

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle <p>Implementation of an Automated Mapping System</p>		5. Report Date <p>December 1973</p>	6. Performing Organization Code
7. Author(s) <p>Tommie F. Howell</p>		8. Performing Organization Report No. <p>THD-1-19-73-40-1F</p>	
9. Performing Organization Name and Address <p>Texas Highway Department 11th and Brazos Austin, Texas 78701</p>		10. Work Unit No.	11. Contract or Grant No. <p>1-19-73-40</p>
12. Sponsoring Agency Name and Address <p>Texas Highway Department 11th and Brazos Austin, Texas 78701</p>		13. Type of Report and Period Covered <p>Final Report</p>	
15. Supplementary Notes <p>Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration</p>		14. Sponsoring Agency Code	
16. Abstract <p>Manual methods of photogrammetric map compilation and graphics for highway engineering are known to have objectionable limitations including the allocation of manpower resources and inflexibility of the maps for automated manipulation for data analysis.</p> <p>The Automated Mapping System as developed and implemented into the production environment of the Texas Highway Department offers the engineer new dimensions and concepts for graphics presentation and/or data manipulation heretofore unavailable from manually produced maps. Implementation of the Automated Mapping System was designed for modular conversion of existing individual stereoplotter units to permit progressive implementation minimizing the interruption of existing map schedule commitments.</p>			
17. Key Words <p>Automated Mapping System, digitizing, numerical image, automated data manipulation, computer map graphics.</p>		18. Distribution Statement	
19. Security Classif. (of this report) <p>Unclassified</p>	20. Security Classif. (of this page) <p>Unclassified</p>	21. No. of Pages <p>38</p>	22. Price

IMPLEMENTATION OF AN AUTOMATED MAPPING SYSTEM

by

Tommie F. Howell

Research Report 40-1F
Implementation of an Automated Mapping System

Research Study 1-19-73-40



Conducted by
Division of Automation
Texas Highway Department
In cooperation with the
U.S. Department of Transportation
Federal Highway Administration

December 1973

The opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the Federal Highway Administration.

SUMMARY

The overall objective of this study was to implement an Automated Mapping System into the production environment of the Texas Highway Department, providing an effective method for collection, storage, manipulation and retrieval of large volumes of map data.

The Automated Mapping System developed for implementation into the production environment of the Texas Highway Department was designed as a modular conversion of existing individual stereoplotter units to permit progressive implementation that could readily be adapted to a total automated system when desired. This conversion scheme minimized the interruption of existing schedule commitments and allowed ample time for operator familiarization and training.

Implementation of this Automated Mapping System offers the engineer new dimensions and concepts for graphic presentations and/or data manipulation heretofore unavailable in manually produced maps. Through digitizing methodology and sophisticated computer software routines, the imagery extracted from the aerial photograph is deposited into a "data bank" (project file) for use in multi-disciplinary engineering management applications as exemplified below:

1. Total Graphics
2. Selective Feature Graphics (Land Use Classifications)
3. Selective Area Graphics ("Windowing")
4. Updating
5. Variable Scales
6. Data Analysis (Perimeters, Areas, etc.)

In order to minimize editing deficiencies and to optimize the overall system, further investigations into a "mini-computer" system are intended by the Texas Highway Department.

IMPLEMENTATION

The overall objective of this study was to implement an automated mapping system into the production environment of the Texas Highway Department. This system, as implemented, provides effective methods for collection, storage and retrieval of large volumes of map data. It also offers the engineer-user a flexibility for data manipulation and graphic presentation not previously available. As this study is subject to progressive implementation, the Texas Highway Department is continuing to investigate means and methods to revise and update the automated mapping system as additional user needs are identified.

