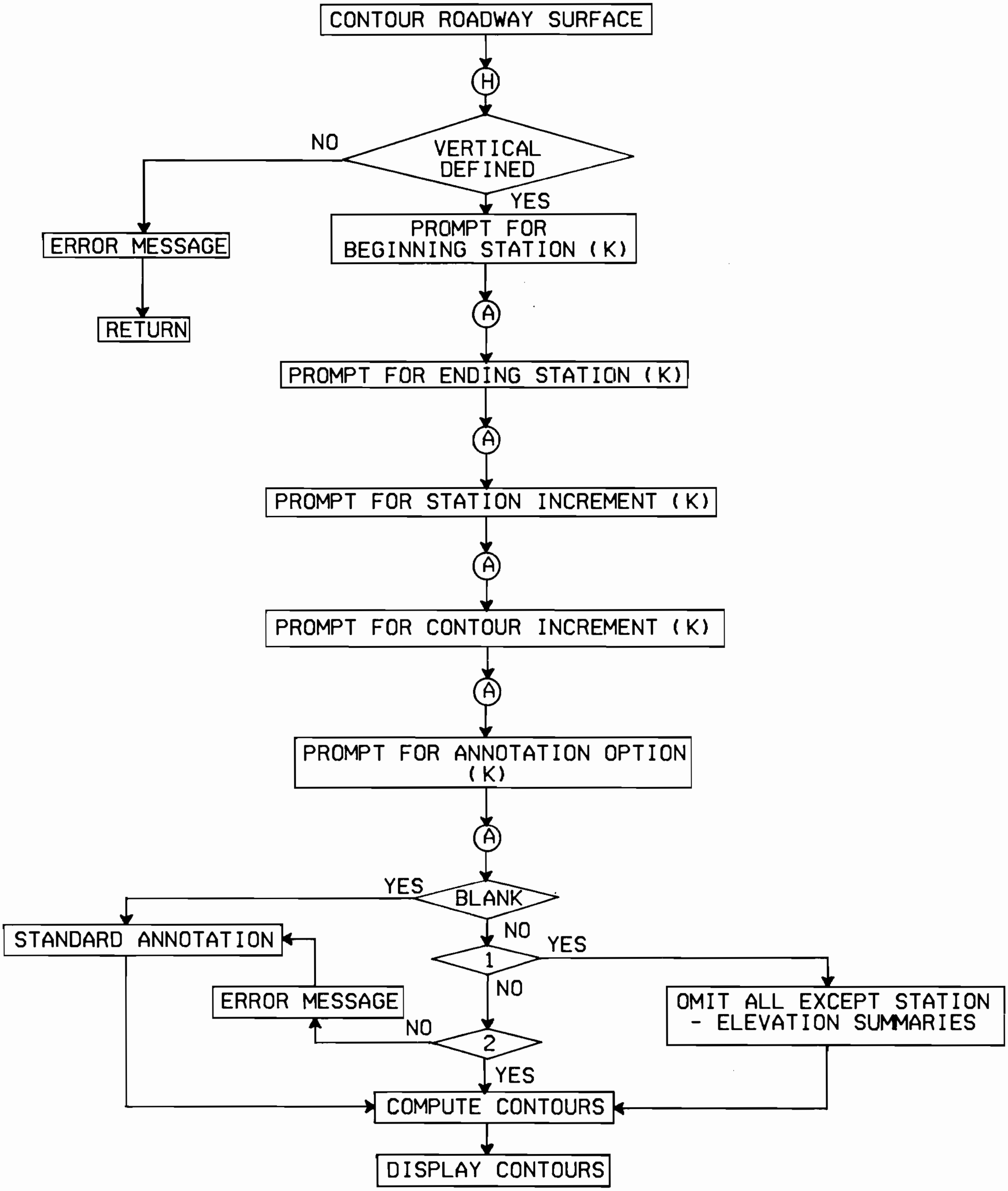


COMMAND INDEX E8

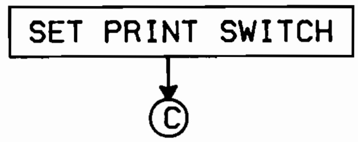

1
COMPUTE AREA, DIMENSIONS, ERROR OF CLOSURE AND PRECISION
DISPLAY PARCEL
DISPLAY PRINT ON GRAPHICS SCREEN
A
IF PRINT SWITCH IS ON, POINT NUMBERS ASSIGNED WILL BE GEOMETRY POINTS AND NOT NECESSARILY CONFORM WITH RWTR NUMBERS.
G
2
PROMPT FOR CHORD DISTANCE (K)
A
PROMPT FOR CHORD BEARING (K)
A
3

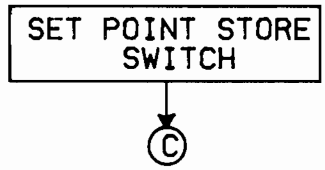


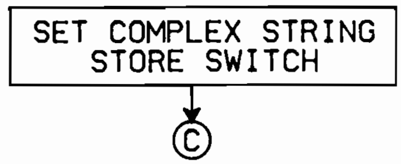
COMMAND INDEX F1

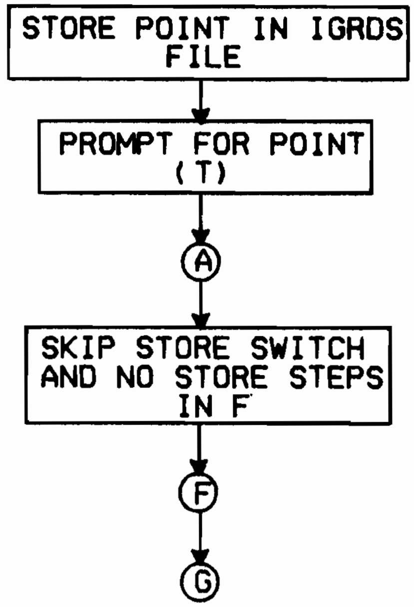


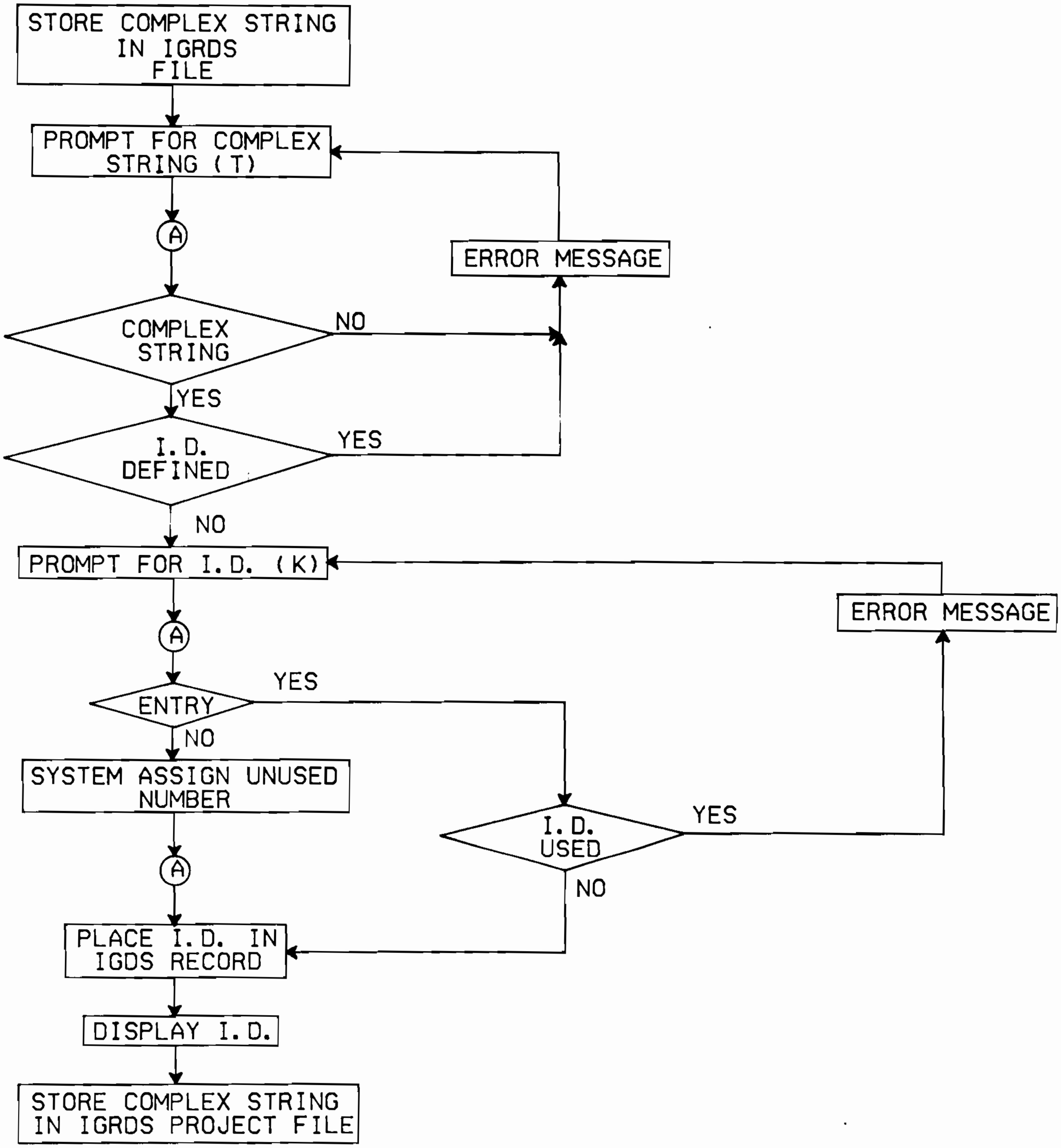
COMMAND INDEX F2


SET PRINT SWITCH
C

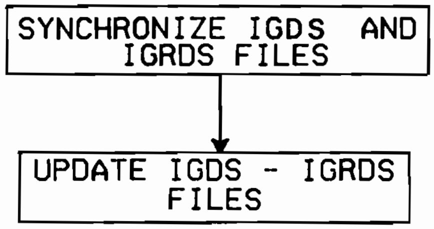

SET POINT STORE SWITCH
C

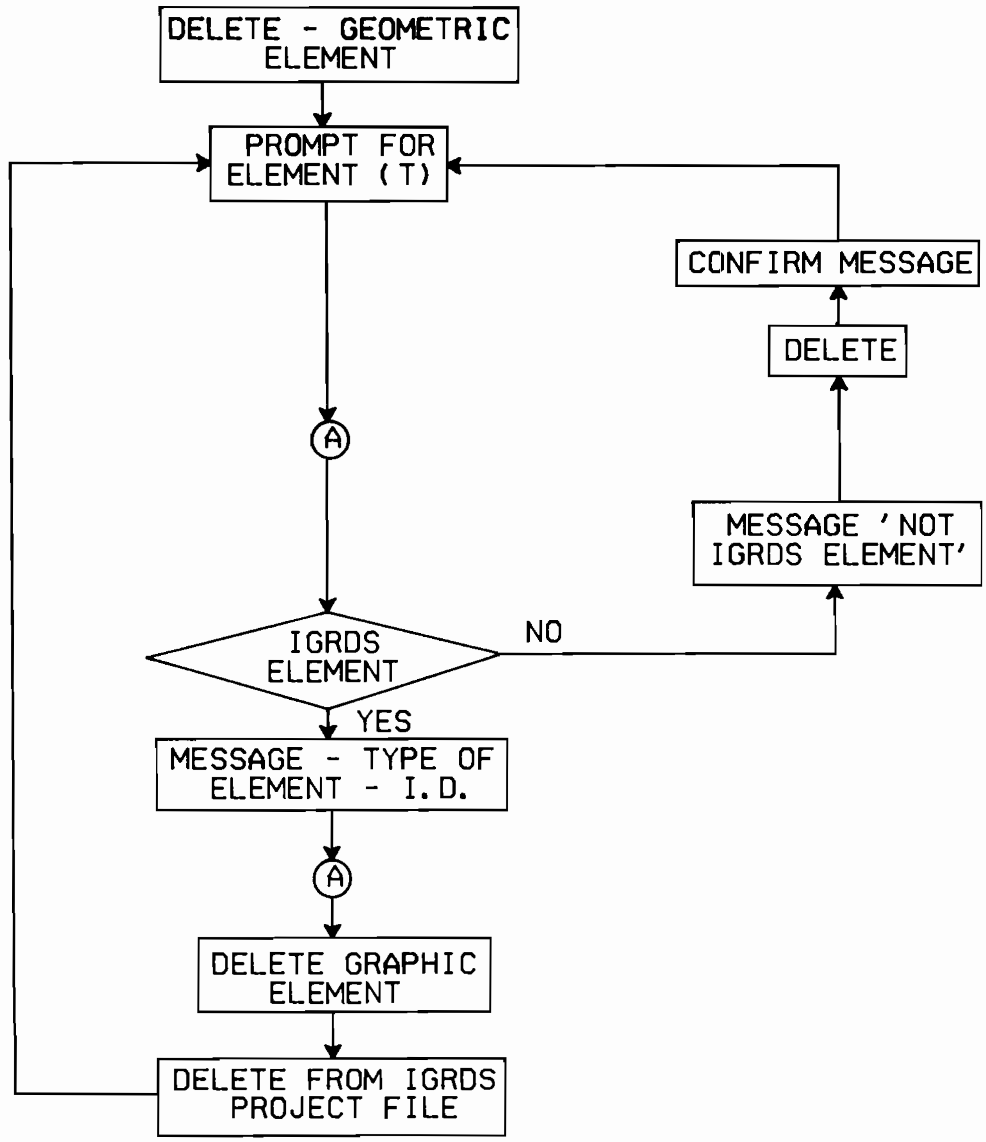

SET COMPLEX STRING
STORE SWITCH
C

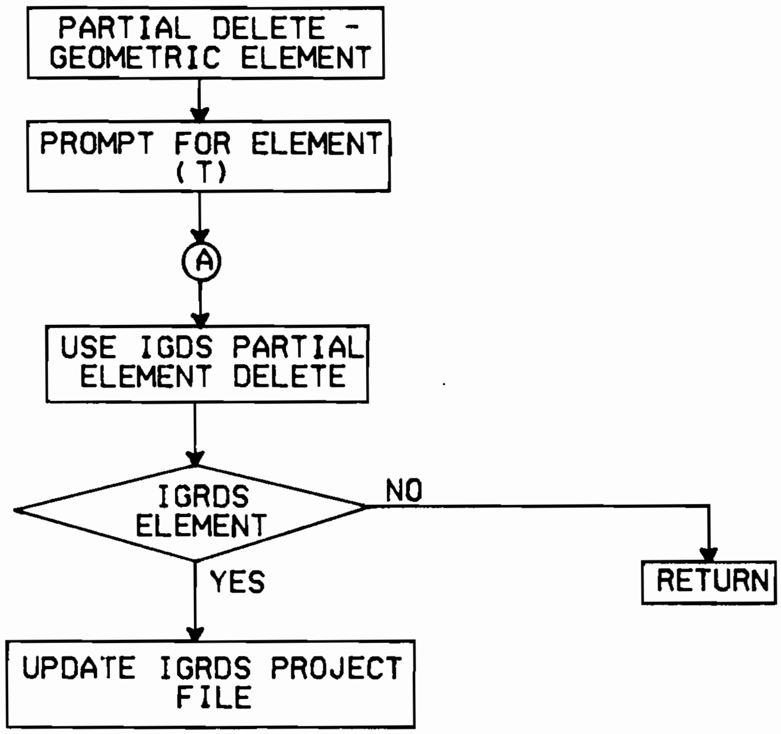

STORE POINT IN IGRDS FILE
PROMPT FOR POINT (T)
A
SKIP STORE SWITCH AND NO STORE STEPS IN F
F
G

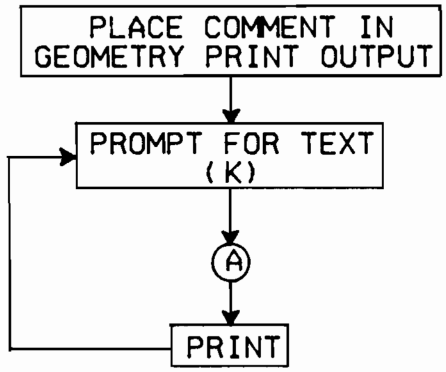


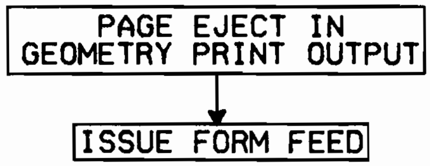
COMMAND INDEX G5

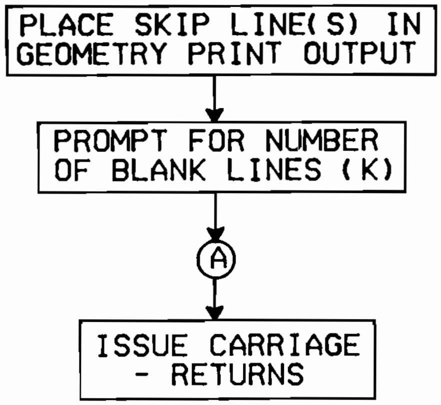

SYNCHRONIZE IGDS AND IGRDS FILES
UPDATE IGDS - IGRDS FILES


DELETE - GEOMETRIC ELEMENT
PROMPT FOR ELEMENT (T)
CONFIRM MESSAGE
DELETE
A
MESSAGE 'NOT IGRDS ELEMENT'
IGRDS ELEMENT
NO
YES
MESSAGE - TYPE OF ELEMENT - I.D.
A
DELETE GRAPHIC ELEMENT
DELETE FROM IGRDS PROJECT FILE

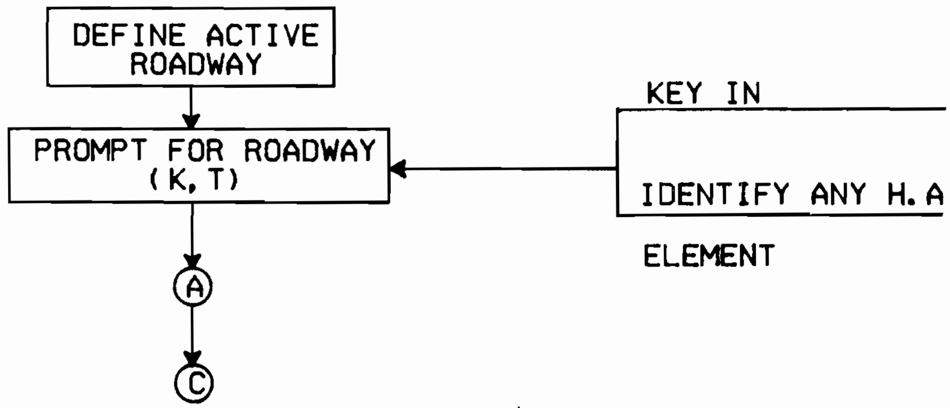

PARTIAL DELETE - GEOMETRIC ELEMENT
PROMPT FOR ELEMENT (T)
A
USE IGDS PARTIAL ELEMENT DELETE
IGRDS ELEMENT
NO
RETURN
YES
UPDATE IGRDS PROJECT FILE