Table of Contents

Introduction	1
Background	1
Objectives and Scope	2
Implementation	4
Equipment	5
Software	14
Comparison of Mapping Procedures	15
Applications of Automated Mapping	20
Conclusions and Recommendations	28
Conclusions	28
Recommendations	29
Appendix	33

List of Figures

1. Automated Mapping System Flow Diagram	6
2. Stereoplotter Unit Converted for Automated Data Collection	7
3. Standard Projection-type Stereoplotter with X-Y Coordinate Arm Assembly	8
4. Stereoplotter Tracing Table Recording Interface	9
5. Remote Data Control Console	10
6. Data Display Console	11
7. Recording Interface and IBM 029 Keypunch	12
8. Digital Plotters Used for Graphic Presentations	13
9. Texas Automated Plotting System (TAPS) Software	16
10. 1"=40' Plot, Plotted on CalComp 1136 Drum Plotter	21
11. 1"=100' Plot, Plotted on CalComp 1136 Drum Plotter	22
12. 1"=40' Plot, Plotted on Gerber Model 32 Precision Flat Bed Plotter ...	23
13. 1"=100' Plot, Plotted on Gerber Model 32 Precision Flat Bed Plotter ..	24
14. 1"=100' Plot, Plotted on Gerber Model 32 Precision Flat Bed Plotter ..	25
15. Selective Map Graphics	27
16. Automated Station	31
17. Total Automated Information Management System	32

IMPLEMENTATION OF AN AUTOMATED MAP SYSTEM

I. Introduction

Background

The Texas Highway Department began using aerial photography for preliminary engineering planning surveys around 1930 with most of the photographs being obtained from the U. S. Department of Agriculture. Sophistication of photogrammetric instruments enabled accurate engineering data to be extracted from the vast amount of information visible in the aerial photographs, and subsequent requests for this information prompted the formation of the Photogrammetry Section within the Highway Design Division in 1957. The Department obtained its initial stereoplotter in early 1958.

Increasing acceptance of this highway engineering tool of photogrammetry prompted continued expansion of equipment and personnel. Highway engineers became increasingly more automation oriented and consequently the Department's existing photogrammetric systems were enhanced to accommodate these demands. When the Photogrammetry Section was combined with the existing Computer and Reproduction Sections to form the new Division of Automation in 1965, automated techniques were being utilized already in film processing, ground control, aerotriangulation and photogrammetric earthwork measurements.

Compilation of map sheets has always been predominantly a manual operation with the map being drawn on a stable-base manuscript by the stereoplotter operator, the penciled lines scribed by a draftsman and a film positive reproduced from the base manuscript. While this method of map compilation offers numerous advantages over field methods, there are many objectionable limitations that should be eliminated or minimized.

Perhaps the most serious limitation to manually produced maps is in their

inflexibility. The tremendous amount of detail that can be captured very accurately from an aerial photograph for a manually produced map is not available for any type of automated manipulation or analysis. Another limitation of manually produced maps is in the allocation of manpower resources. Photogrammetric map cartography requires considerable manpower and is usually in an environment of fluctuating workloads, thus affecting time schedules, sheet quality and certainly the overall economics of mapping. Therefore, a more flexible system for collecting, storing, retrieving and presenting map graphics was needed to improve planning, coordination and management of the information, emphasizing the use of the Department's existing photogrammetric equipment.

Objectives and Scope

The overall objective for this study was the implementation of an Automated Mapping System, within the production routine of the Texas Highway Department, flexible enough to allow full utilization in multi-disciplinary engineering applications. This objective was approached through the following tasks:

1. Review and evaluate existing Automated Map Systems.
2. Complete preliminary graphics software.
3. Develop new software routines for data storage, manipulation, edit and optimization of routines for the generation of plots.
4. Generate initial plots for demonstration and refinement.
5. Improve digitizing techniques and methodology.
6. Implement the Automated Map System into the map production environment.
7. Continue to improve and enhance the overall system.

Development of an Automated Mapping System as outlined would offer much more flexibility in the application of engineering maps, especially when multi-disciplinary information is desired for analysis.

II. Implementation

The overall objective of this study was to implement an Automated Mapping System into the production environment of the Texas Highway Department, providing an effective method for collection, storage manipulation and retrieval of large volumes of map data. In accordance with the guidelines set forth in the study proposal, existing Automated Mapping Systems were reviewed and evaluated. While these systems yielded some suggestions for implementation of a Texas Highway Department system, they were dedicated to a different map production environment and made use of equipment not readily available to the Department.

The Department had already developed automated capabilities for processing the preliminary data necessary for map production as follows:

1. The aerial film obtained using Wild RC-8 aerial cameras is processed by GAF Transflo automated processors.
2. Photographic prints and diapositive plates are prepared using a LogEtronic Mark III printer.
3. Primary ground control is obtained using various types of electronic distance measuring units with the traverse data processed and adjusted in the computer by specialized software programs.
4. Supplemental mapping control is accomplished through aerotriangulation techniques for strip and block photography adjustments. The desired coordinate readouts for the required control points are obtained through computer programming dedicated to this purpose.
5. Map sheet layout work is semi-automated through the use of digital readout equipment.

To complete the automation flow diagram as represented in Figure 1, the next step in the development of an Automated Mapping System was to convert map compilation and drafting from the standard manual graphics imagery presentation to numerical imagery for computer processing, map data manipulation and plotting. This conversion would represent a significant departure from previous map oriented information system approaches which have been primarily dedicated to yield limited types of data for specific operational applications.

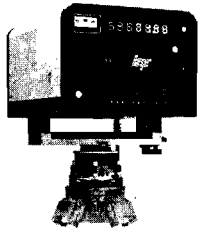
The Automated Mapping System developed for implementation into the production environment of the Texas Highway Department was designed as a modular conversion of existing individual stereoplotters units to permit progressive implementation that could readily be adapted to a total automated system when desired. This conversion scheme minimized the interruption of existing schedule commitments and allowed ample time for operator familiarization and training.

Equipment

Inasmuch as the Texas Highway Department has fifteen (15) projection type stereoplotters in operation and five (5) of these stereoplotters had already been converted for automation to yield Y-Z numerical values for terrain analysis (cross-sections for earthwork measurements), emphasis was directed toward modifying the remaining units for automated map compilation. Preliminary investigations using an existing stereoplotters unit with the Y-Z digital output modified to yield X-Y data demonstrated that numerical information could successfully be captured with this type equipment configuration.

At this time the Department has modified six (6) of ten (10) map compilation stereoplotters units for automation with each unit containing an equipment configuration as shown in Figure 2. Figures 3 through 8 further detail the individual components of the digital and plotting equipment configurations.