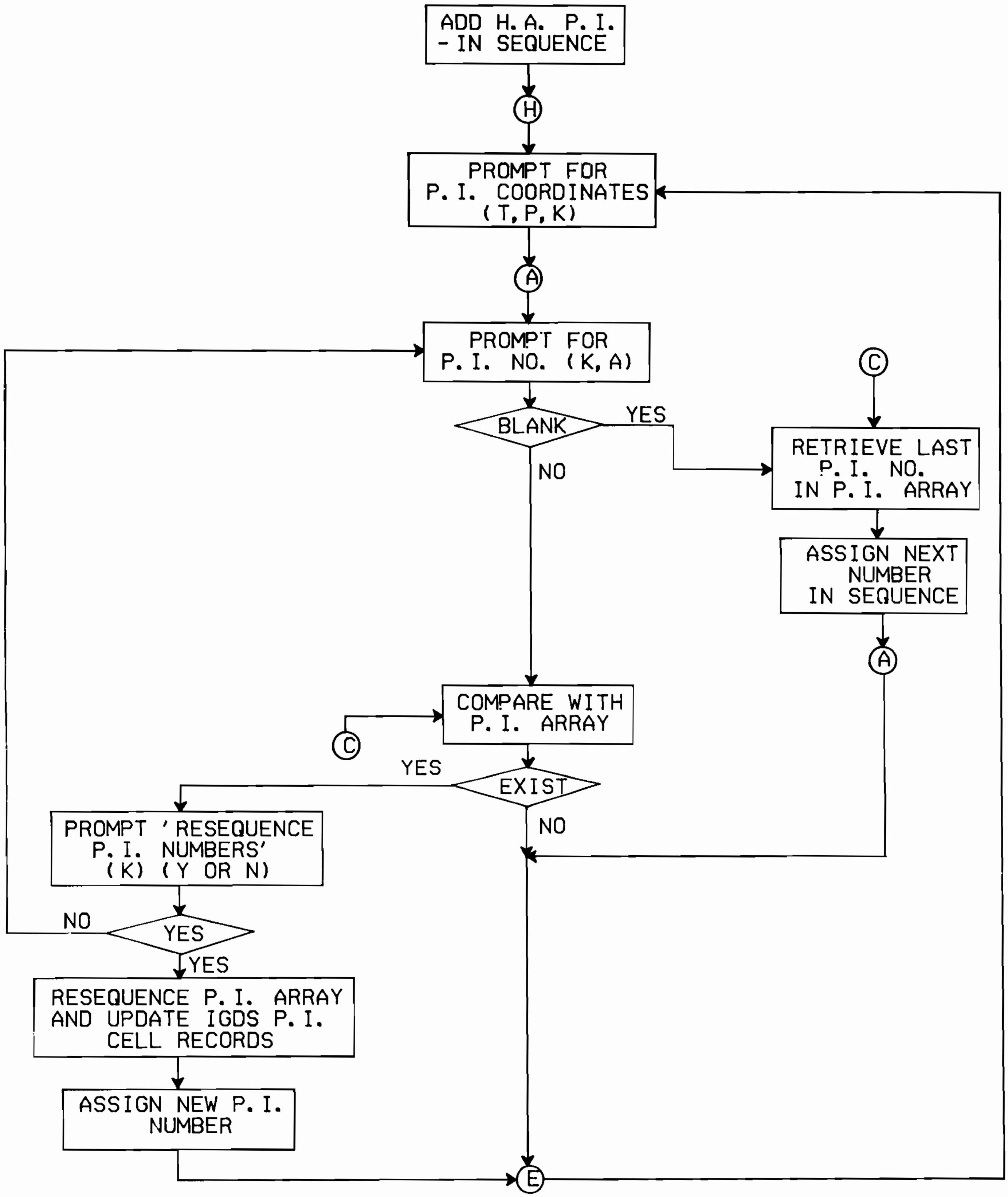

PLACE COMMENT IN GEOMETRY PRINT OUTPUT
PROMPT FOR TEXT (K)
A
PRINT


PAGE EJECT IN
GEOMETRY PRINT OUTPUT
ISSUE FORM FEED

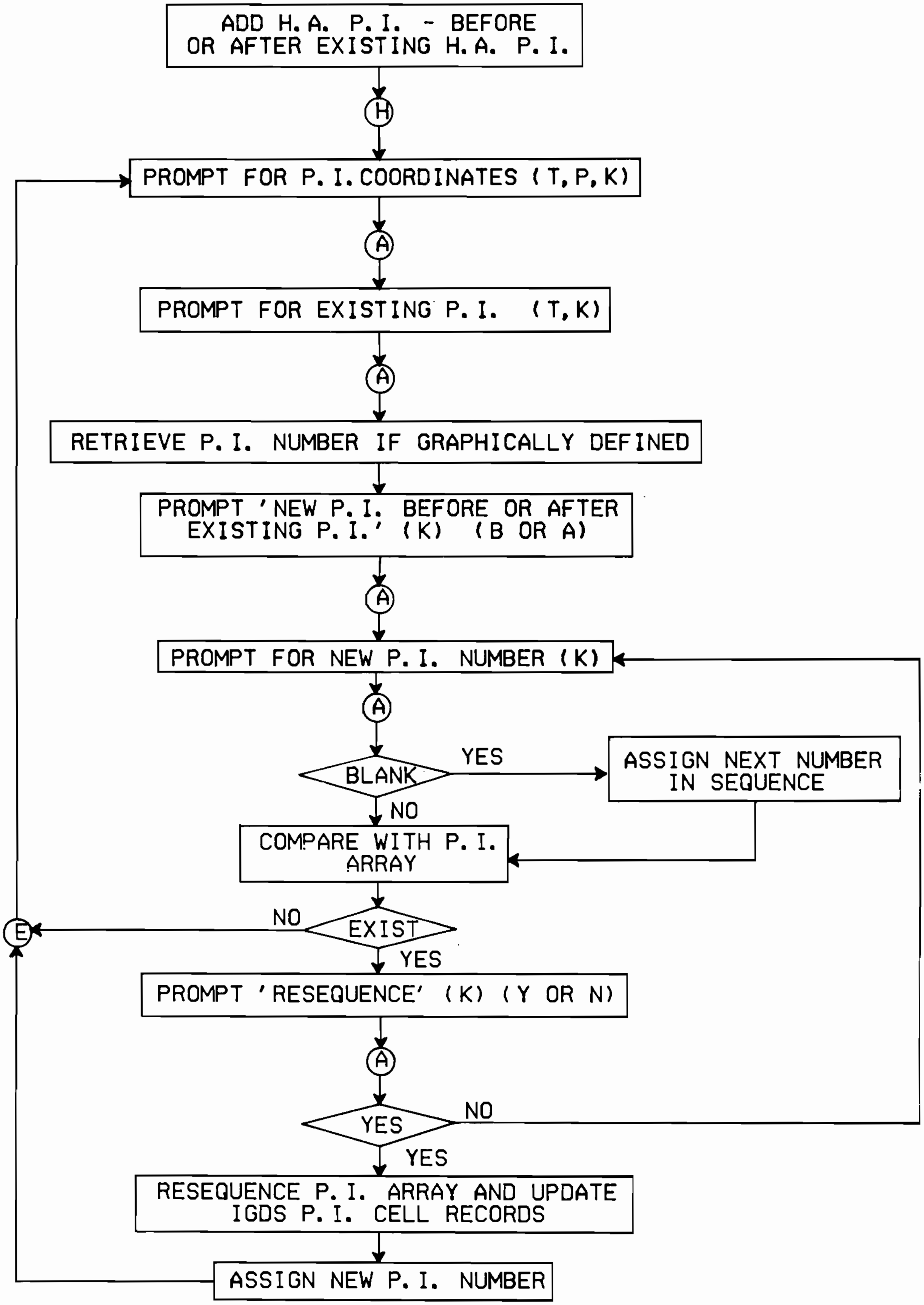


COMMAND INDEX G11

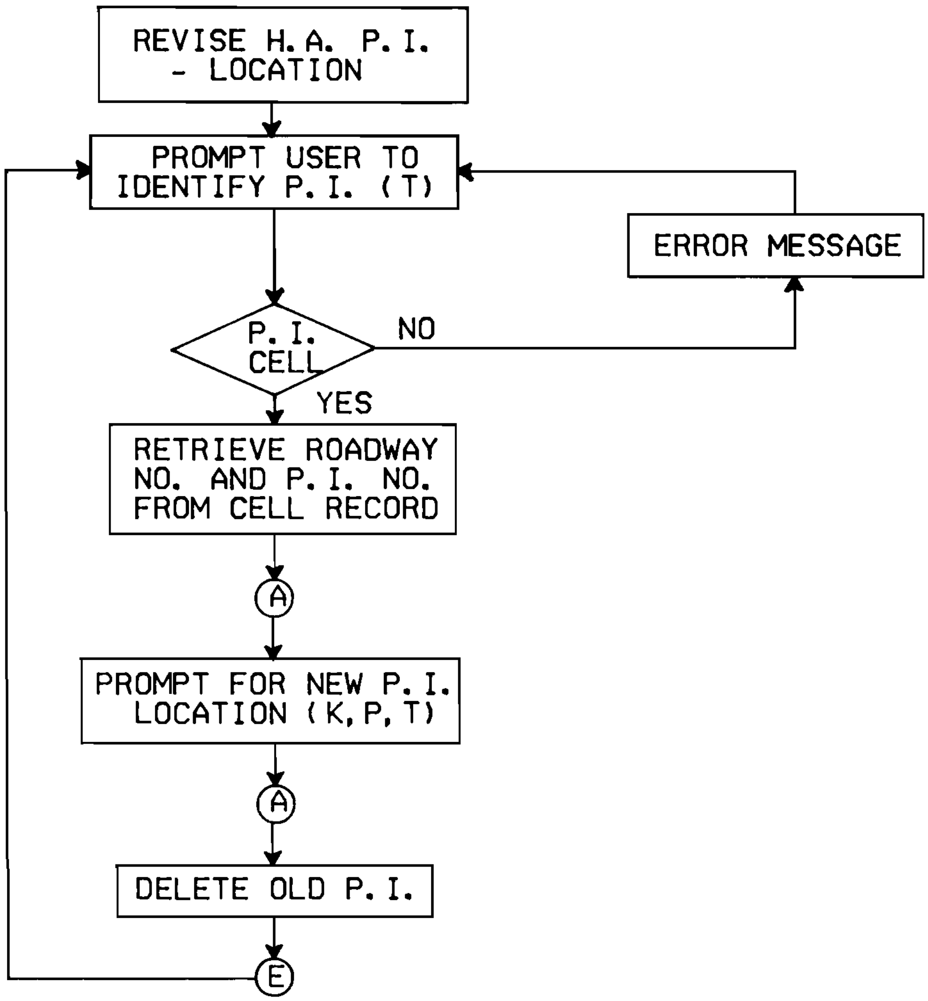

DEFINE ACTIVE ROADWAY
PROMPT FOR ROADWAY (K, T)
KEY IN
IDENTIFY ANY H. A
ELEMENT
A
C

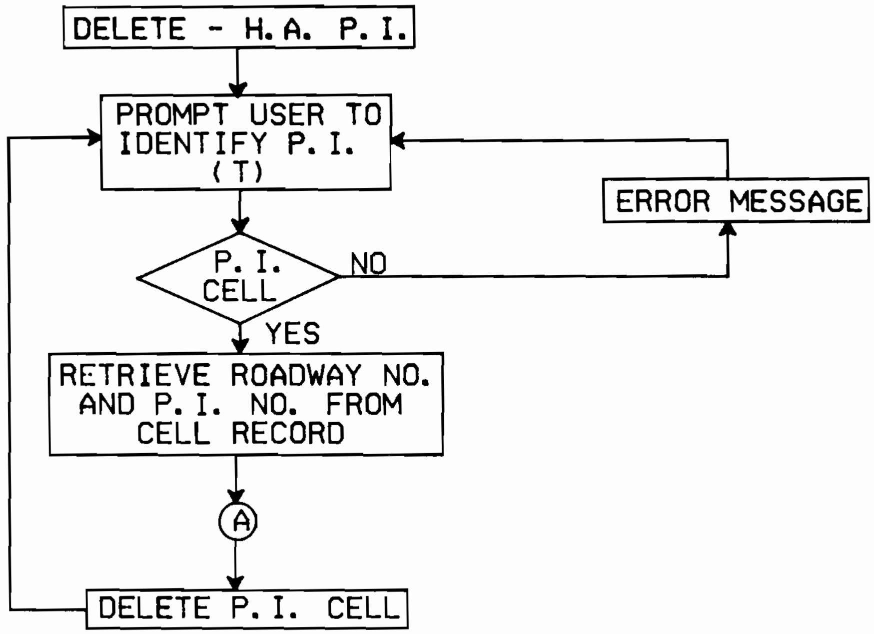


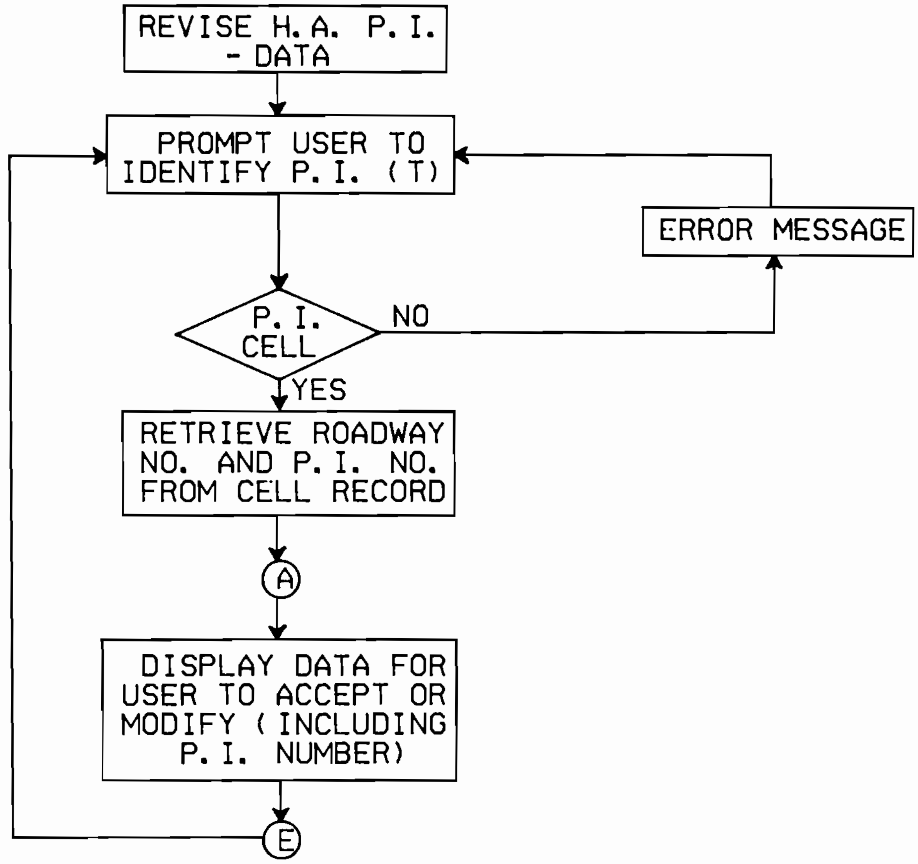
COMMAND INDEX I1

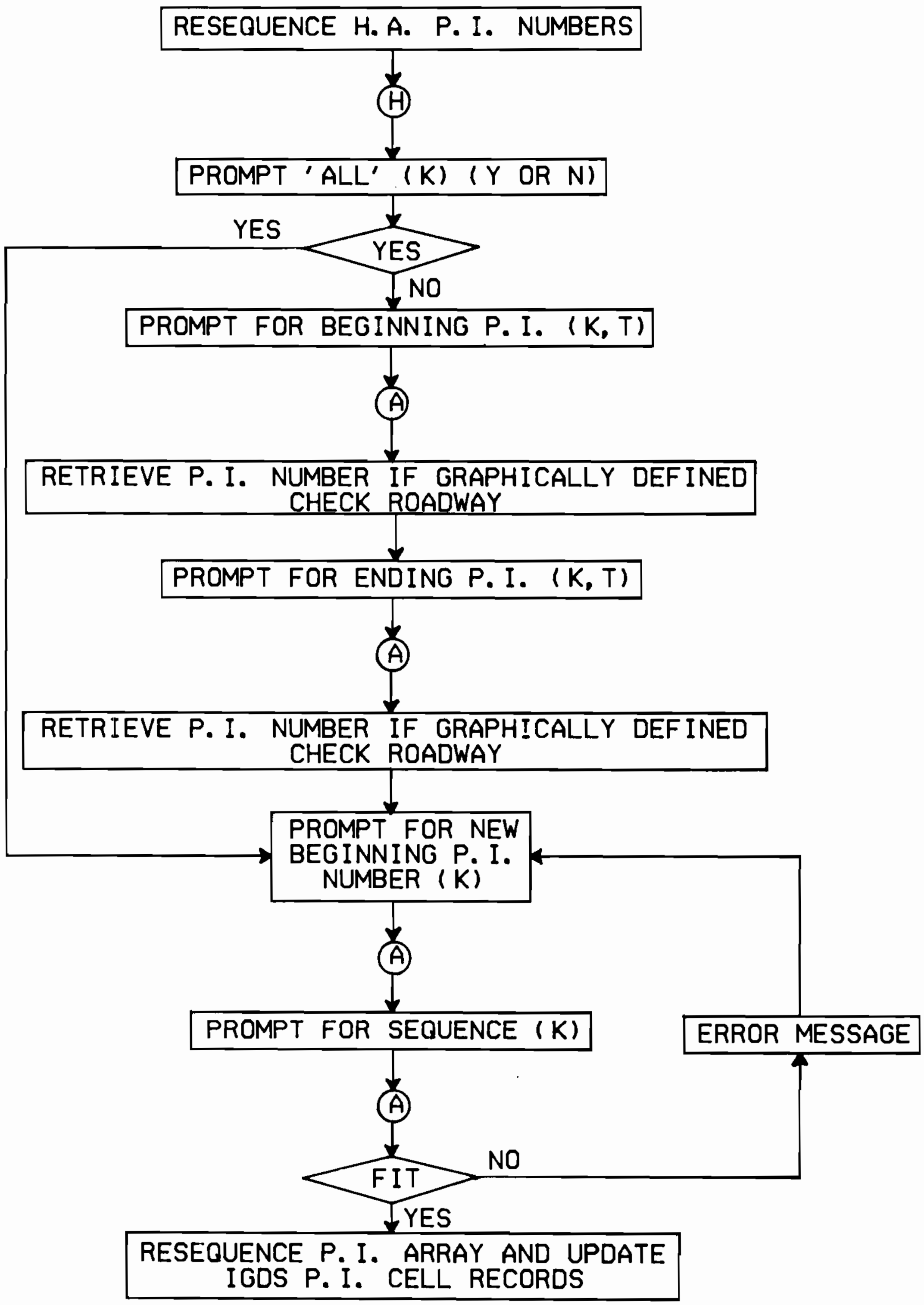


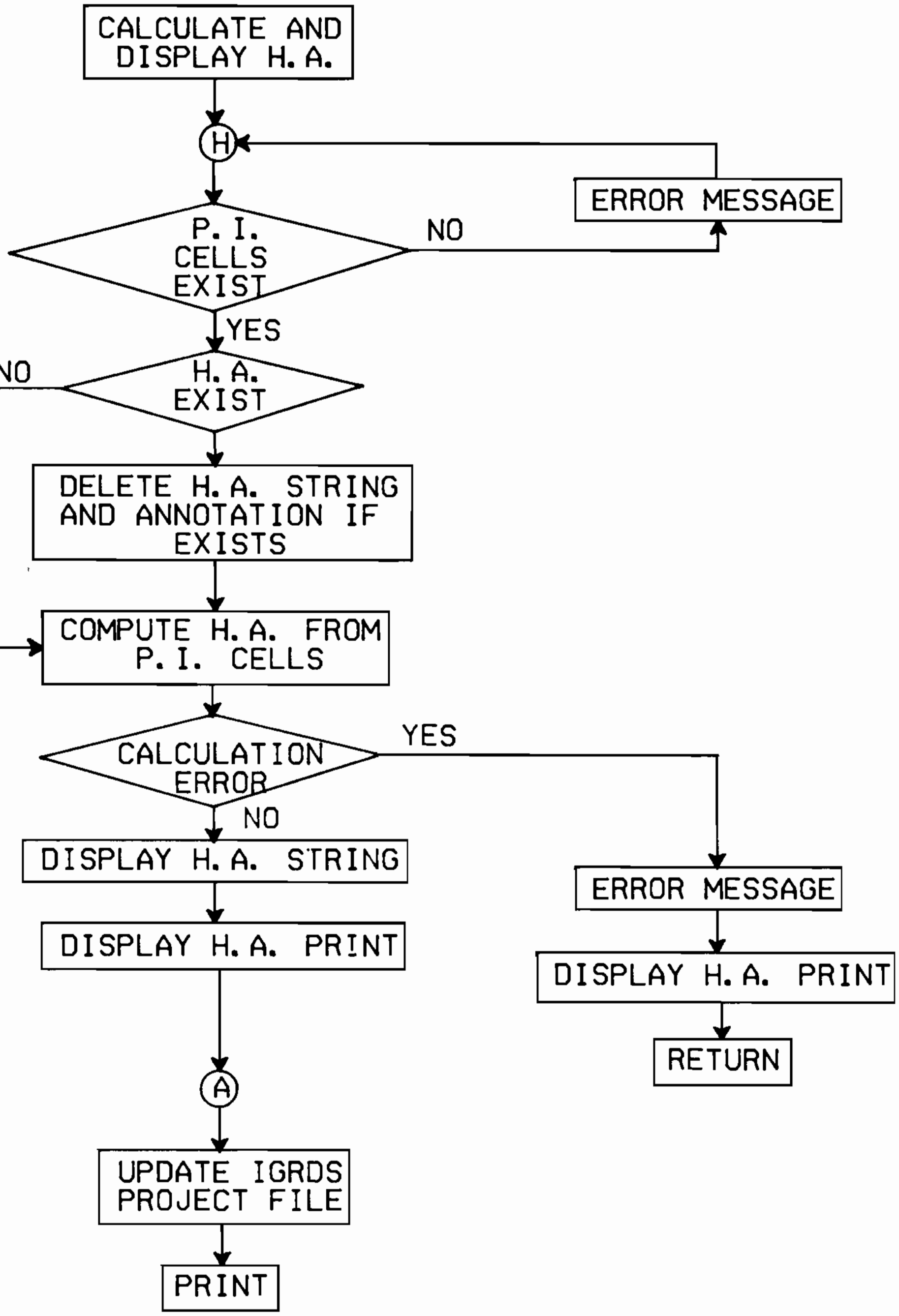
COMMAND INDEX I2

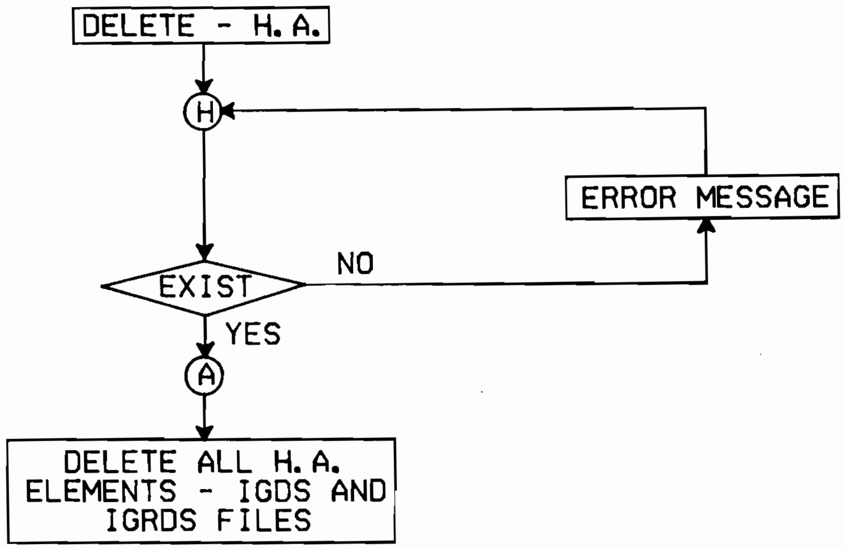

REVISE H.A. P.I. - LOCATION
PROMPT USER TO IDENTIFY P.I. (T)
ERROR MESSAGE
P.I. CELL
NO
YES
RETRIEVE ROADWAY NO. AND P.I. NO. FROM CELL RECORD
A
PROMPT FOR NEW P.I. LOCATION (K,P,T)
A
DELETE OLD P.I.
E

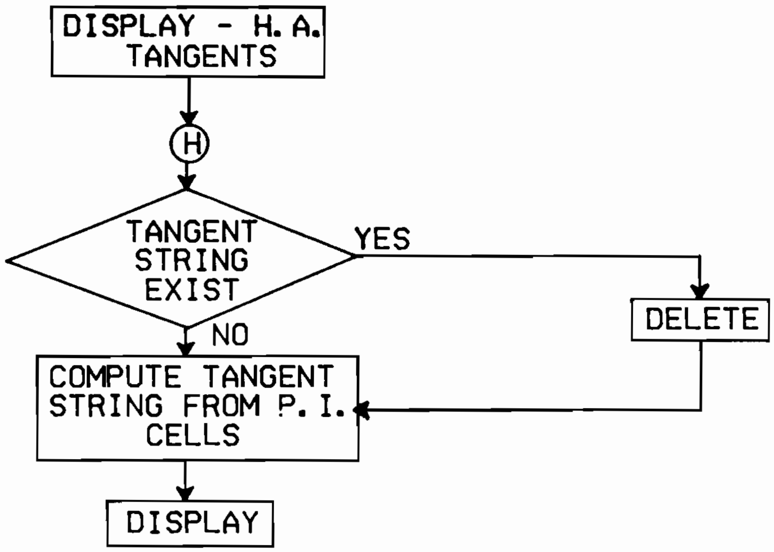

DELETE - H. A. P. I.
PROMPT USER TO IDENTIFY P. I. (T)
ERROR MESSAGE
P. I. CELL
NO
YES
RETRIEVE ROADWAY NO. AND P. I. NO. FROM CELL RECORD
A
DELETE P. I. CELL

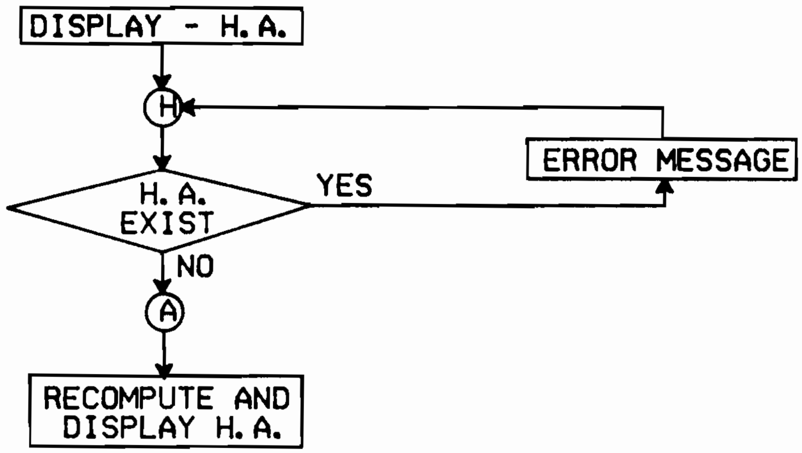

REVISE H.A. P.I. - DATA
PROMPT USER TO IDENTIFY P.I. (T)
ERROR MESSAGE
P.I. CELL
NO
YES
RETRIEVE ROADWAY NO. AND P.I. NO. FROM CELL RECORD
A
DISPLAY DATA FOR USER TO ACCEPT OR MODIFY (INCLUDING P.I. NUMBER)
E

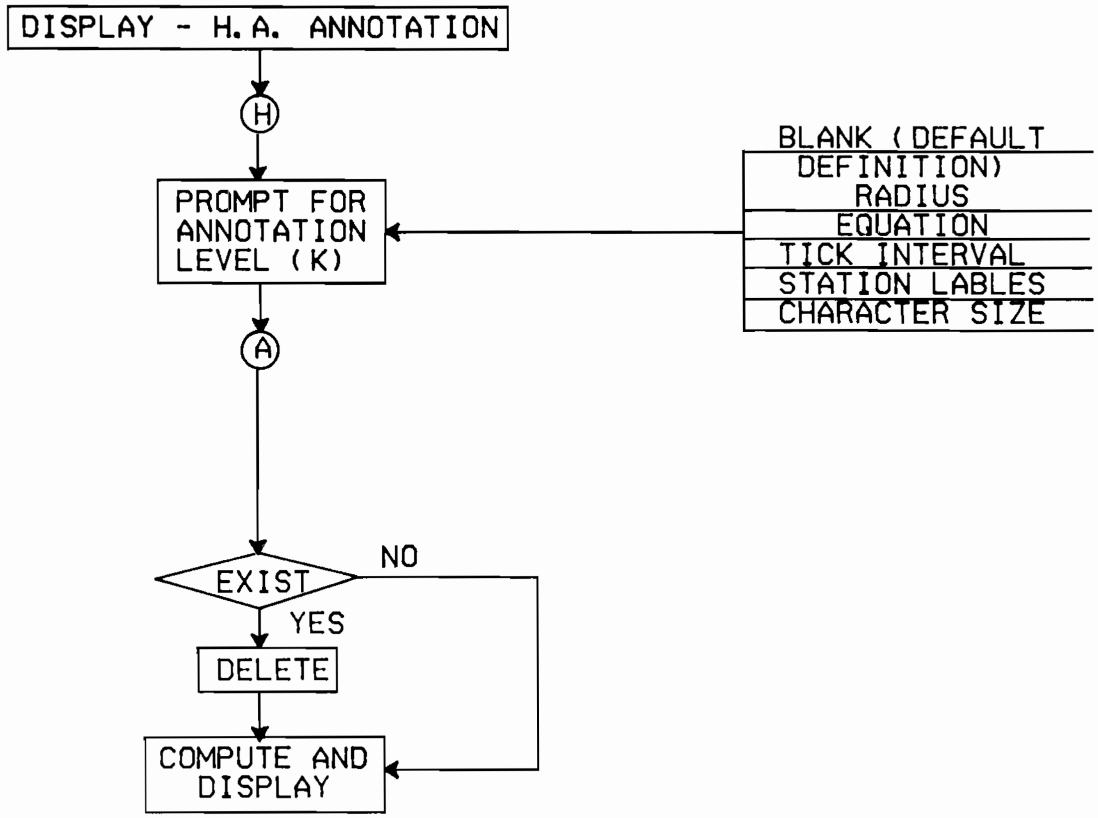

RESEQUENCE H.A. P.I. NUMBERS
H
PROMPT 'ALL' (K) (Y OR N)
YES
YES
NO
PROMPT FOR BEGINNING P.I. (K,T)
A
RETRIEVE P.I. NUMBER IF GRAPHICALLY DEFINED CHECK ROADWAY
PROMPT FOR ENDING P.I. (K,T)
A
RETRIEVE P.I. NUMBER IF GRAPHICALLY DEFINED CHECK ROADWAY
PROMPT FOR NEW BEGINNING P.I. NUMBER (K)
A
PROMPT FOR SEQUENCE (K)
ERROR MESSAGE
A
FIT
NO
YES
RESEQUENCE P.I. ARRAY AND UPDATE IGDS P.I. CELL RECORDS

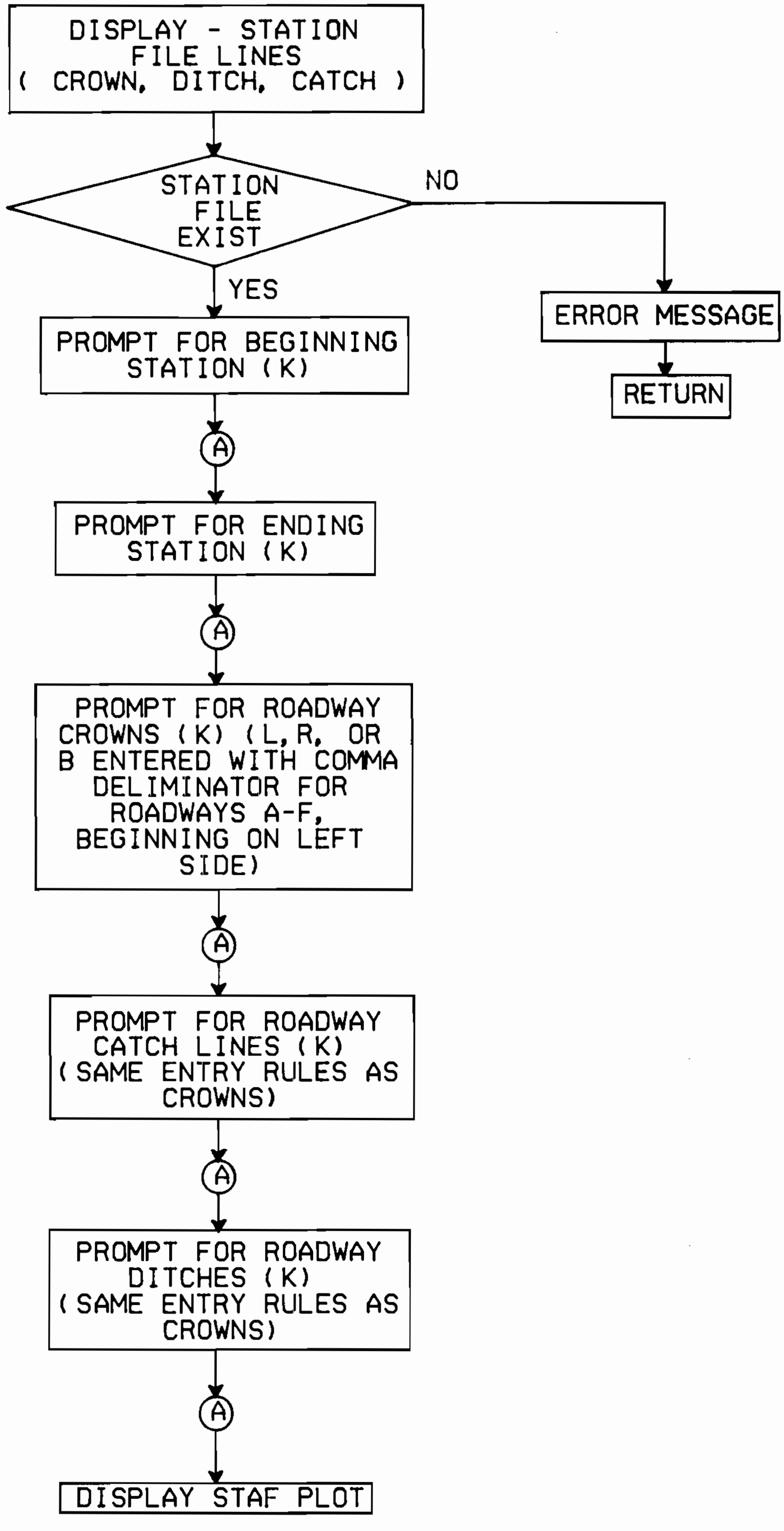

CALCULATE AND DISPLAY H.A.
H
ERROR MESSAGE
P.I. CELLS EXIST
NO
YES
NO
H.A. EXIST
DELETE H.A. STRING AND ANNOTATION IF EXISTS
COMPUTE H.A. FROM P.I. CELLS
YES
CALCULATION ERROR
NO
DISPLAY H.A. STRING
ERROR MESSAGE
DISPLAY H.A. PRINT
DISPLAY H.A. PRINT
RETURN
A
UPDATE IGRDS PROJECT FILE
PRINT


DELETE - H. A.
H
ERROR MESSAGE
NO
EXIST
YES
A
DELETE ALL H. A. ELEMENTS - IGDS AND IGRDS FILES

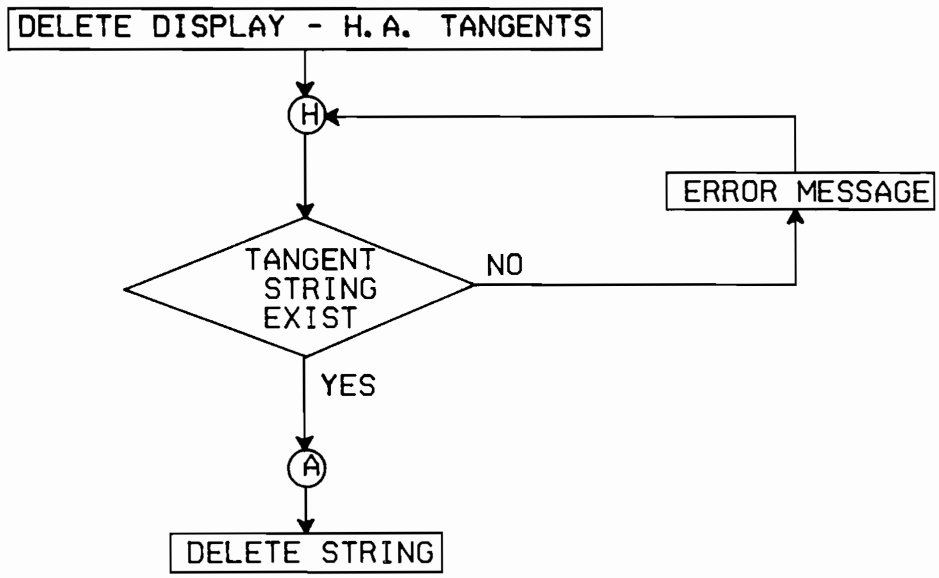

DISPLAY - H. A. TANGENTS
H
TANGENT STRING EXIST
YES
DELETE
NO
COMPUTE TANGENT STRING FROM P. I. CELLS
DISPLAY

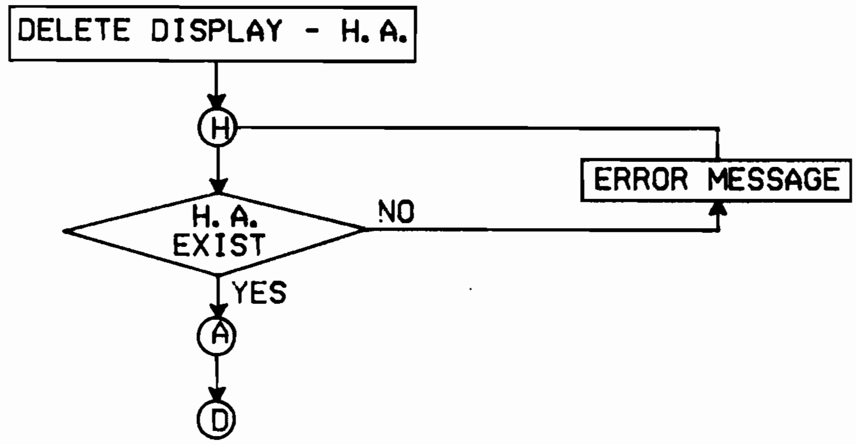

DISPLAY - H. A.
H
ERROR MESSAGE
YES
H. A.
EXIST
NO
A
RECOMPUTE AND
DISPLAY H. A.