AUTOMATED MAPPING SYSTEM



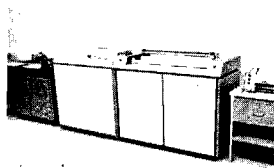
ELECTRONIC GROUND SURVEYS



AERIAL PHOTOGRAPHY



AEROTRIANGULATION



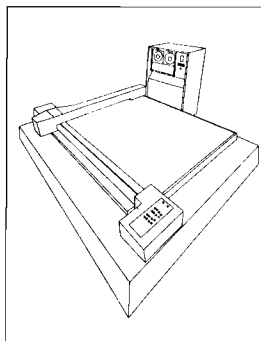
HIGH-SPEED EDIT



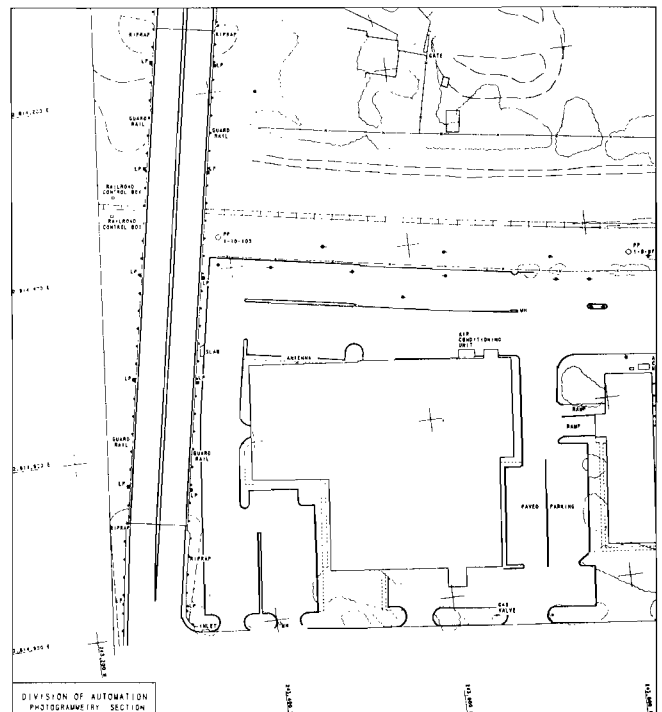
DIGITAL MAP COMPILATION