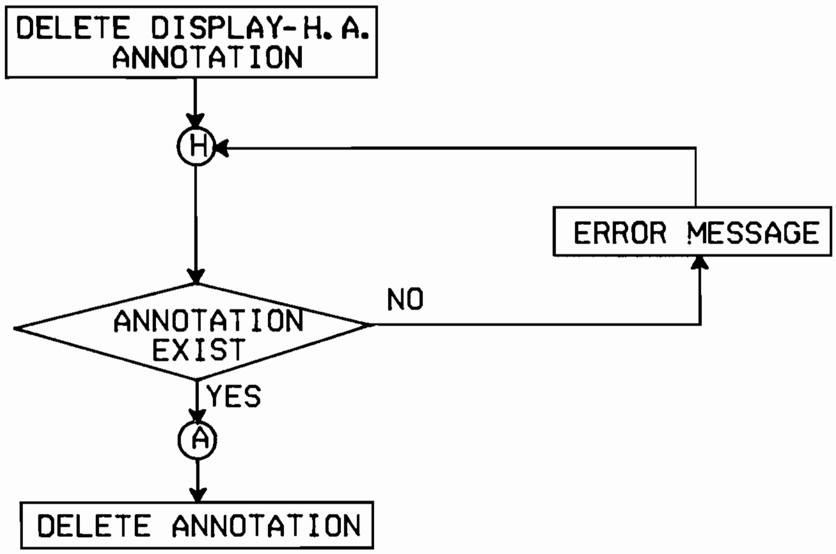

DISPLAY - H. A. ANNOTATION
H
PROMPT FOR ANNOTATION LEVEL (K)
BLANK (DEFAULT DEFINITION)
RADIUS
EQUATION
TICK INTERVAL
STATION LABLES
CHARACTER SIZE
A
EXIST
NO
YES
DELETE
COMPUTE AND DISPLAY

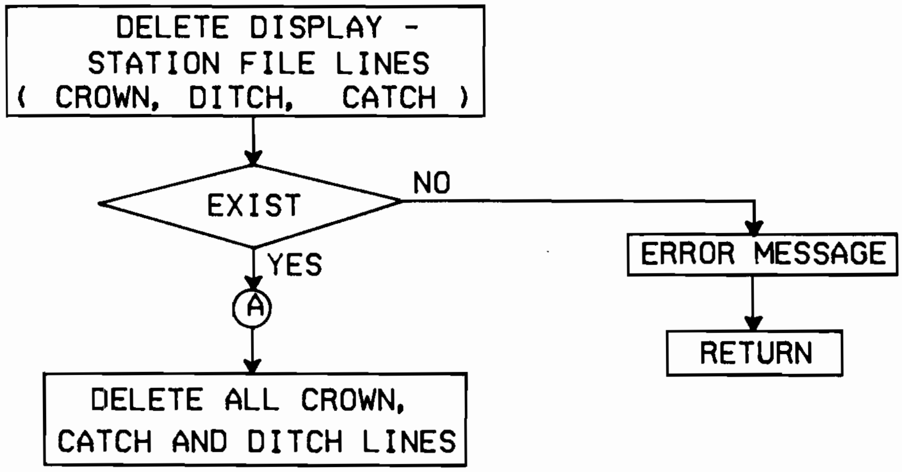


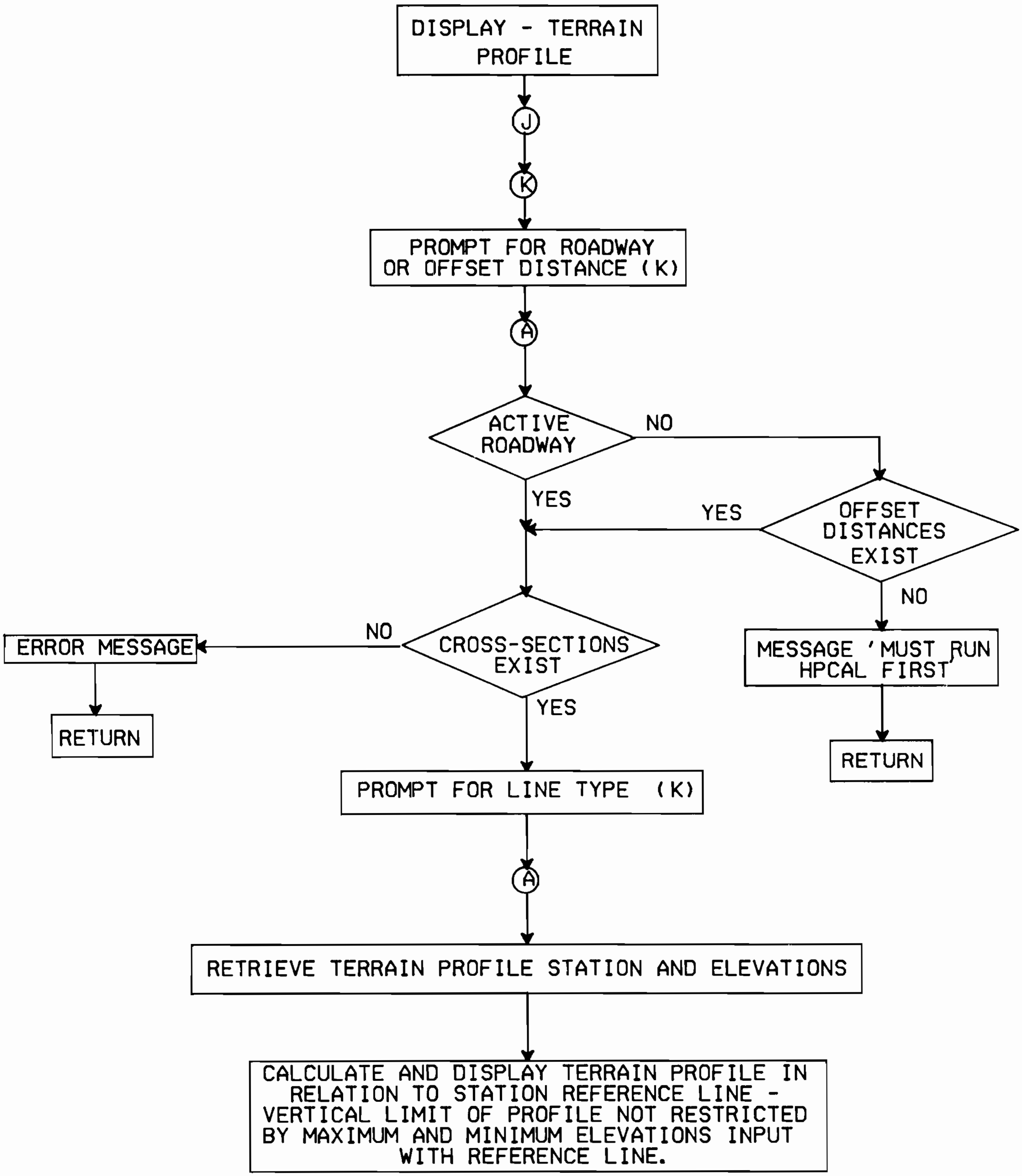
COMMAND INDEX K4


DELETE DISPLAY - H. A. TANGENTS
H
ERROR MESSAGE
TANGENT STRING EXIST
NO
YES
A
DELETE STRING

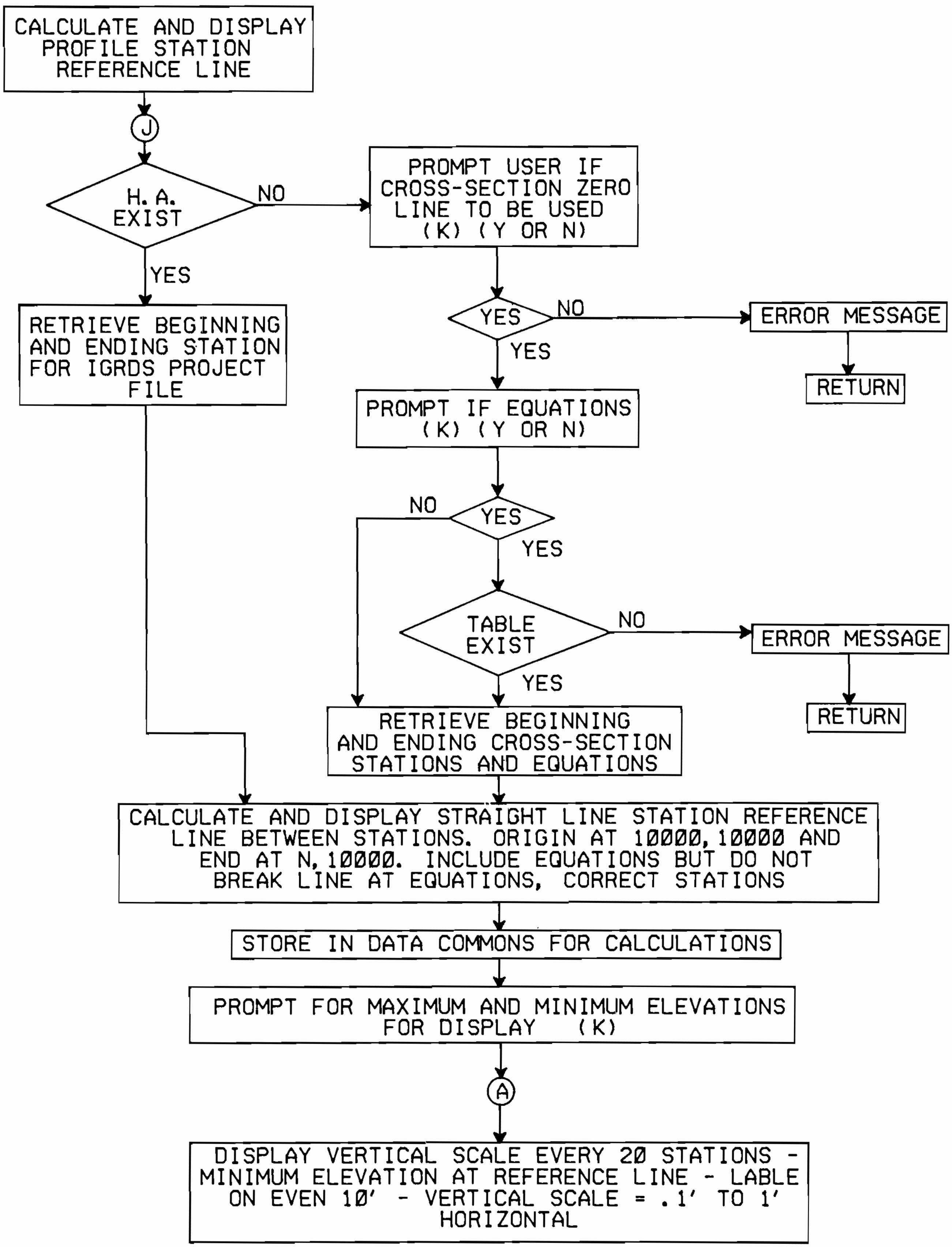

DELETE DISPLAY - H. A.
H
H. A.
EXIST
NO
ERROR MESSAGE
YES
A
D


DELETE DISPLAY-H. A. ANNOTATION
H
ERROR MESSAGE
NO
ANNOTATION EXIST
YES
A
DELETE ANNOTATION

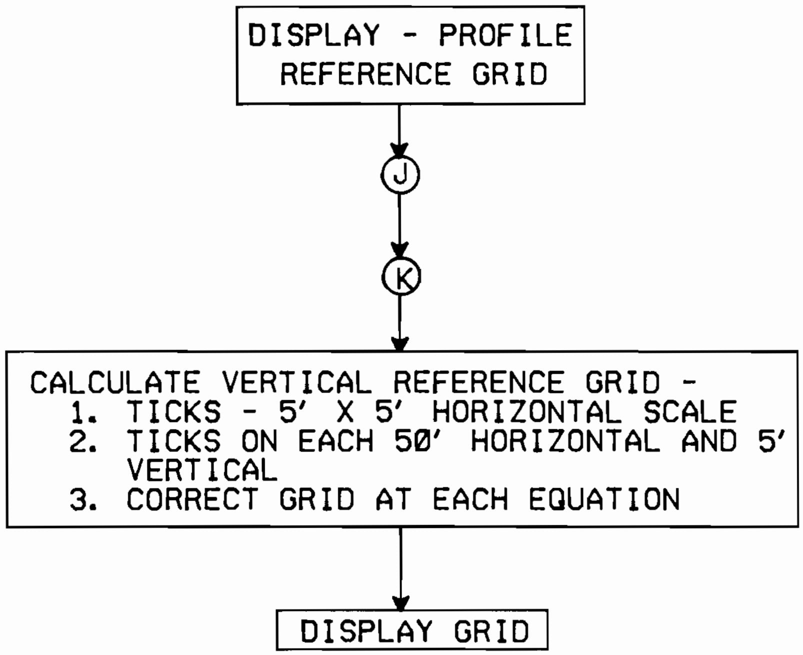

DELETE DISPLAY -
STATION FILE LINES
(CROWN, DITCH, CATCH)
EXIST
NO
YES
A
ERROR MESSAGE
RETURN
DELETE ALL CROWN,
CATCH AND DITCH LINES

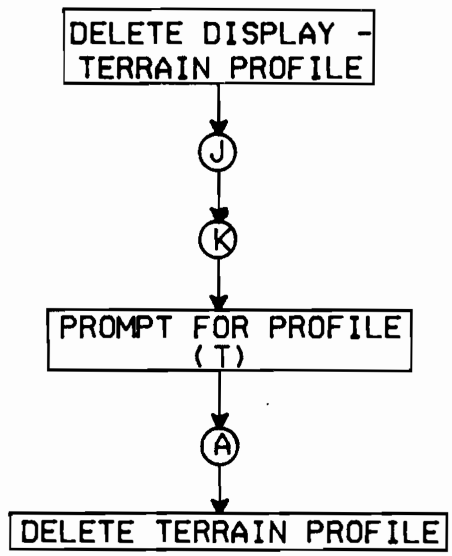


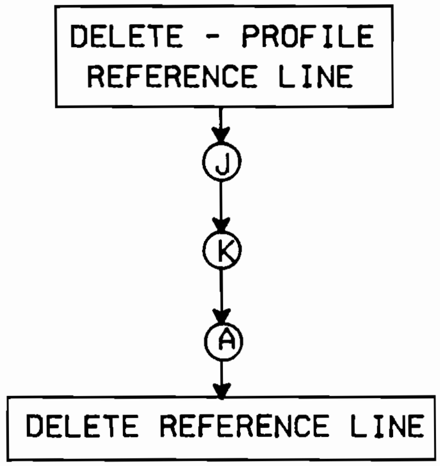
COMMAND INDEX L1

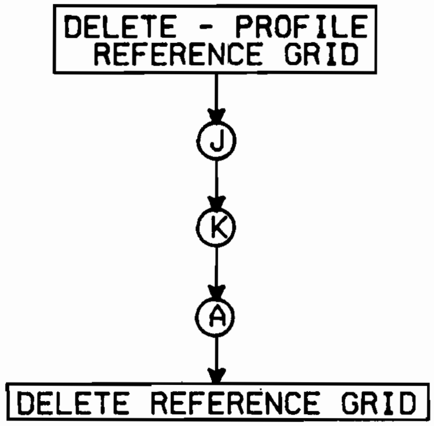


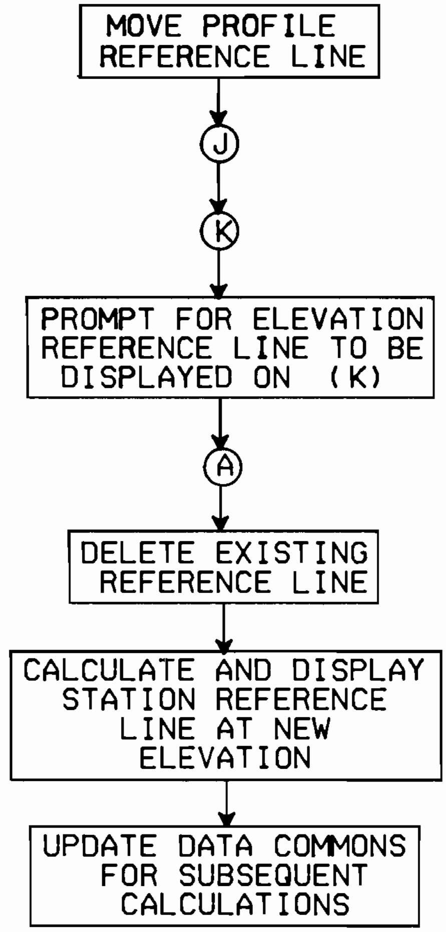
COMMAND INDEX L2


DISPLAY - PROFILE REFERENCE GRID
J
K
CALCULATE VERTICAL REFERENCE GRID -
1. TICKS - 5' X 5' HORIZONTAL SCALE
2. TICKS ON EACH 50' HORIZONTAL AND 5' VERTICAL
3. CORRECT GRID AT EACH EQUATION
DISPLAY GRID

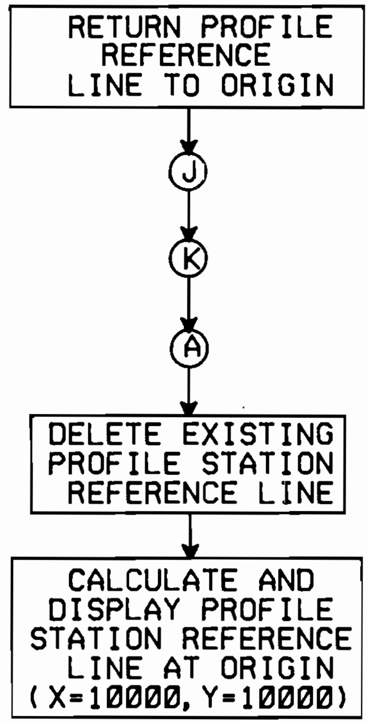

DELETE DISPLAY - TERRAIN PROFILE
J
K
PROMPT FOR PROFILE (T)
A
DELETE TERRAIN PROFILE

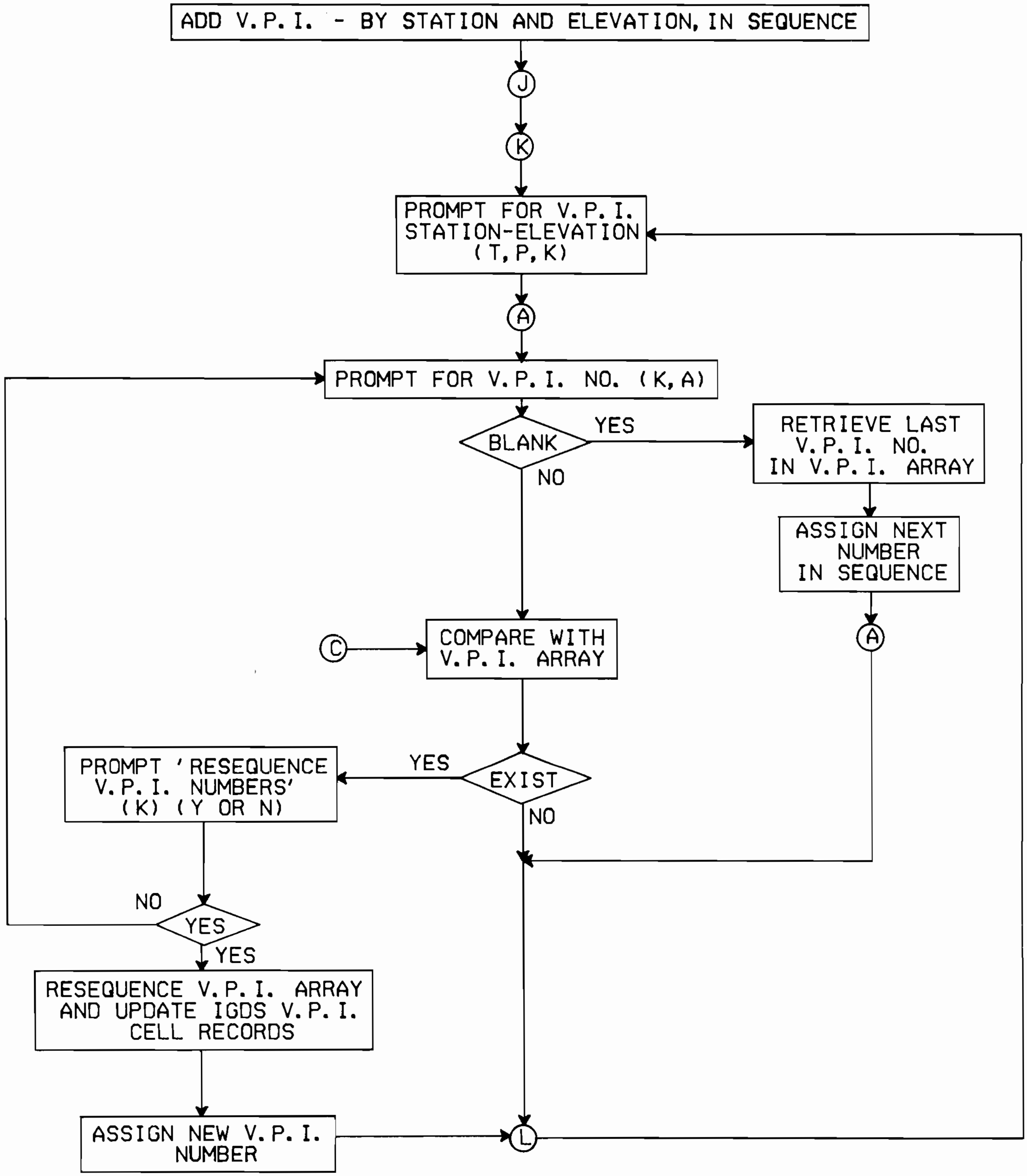

DELETE - PROFILE REFERENCE LINE
J
K
A
DELETE REFERENCE LINE


DELETE - PROFILE REFERENCE GRID
J
K
A
DELETE REFERENCE GRID

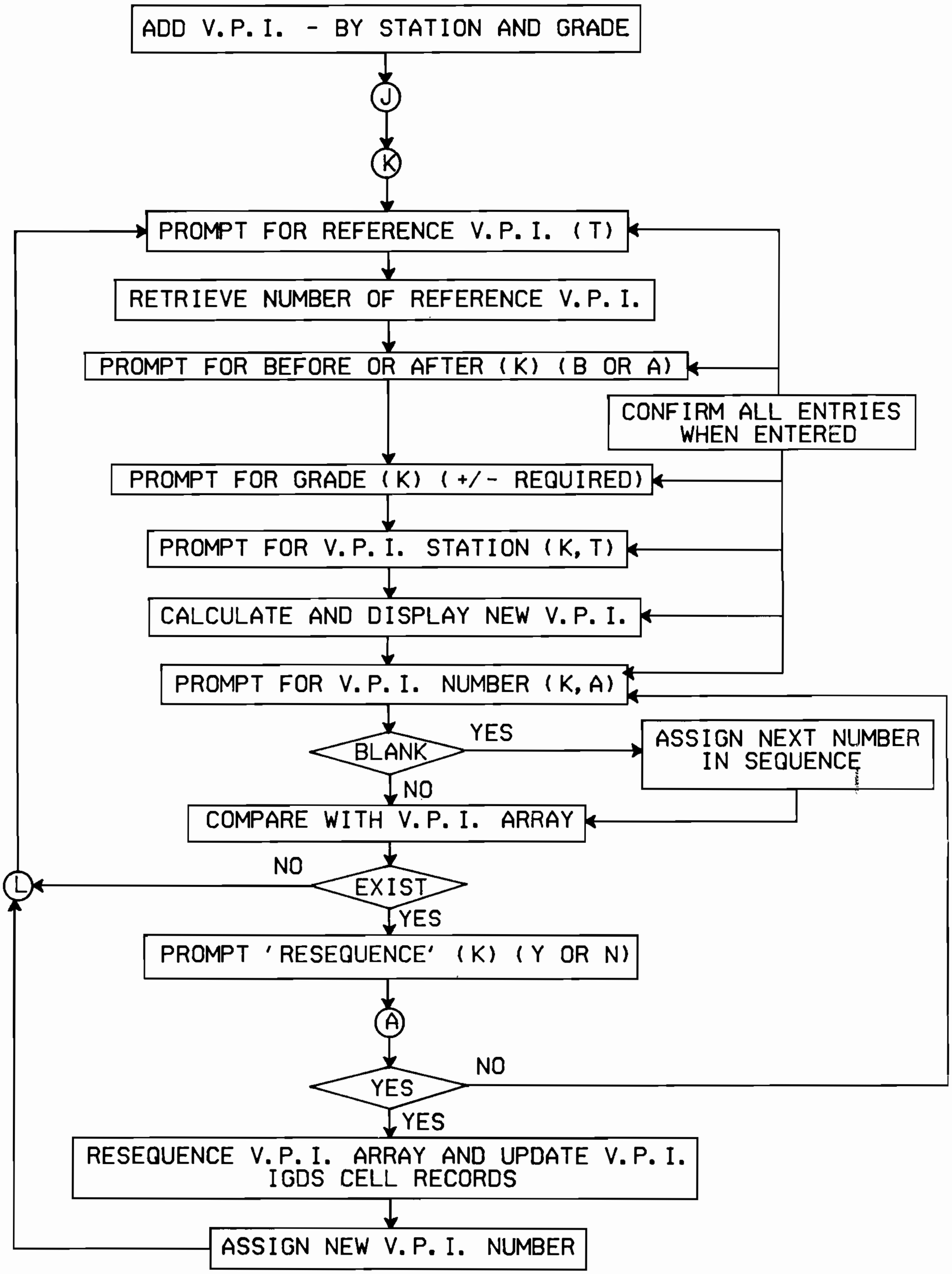


COMMAND INDEX L7

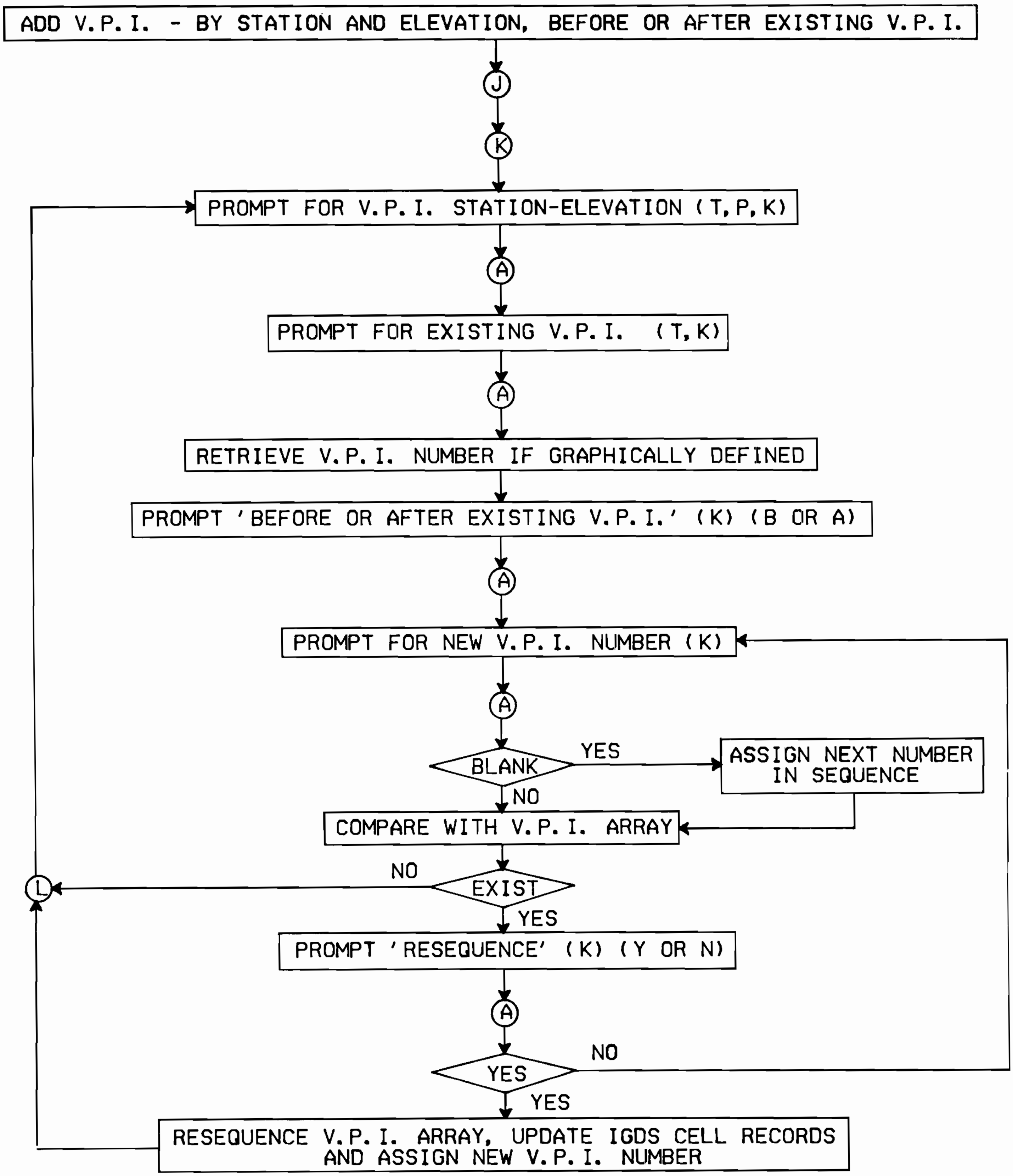

RETURN PROFILE REFERENCE LINE TO ORIGIN
J
K
A
DELETE EXISTING PROFILE STATION REFERENCE LINE
CALCULATE AND DISPLAY PROFILE STATION REFERENCE LINE AT ORIGIN (X=10000, Y=10000)



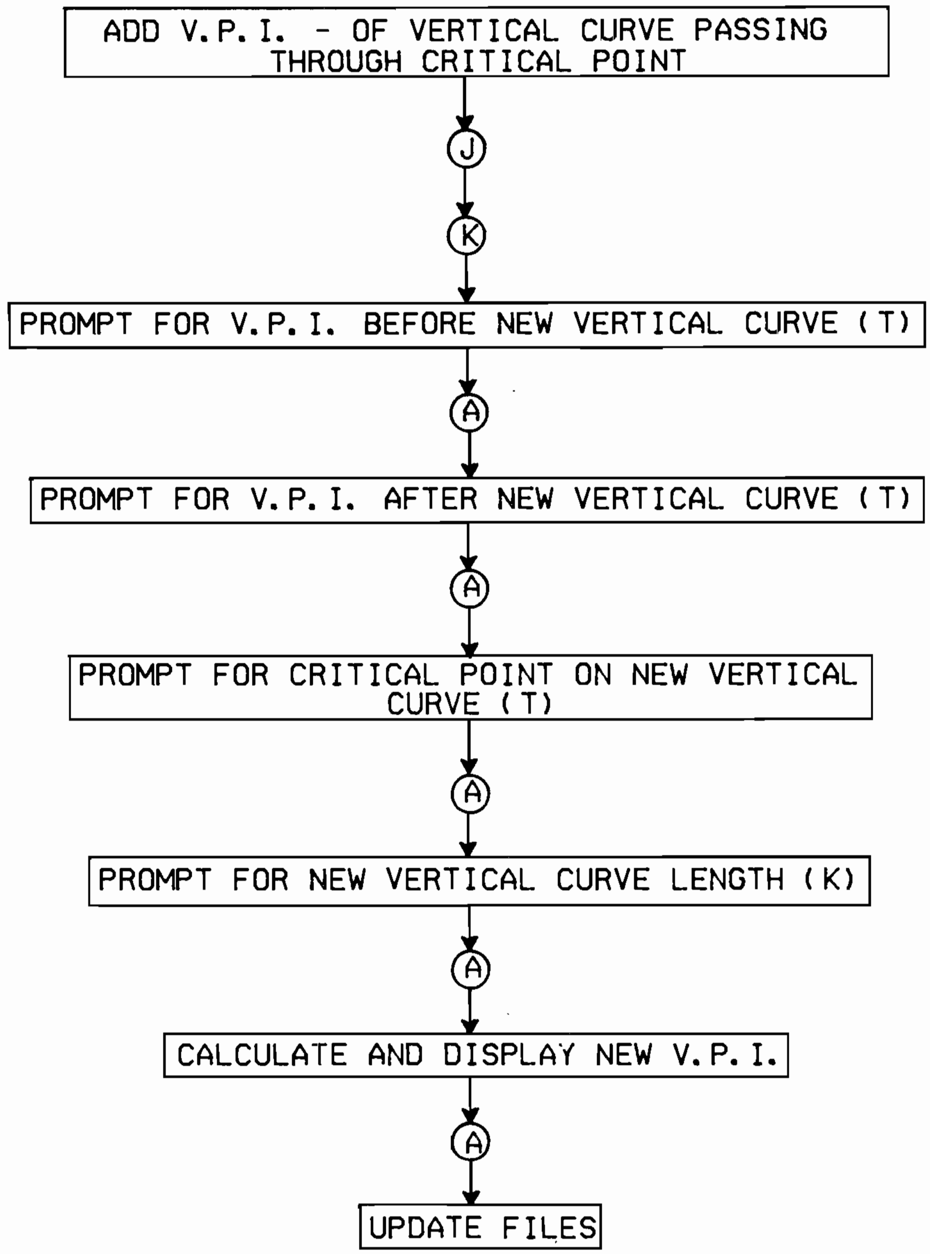
COMMAND INDEX M1

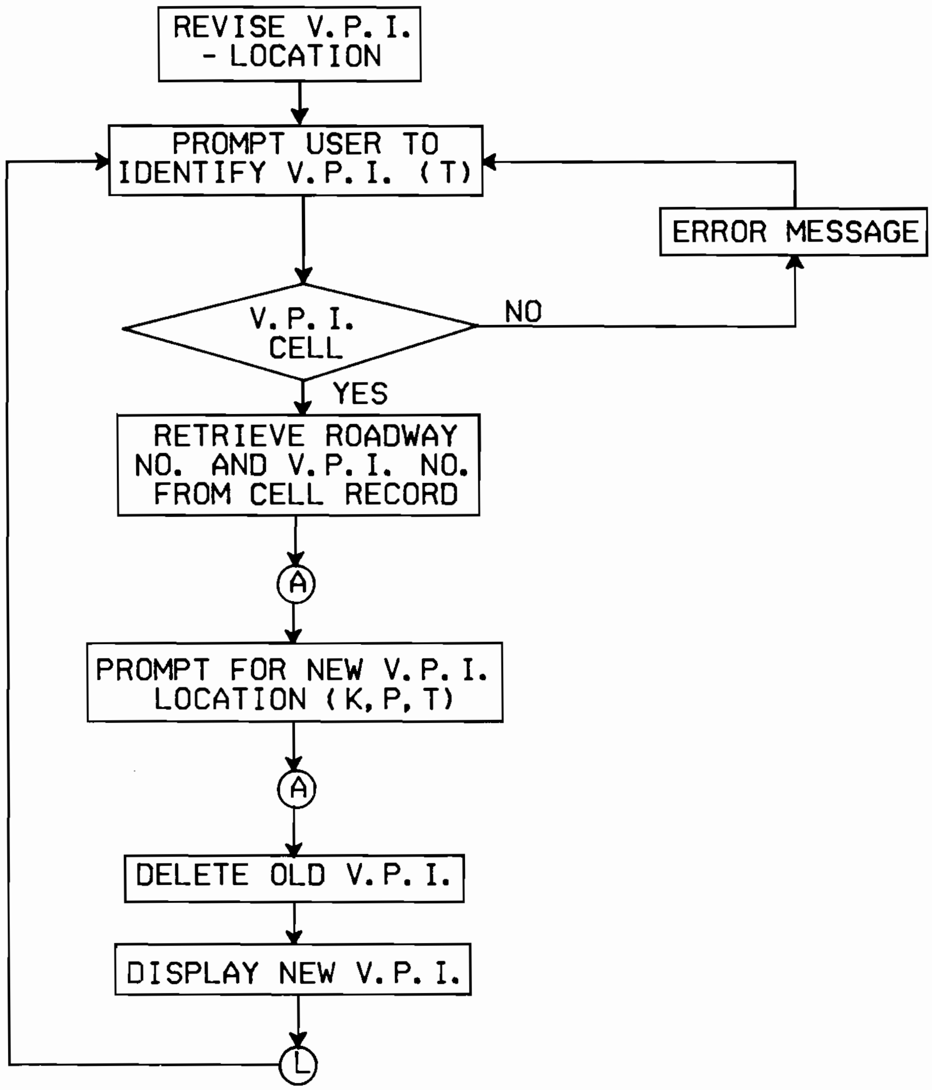


COMMAND INDEX M2

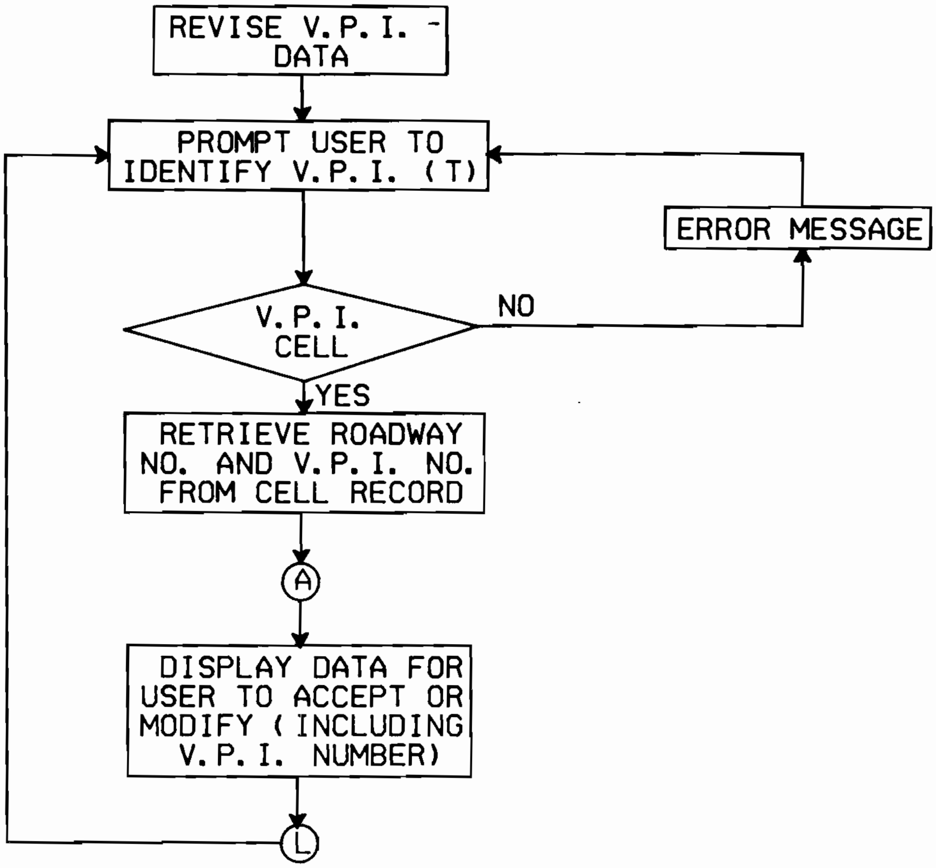


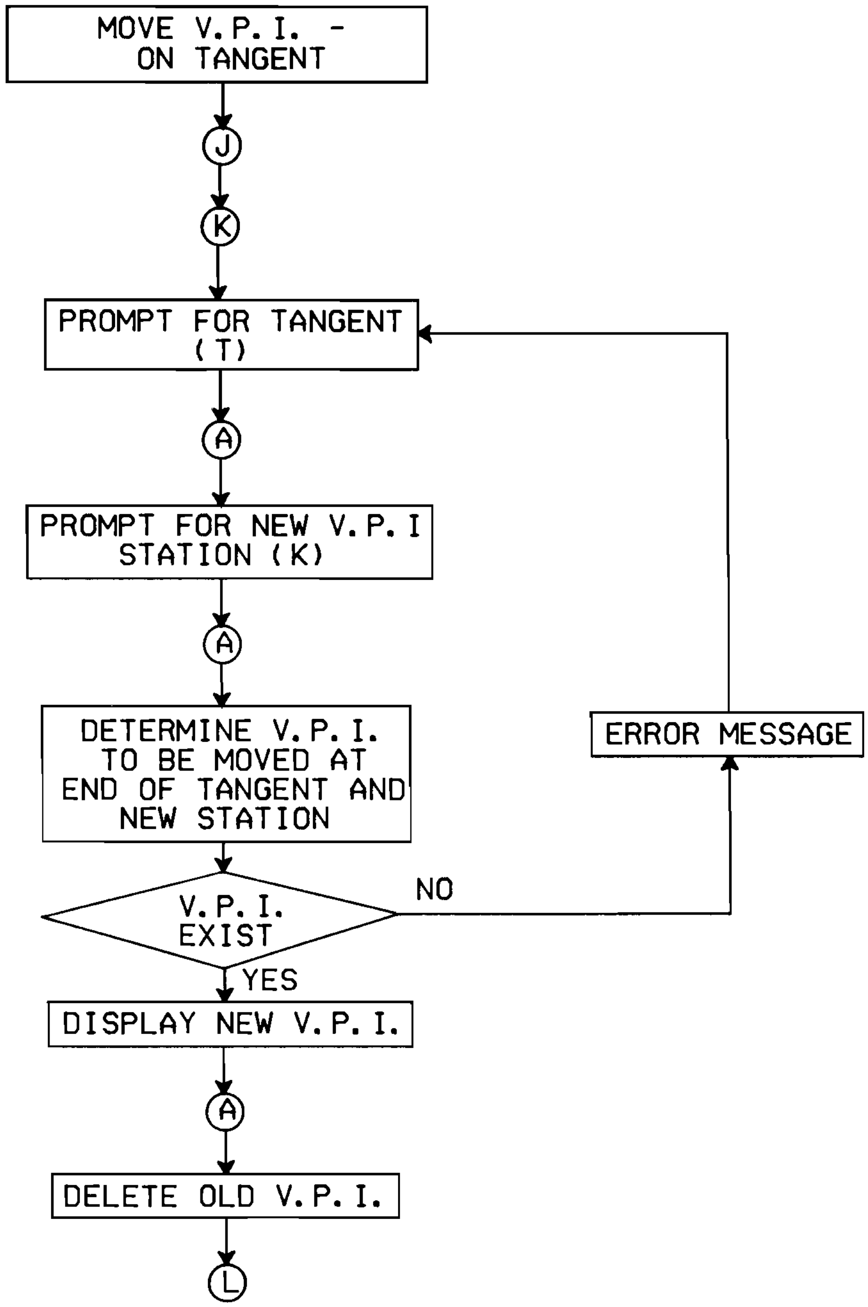
COMMAND INDEX M3

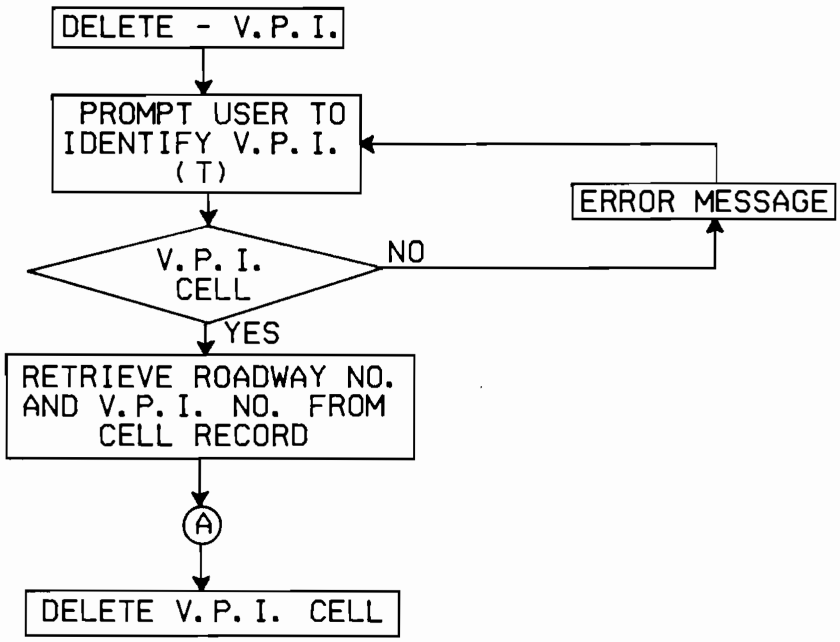

ADD V.P.I. - OF VERTICAL CURVE PASSING THROUGH CRITICAL POINT
J
K
PROMPT FOR V.P.I. BEFORE NEW VERTICAL CURVE (T)
A
PROMPT FOR V.P.I. AFTER NEW VERTICAL CURVE (T)
A
PROMPT FOR CRITICAL POINT ON NEW VERTICAL CURVE (T)
A
PROMPT FOR NEW VERTICAL CURVE LENGTH (K)
A
CALCULATE AND DISPLAY NEW V.P.I.
A
UPDATE FILES