DIGITAL CONTROL LAYOUT



AUTOMATED PRECISION GRAPHICS



PHOTOGAMMETRIC ENGINEERING MAP

Figure 1. Automated Mapping System Flow Diagram

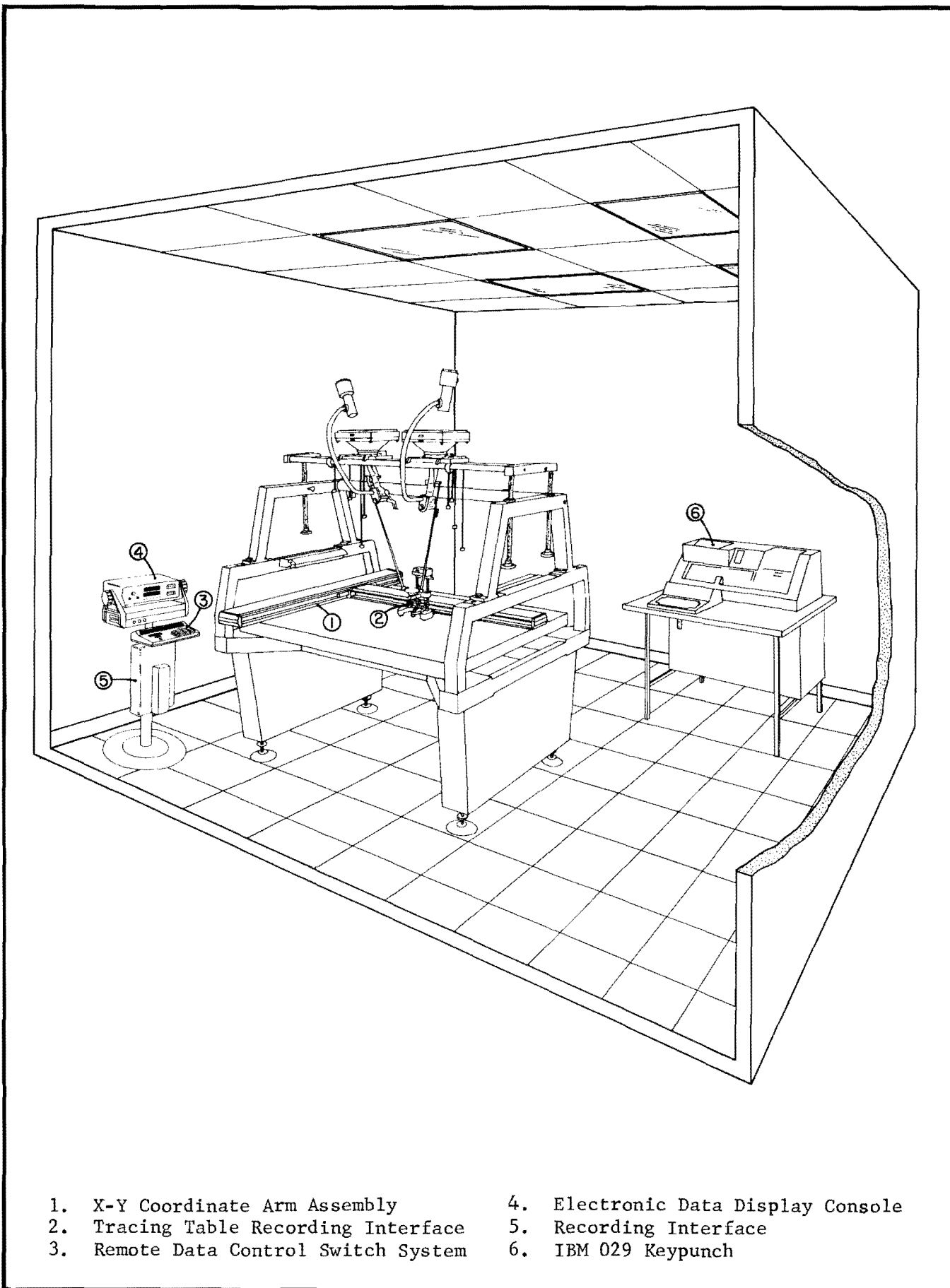
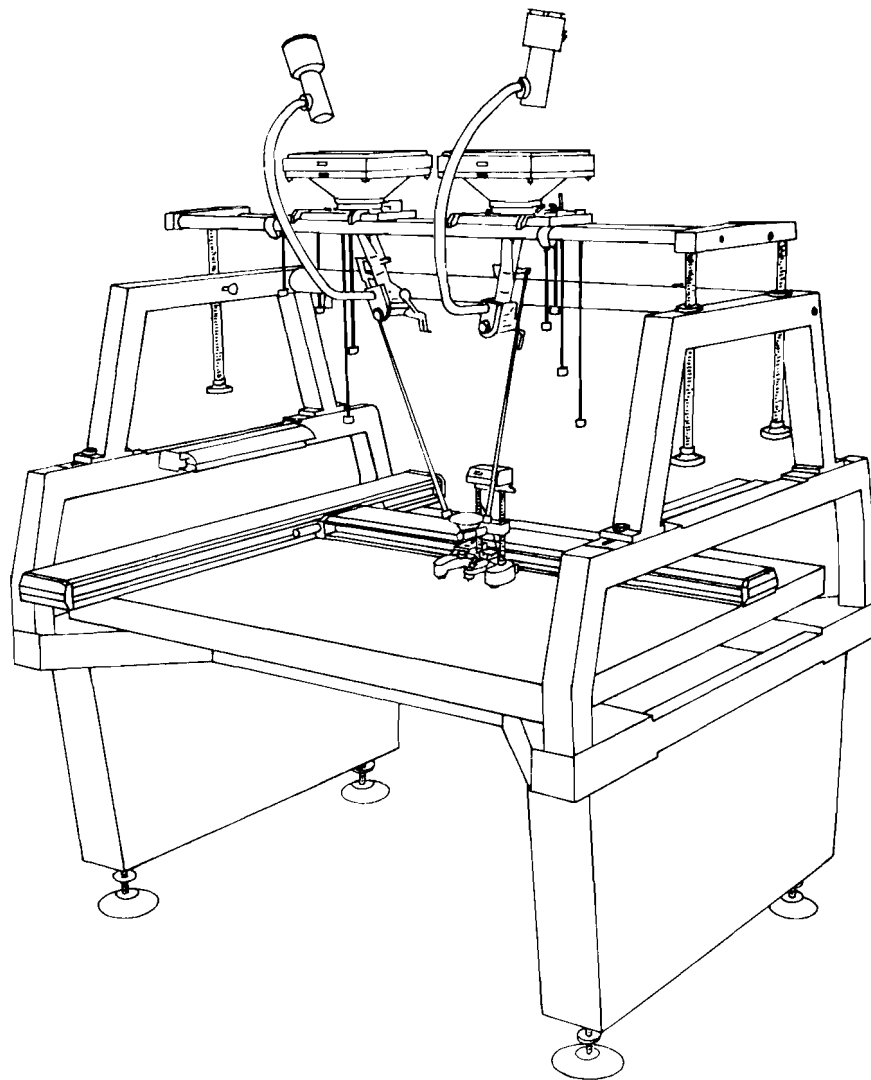
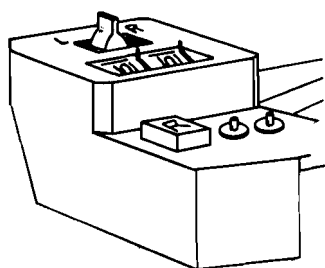


Figure 2. Stereoplottter Unit Converted for Automated Data Collection



The X-Y coordinate arm assembly is designed for high accuracy positioning anywhere on the stereoplottter drawing surface to 0.001" per foot of arm length. The arms have rack and pinion activated non-contacting rotary optical encoders. The stereoplottter tracing table is attached to the X axis arm. The dimensions of the arms are customized to utilize the maximum amount of drawing surface afforded by each stereoplottter and each arm is equipped with fine adjustment motion for precise positioning.

Figure 3. Standard Projection-type Stereoplottter with X-Y Coordinate Arm Assembly

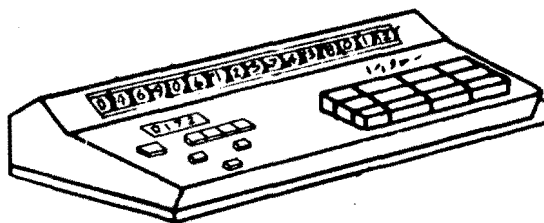


The stereoplotter tracing table recording interface is a mechanical attachment to the X axis coordinate arm and contains two (2) 0-9 manual data switches; one (1) three-position switch; and the record, the final record and clear buttons.

The two 0-9 manual data switches are used to enter the identification codes of the features being digitized. This enables the data to be entered for manipulation through routine software programs. The three (3) positional switch allows the operator to enter the direction the stereo model will be tied to the adjacent stereo model and the features that will be included in the tie.

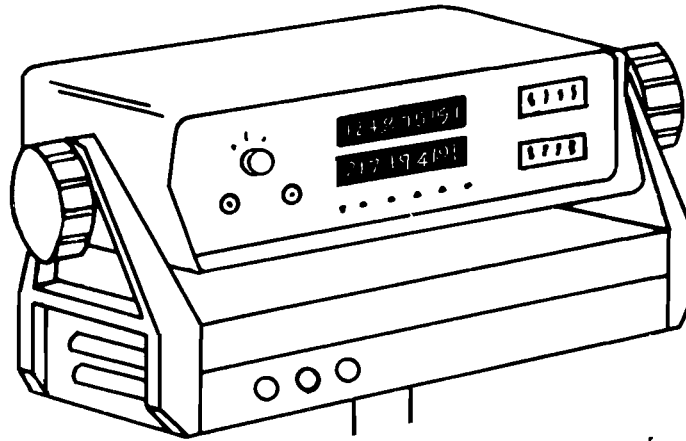
The record button enters each set of X-Y coordinate data for the feature being digitized; and depression of the final record button enters the final X-Y coordinates for the feature and releases the card.

Figure 4. Stereoplotter Tracing Table Recording Interface



The remote data control console consists of seventeen (17) manual switches for entering constant and variable data. The constant data includes such information as accounting information, model identification and sheet numbers. Variable data could include any code identifier that would permit later accessing of the computer stored data. The constant data setting remains the same throughout the model digitizing operation and is automatically added to each punch card.