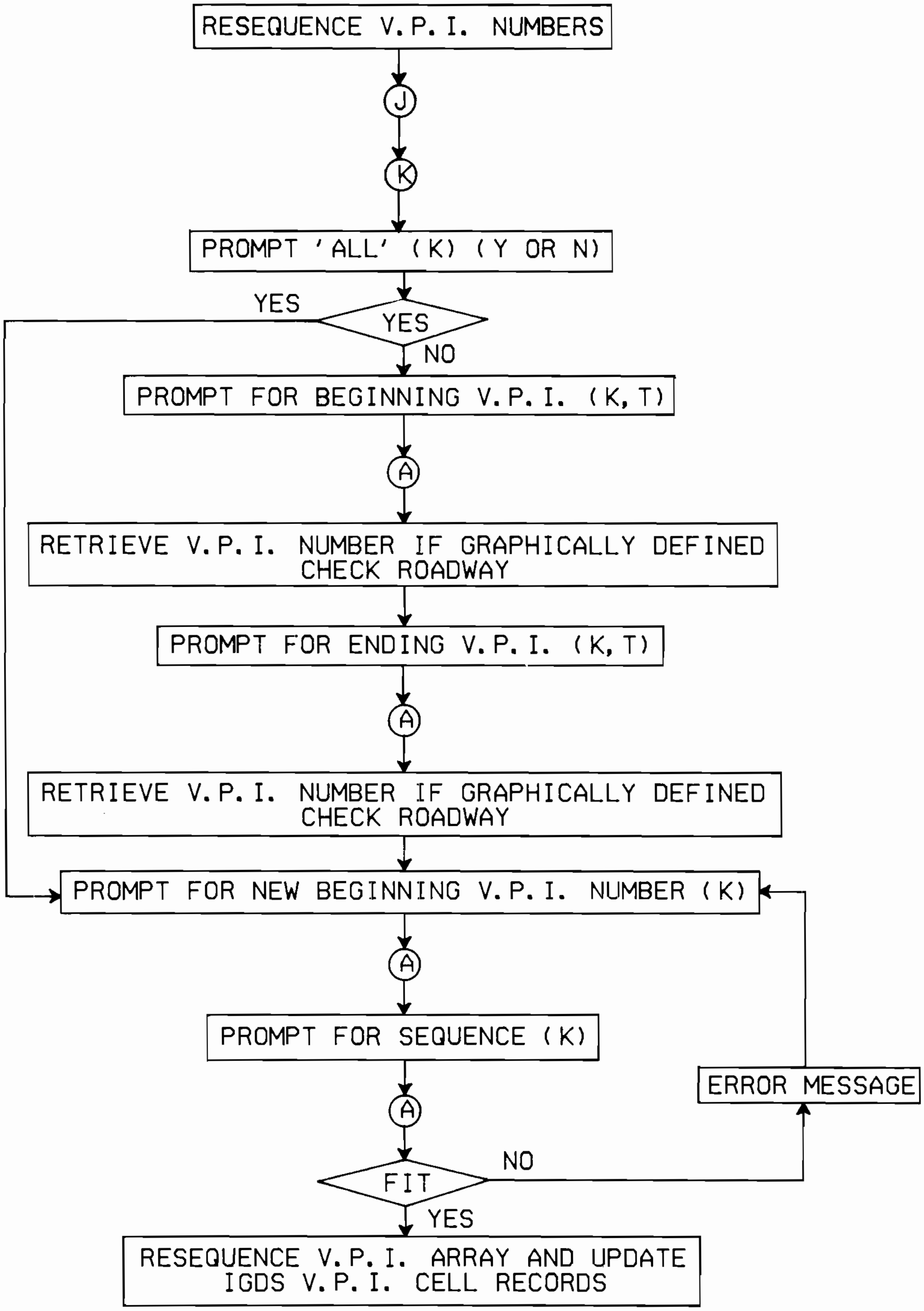


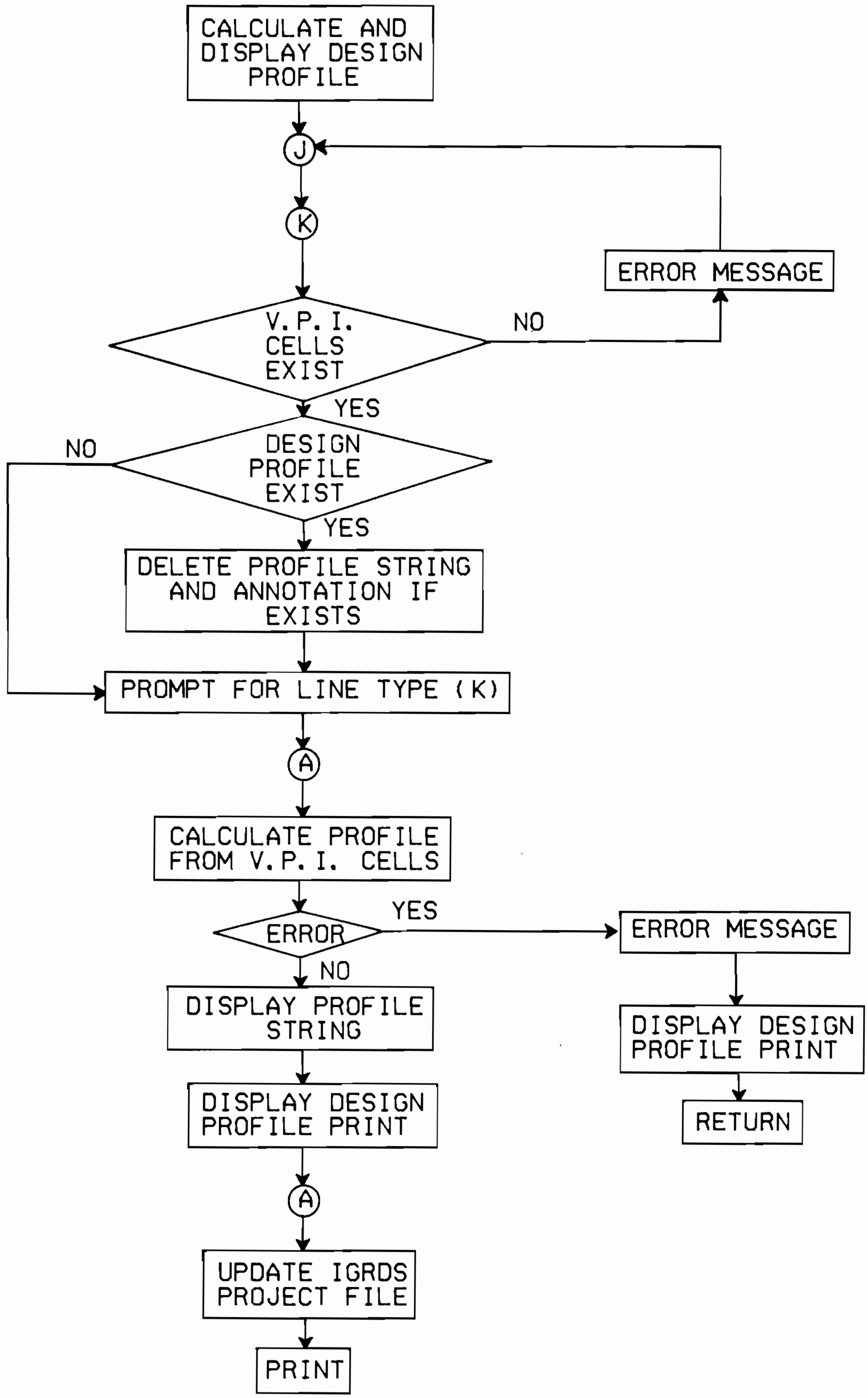
COMMAND INDEX M5


REVISE V.P.I. - DATA
PROMPT USER TO IDENTIFY V.P.I. (T)
ERROR MESSAGE
NO
V.P.I. CELL
YES
RETRIEVE ROADWAY NO. AND V.P.I. NO. FROM CELL RECORD
A
DISPLAY DATA FOR USER TO ACCEPT OR MODIFY (INCLUDING V.P.I. NUMBER)
L

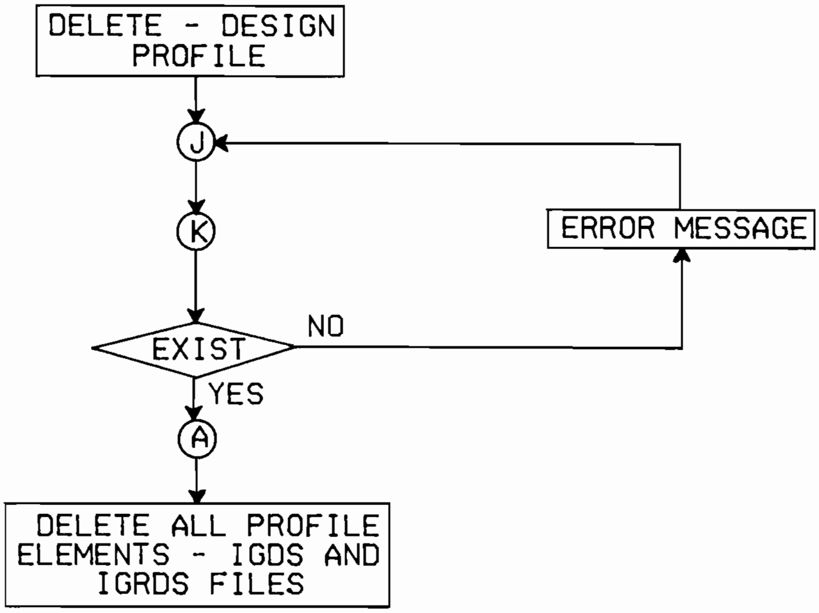

MOVE V.P.I. -
ON TANGENT
J
K
PROMPT FOR TANGENT
(T)
A
PROMPT FOR NEW V.P.I
STATION (K)
A
DETERMINE V.P.I.
TO BE MOVED AT
END OF TANGENT AND
NEW STATION
V.P.I.
EXIST
NO
ERROR MESSAGE
YES
DISPLAY NEW V.P.I.
A
DELETE OLD V.P.I.
L

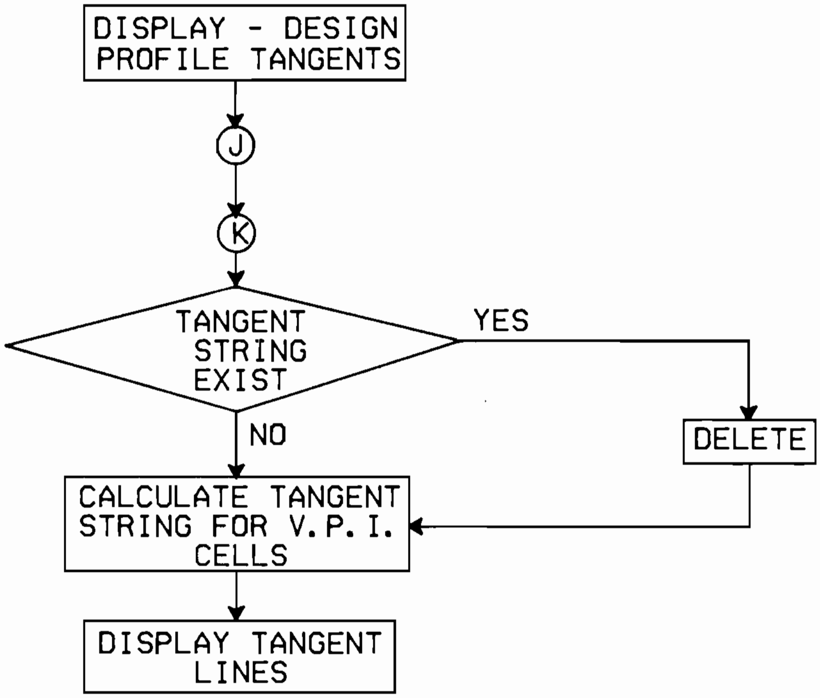

DELETE - V.P.I.
PROMPT USER TO IDENTIFY V.P.I. (T)
ERROR MESSAGE
V.P.I. CELL
NO
YES
RETRIEVE ROADWAY NO. AND V.P.I. NO. FROM CELL RECORD
A
DELETE V.P.I. CELL

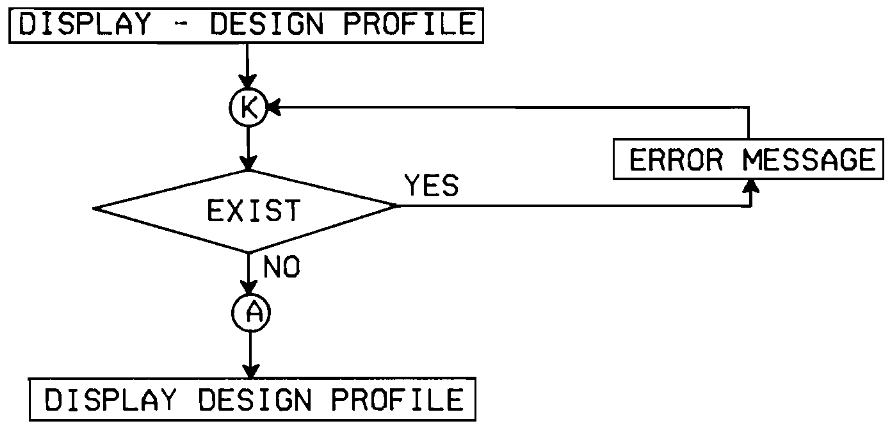

RESEQUENCE V.P.I. NUMBERS
J
K
PROMPT 'ALL' (K) (Y OR N)
YES
YES
NO
PROMPT FOR BEGINNING V.P.I. (K,T)
A
RETRIEVE V.P.I. NUMBER IF GRAPHICALLY DEFINED CHECK ROADWAY
PROMPT FOR ENDING V.P.I. (K,T)
A
RETRIEVE V.P.I. NUMBER IF GRAPHICALLY DEFINED CHECK ROADWAY
PROMPT FOR NEW BEGINNING V.P.I. NUMBER (K)
A
PROMPT FOR SEQUENCE (K)
ERROR MESSAGE
A
FIT
NO
YES
RESEQUENCE V.P.I. ARRAY AND UPDATE IGDS V.P.I. CELL RECORDS