Figure 5. Remote Data Control Console

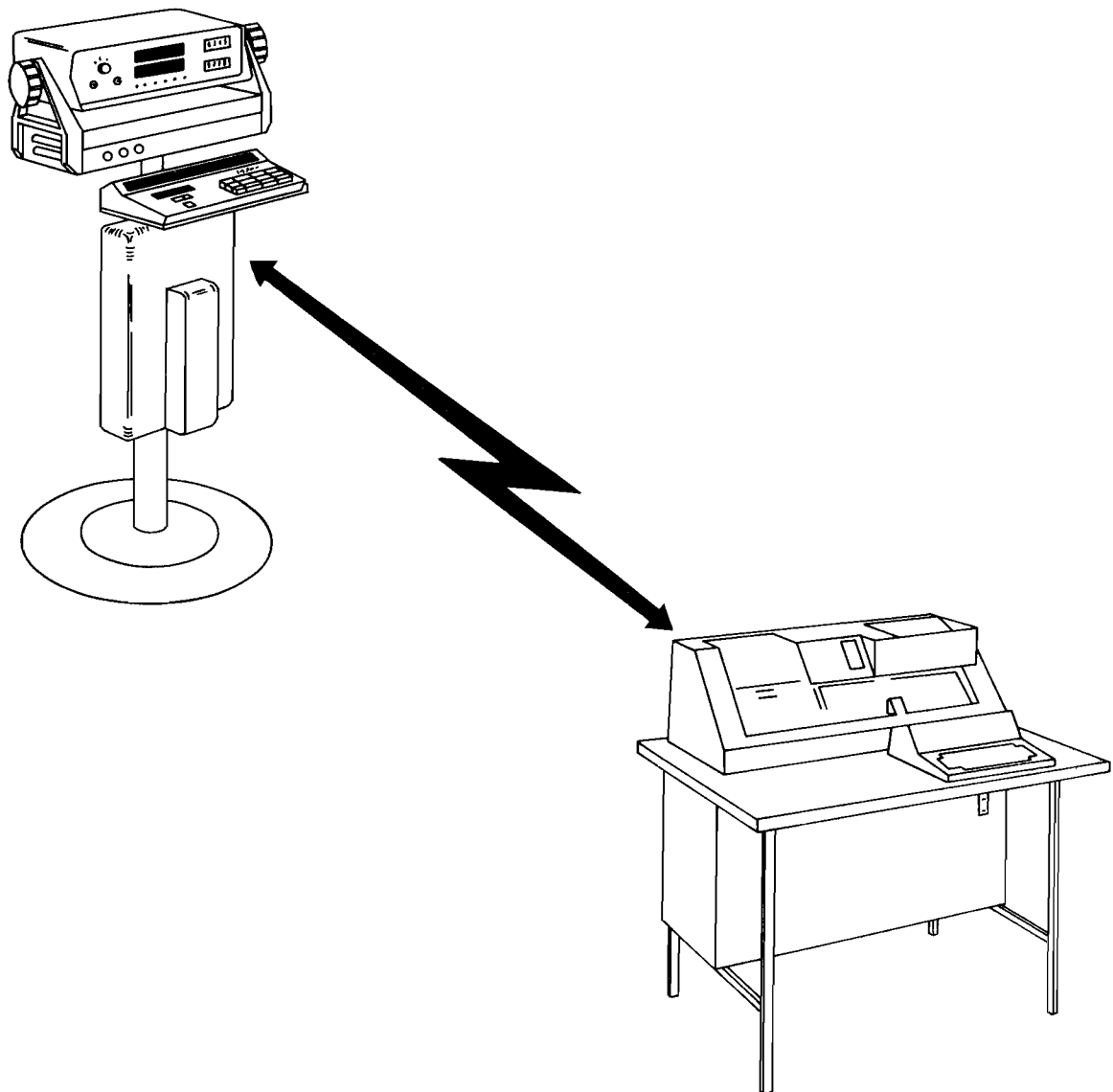


The data display console receives X-Y positional data as measured by the floating mark of the stereoplotter tracing table and transmitted from the coordinate assembly arm. The display unit consists of two (2) axis displays with each axis having five (5) numerical digits, a floating decimal indicator, + and - signs, and X or Y indicators. The five (5) digits of each axis are displayed by bi-directional Light Emitting Diode (L.E.D.) accumulative counters. Each decade of both the X and Y display permits random presetting to any desired number.

The console allows complete variable scale selection which is independent in each axis. The scale factors are selectable for each axis through five (5) thumb-wheel switches.