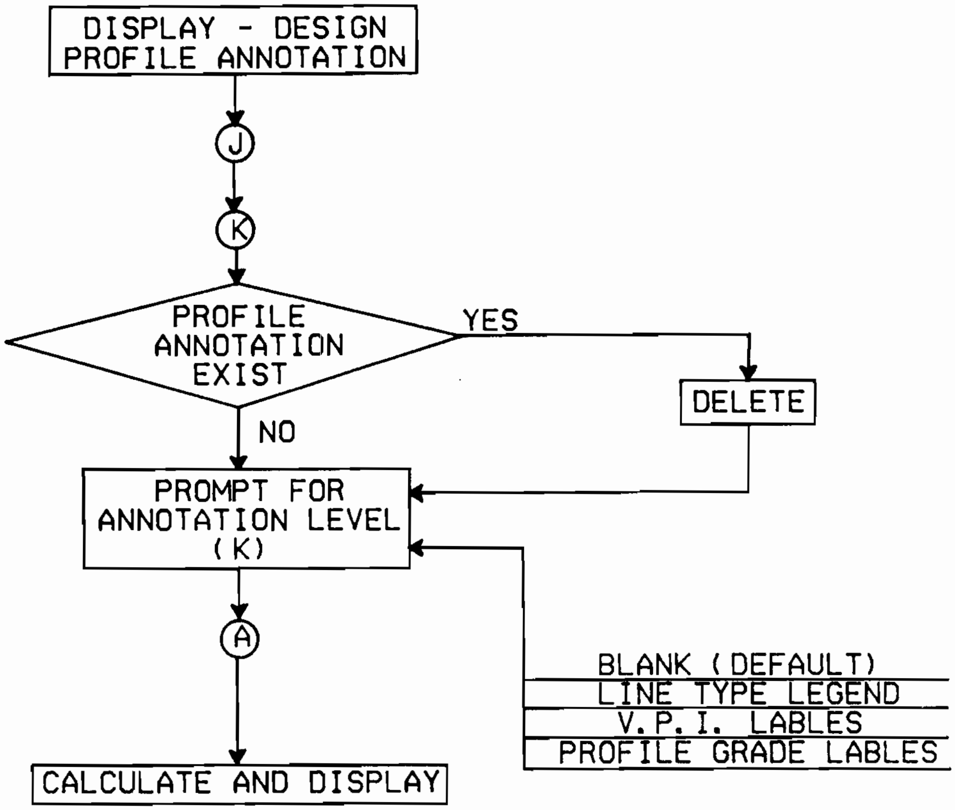


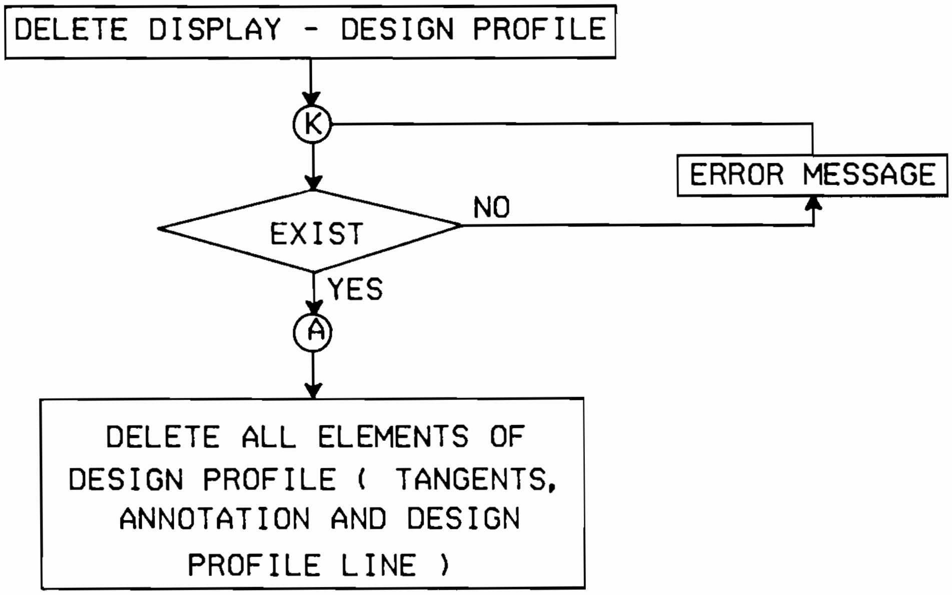
COMMAND INDEX N1

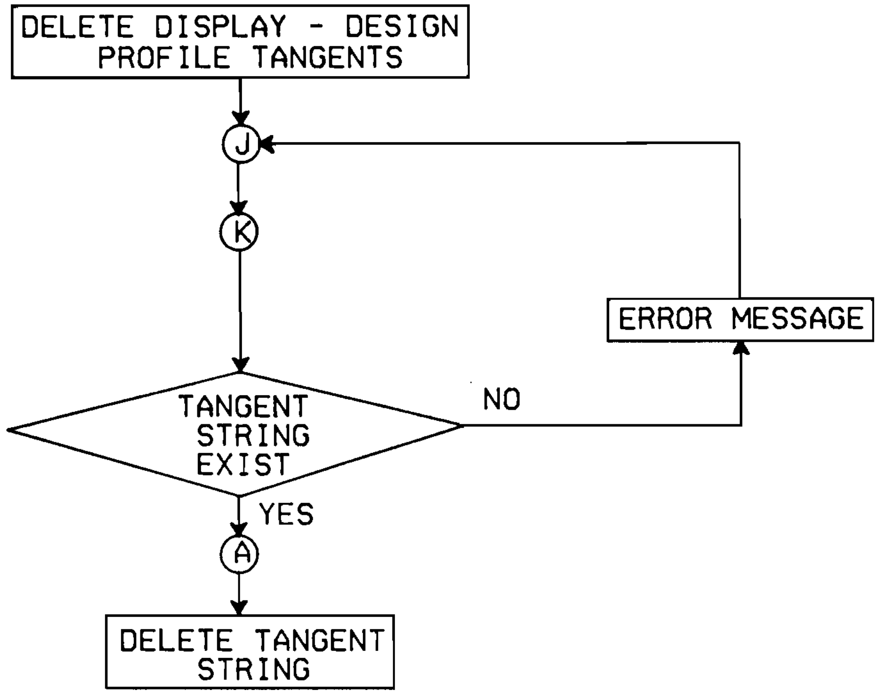

DELETE - DESIGN PROFILE
J
K
ERROR MESSAGE
NO
EXIST
YES
A
DELETE ALL PROFILE ELEMENTS - IGDS AND IGRDS FILES

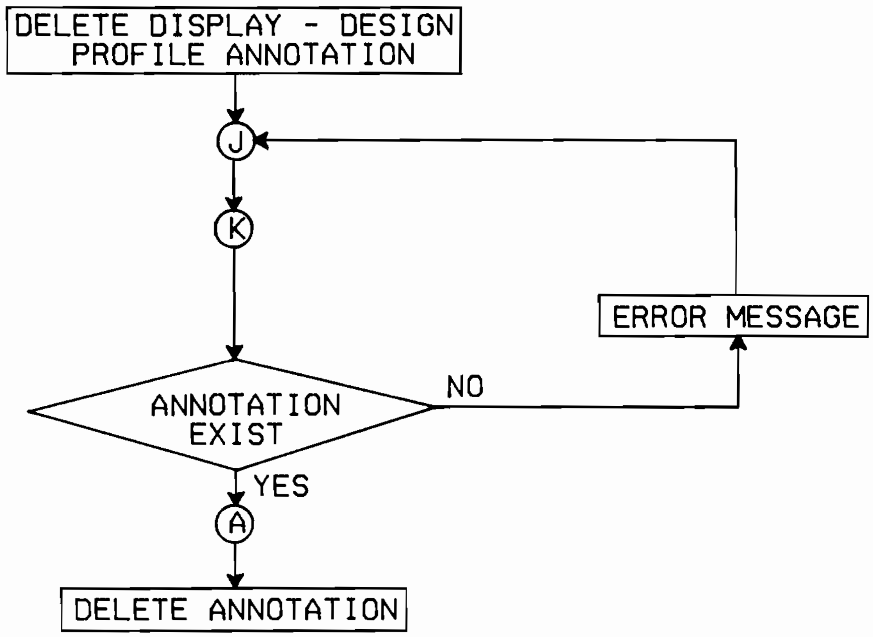

DISPLAY - DESIGN PROFILE TANGENTS
J
K
TANGENT STRING EXIST
YES
NO
DELETE
CALCULATE TANGENT STRING FOR V.P.I. CELLS
DISPLAY TANGENT LINES

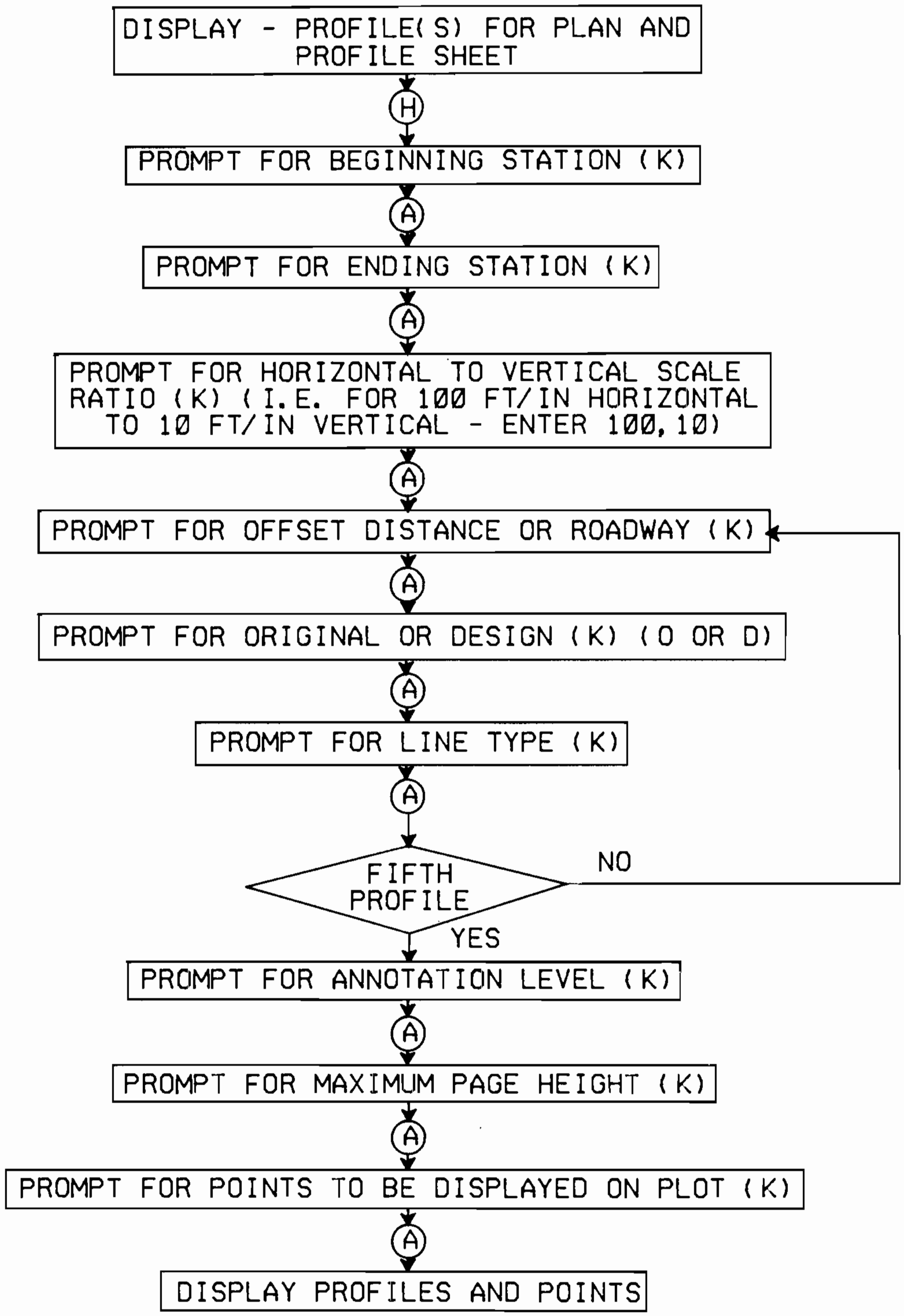

DISPLAY - DESIGN PROFILE
K
ERROR MESSAGE
YES
EXIST
NO
A
DISPLAY DESIGN PROFILE

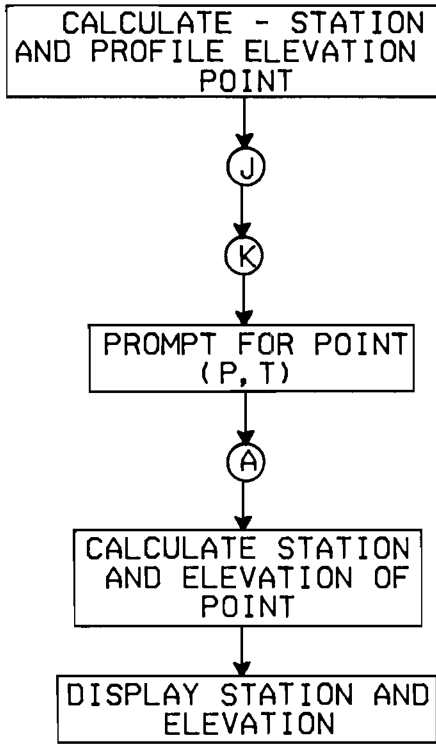

DISPLAY - DESIGN PROFILE ANNOTATION
J
K
PROFILE ANNOTATION EXIST
YES
DELETE
NO
PROMPT FOR ANNOTATION LEVEL (K)
A
BLANK (DEFAULT)
LINE TYPE LEGEND
V.P.I. LABLES
PROFILE GRADE LABLES
CALCULATE AND DISPLAY


DELETE DISPLAY - DESIGN PROFILE
K
ERROR MESSAGE
NO
EXIST
YES
A
DELETE ALL ELEMENTS OF DESIGN PROFILE (TANGENTS, ANNOTATION AND DESIGN PROFILE LINE)

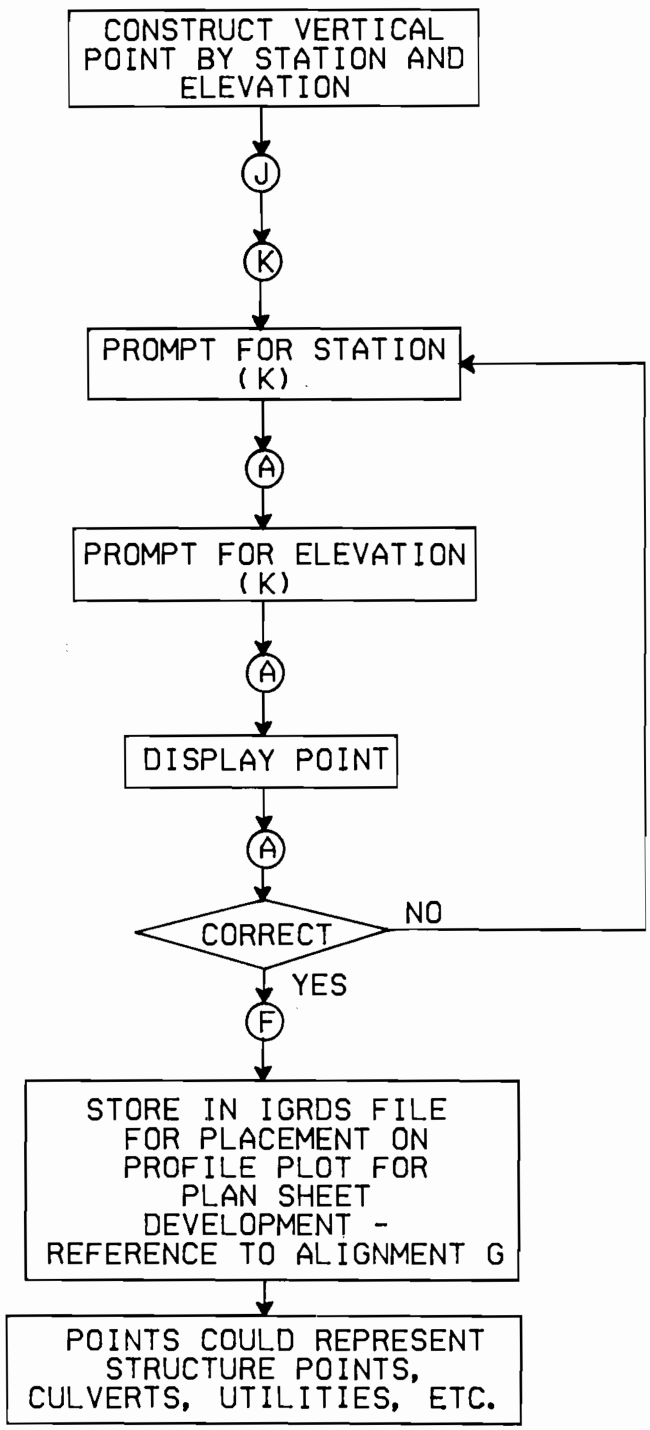

DELETE DISPLAY - DESIGN PROFILE TANGENTS
J
K
ERROR MESSAGE
NO
TANGENT STRING EXIST
YES
A
DELETE TANGENT STRING

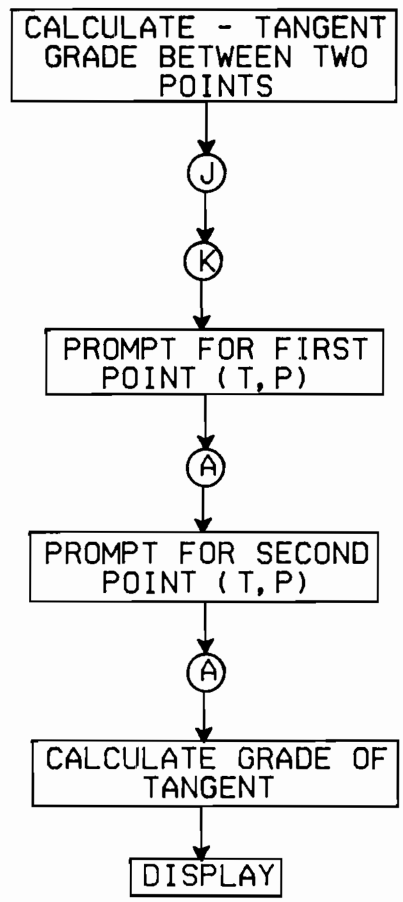

DELETE DISPLAY - DESIGN PROFILE ANNOTATION
J
K
ERROR MESSAGE
ANNOTATION EXIST
NO
YES
A
DELETE ANNOTATION

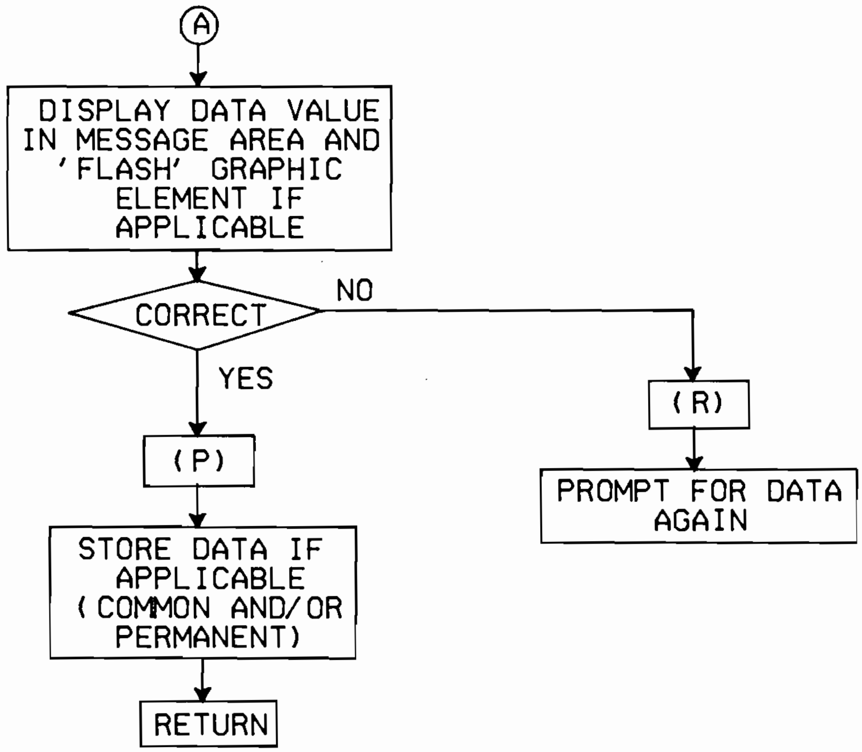

DISPLAY - PROFILE(S) FOR PLAN AND PROFILE SHEET
H
PROMPT FOR BEGINNING STATION (K)
A
PROMPT FOR ENDING STATION (K)
A
PROMPT FOR HORIZONTAL TO VERTICAL SCALE RATIO (K) (I.E. FOR 100 FT/IN HORIZONTAL TO 10 FT/IN VERTICAL - ENTER 100,10)
A
PROMPT FOR OFFSET DISTANCE OR ROADWAY (K)
A
PROMPT FOR ORIGINAL OR DESIGN (K) (O OR D)
A
PROMPT FOR LINE TYPE (K)
A
FIFTH PROFILE
NO
YES
PROMPT FOR ANNOTATION LEVEL (K)
A
PROMPT FOR MAXIMUM PAGE HEIGHT (K)
A
PROMPT FOR POINTS TO BE DISPLAYED ON PLOT (K)
A
DISPLAY PROFILES AND POINTS



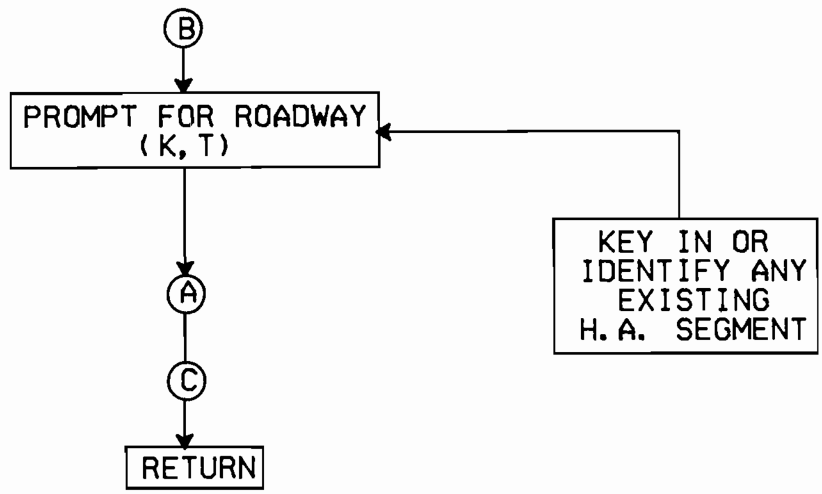
COMMAND INDEX P1

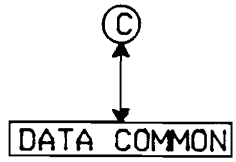

CONSTRUCT VERTICAL POINT BY STATION AND ELEVATION
J
K
PROMPT FOR STATION (K)
A
PROMPT FOR ELEVATION (K)
A
DISPLAY POINT
A
CORRECT
NO
YES
F
STORE IN IGRDS FILE FOR PLACEMENT ON PROFILE PLOT FOR PLAN SHEET DEVELOPMENT - REFERENCE TO ALIGNMENT G
POINTS COULD REPRESENT STRUCTURE POINTS, CULVERTS, UTILITIES, ETC.

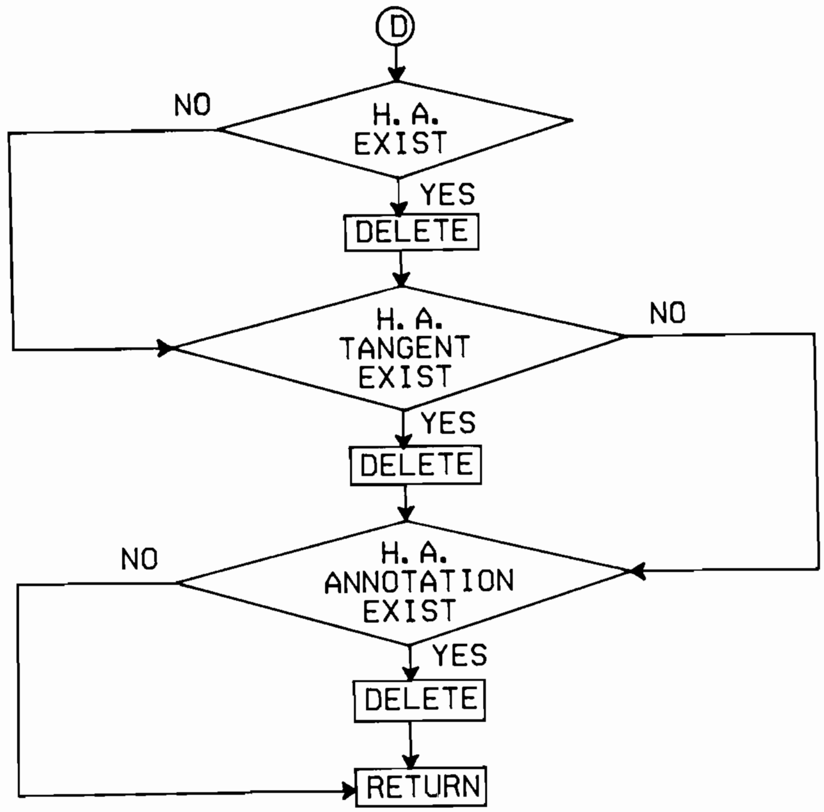

CALCULATE - TANGENT GRADE BETWEEN TWO POINTS
J
K
PROMPT FOR FIRST POINT (T,P)
A
PROMPT FOR SECOND POINT (T,P)
A
CALCULATE GRADE OF TANGENT
DISPLAY

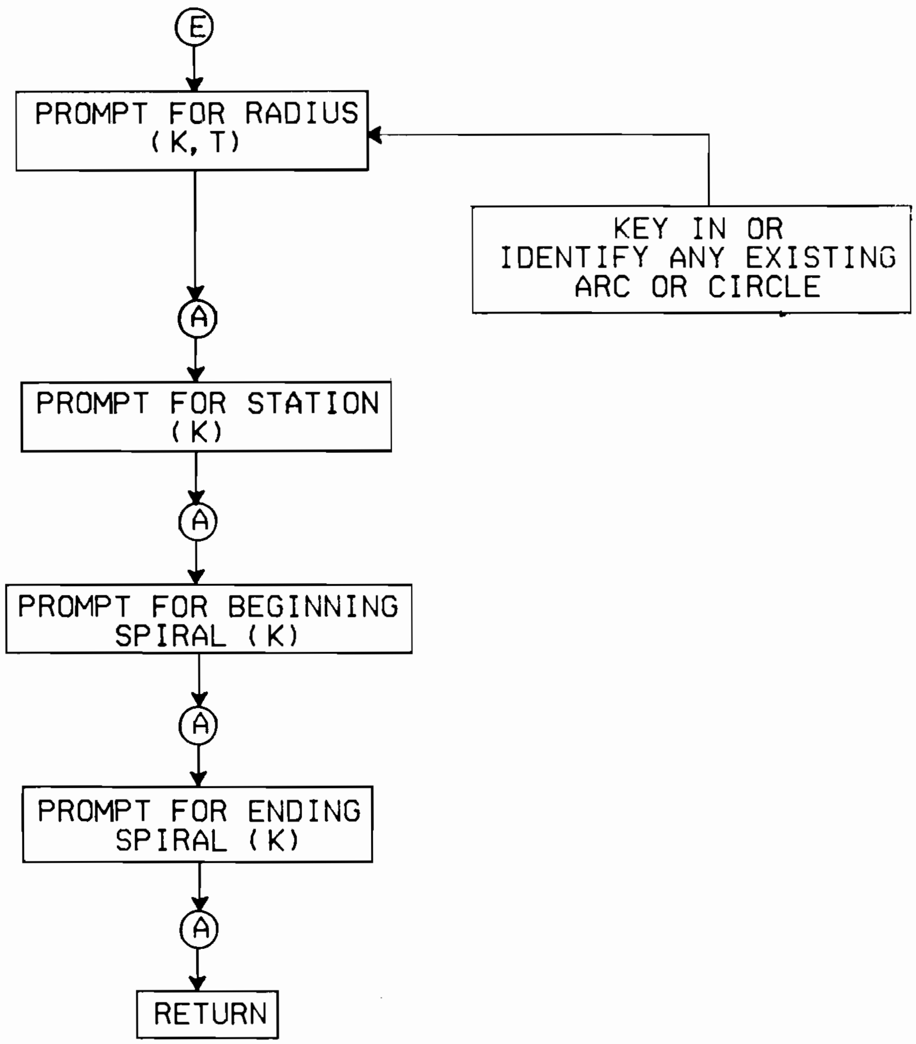


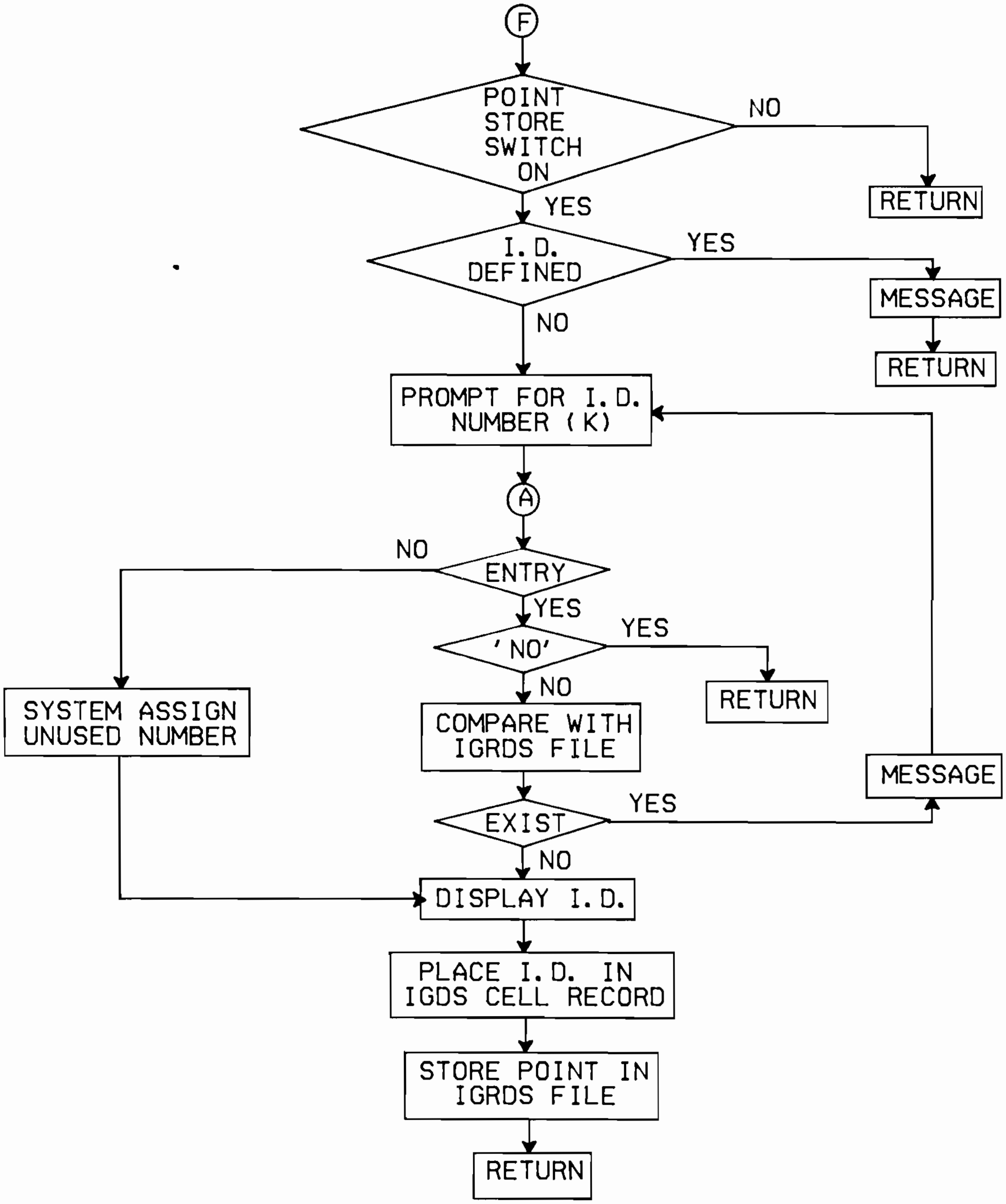
NOTE: THIS AND FOLLOWING FLOW CHARTS ARE REFERENCED IN COMMAND FLOW CHARTS BY THE BEGINNING LETTER (I.E. - 'A')


B
PROMPT FOR ROADWAY
(K, T)
KEY IN OR
IDENTIFY ANY
EXISTING
H. A. SEGMENT
A
C
RETURN

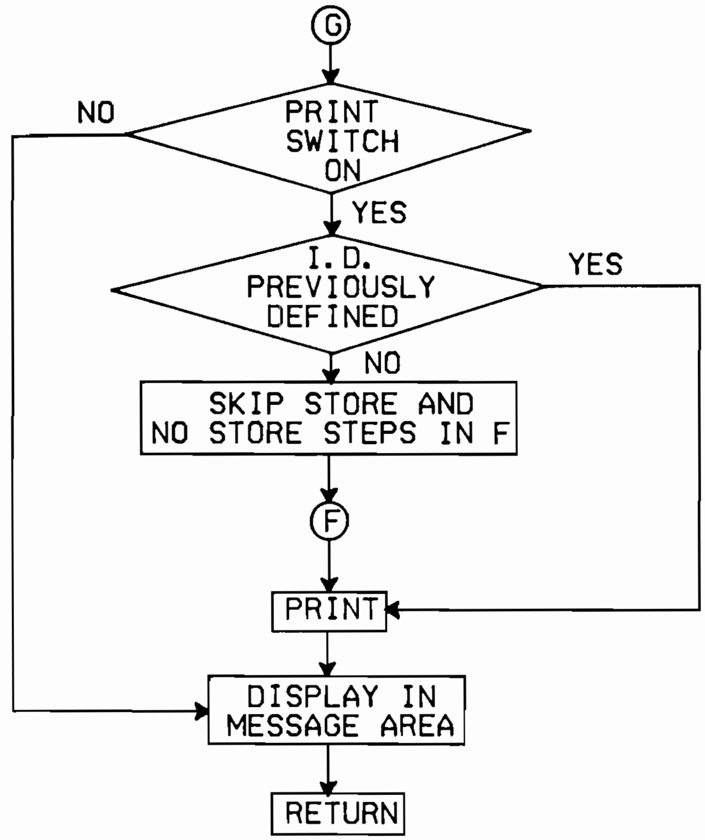

C
DATA COMMON

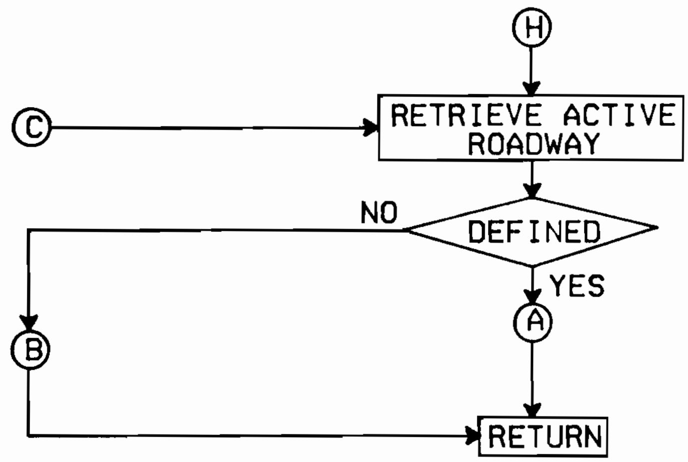

D
H. A.
EXIST
NO
YES
DELETE
H. A.
TANGENT
EXIST
NO
YES
DELETE
H. A.
ANNOTATION
EXIST
NO
YES
DELETE
RETURN


E
PROMPT FOR RADIUS (K,T)
KEY IN OR IDENTIFY ANY EXISTING ARC OR CIRCLE
A
PROMPT FOR STATION (K)
A
PROMPT FOR BEGINNING SPIRAL (K)
A
PROMPT FOR ENDING SPIRAL (K)
A
RETURN

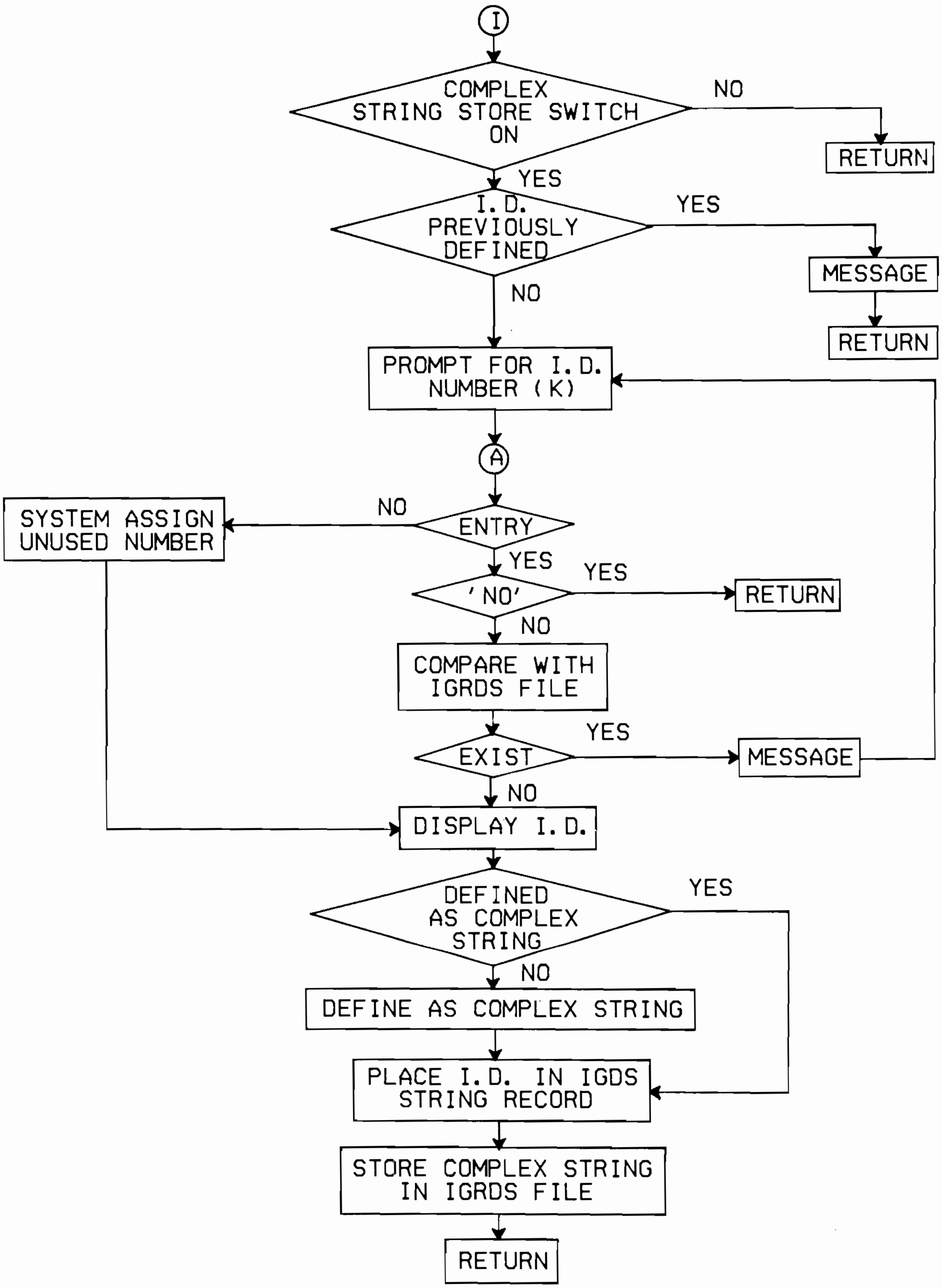


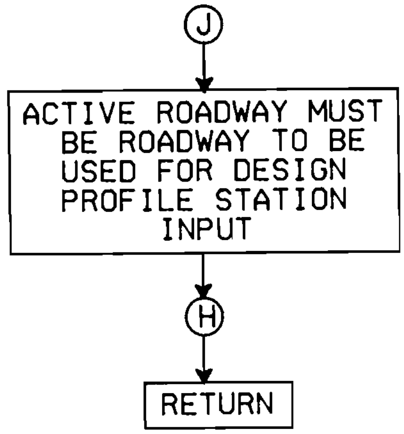
COMMAND INDEX 06

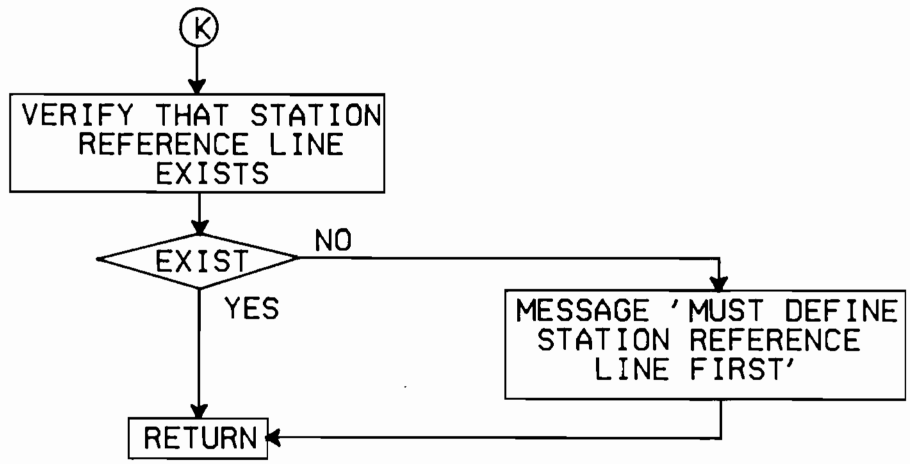

G
NO
PRINT SWITCH ON
YES
I.D. PREVIOUSLY DEFINED
YES
NO
SKIP STORE AND NO STORE STEPS IN F
F
PRINT
DISPLAY IN MESSAGE AREA
RETURN

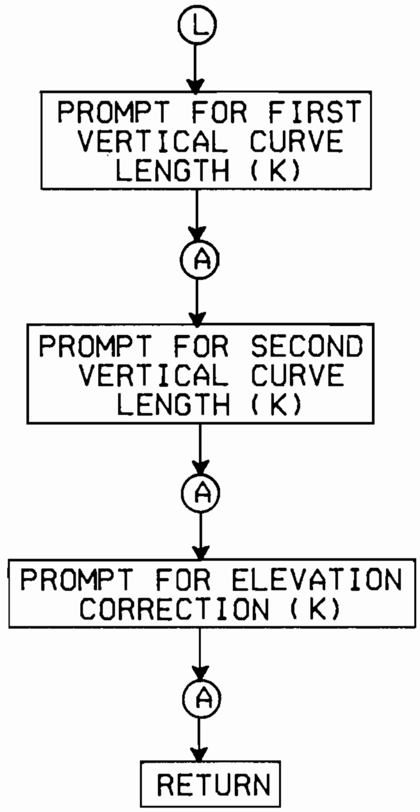


COMMAND INDEX Q8


I
COMPLEX STRING STORE SWITCH ON
NO
RETURN
YES
I.D. PREVIOUSLY DEFINED
YES
MESSAGE
RETURN
NO
PROMPT FOR I.D. NUMBER (K)
A
NO
SYSTEM ASSIGN UNUSED NUMBER
ENTRY
YES
'NO'
YES
RETURN
NO
COMPARE WITH IGRDS FILE
EXIST
YES
MESSAGE
NO
DISPLAY I.D.
DEFINED AS COMPLEX STRING
YES
NO
DEFINE AS COMPLEX STRING
PLACE I.D. IN IGDS STRING RECORD
STORE COMPLEX STRING IN IGRDS FILE
RETURN


J
ACTIVE ROADWAY MUST BE ROADWAY TO BE USED FOR DESIGN PROFILE STATION INPUT
H
RETURN


K
VERIFY THAT STATION REFERENCE LINE EXISTS
EXIST
NO
YES
MESSAGE 'MUST DEFINE STATION REFERENCE LINE FIRST'
RETURN


L
PROMPT FOR FIRST VERTICAL CURVE LENGTH (K)
A
PROMPT FOR SECOND VERTICAL CURVE LENGTH (K)
A
PROMPT FOR ELEVATION CORRECTION (K)
A
RETURN