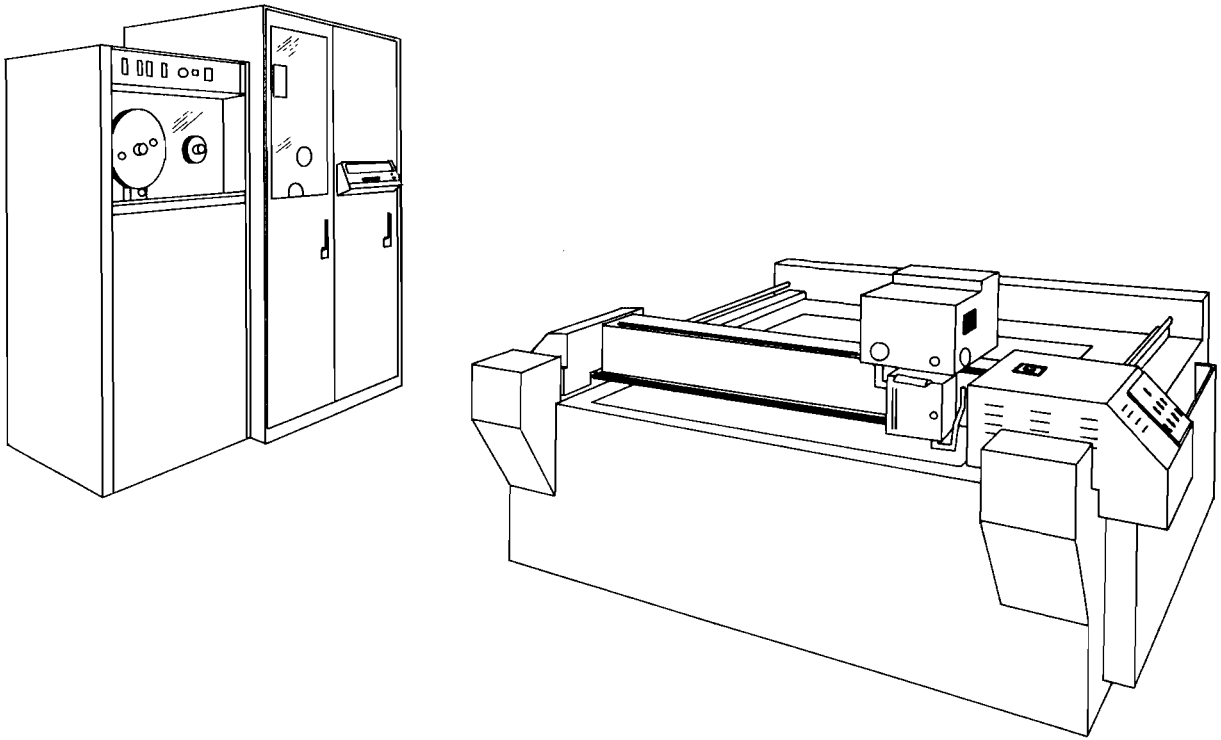
In addition to X-Y coordinate recording, the console is capable of computing the area of any dimensional shape and registering the resultant area in the Y axis display.

Figure 6. Data Display Console

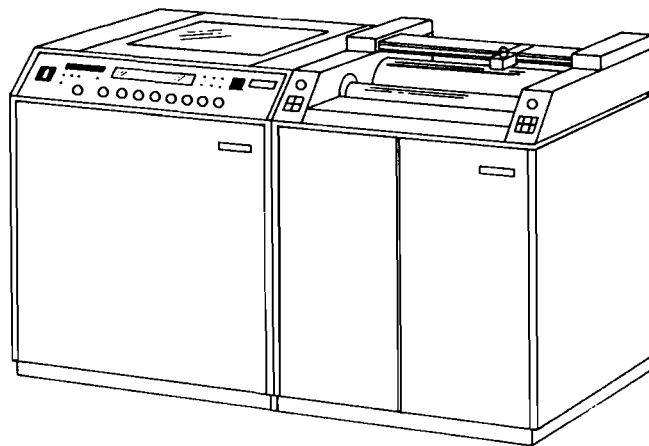


The recording interface and IBM 029 Keypunch provide the means for data collection in the desired card format. A patch panel is included with the recording interface to permit card format modifications.

Figure 7. Recording Interface and IBM 029 Keypunch



Gerber Model 32 Precision Flat Bed Plotter



CalComp II36 Drum Plotter

Figure 8. Digital Plotters Used For Graphic Presentations

Software

Prior to the initiation of this study project, the Texas Highway Department had made some progress in the development of computer programs for automating map graphics through in-house research. The objective of these preliminary efforts had been dedicated to producing basic graphics for studying procedures for digitizing map data and to determine if the stereoplotter operators could successfully capture and identify the required data. These initial plots satisfactorily demonstrated that both of these requirements could be met.

The preliminary software package for this study was designed primarily for testing graphics output and allowed no data manipulation. Expansion of the package has allowed the further testing of map plots and introduced new capabilities into the software package to permit edit, data storage and manipulation and also optimized the graphics generation computations.

This expanded Texas Automated Plotting System (TAPS) software package was designed and developed to perform the following functions:

1. Edit and Special Routines - The digitized data is initially subjected to an edit analysis for the detection of various stereoplotter operator input errors such as duplications, closure gaps, squaring techniques, insufficient data, improper coding and omissions. These errors are noted and corrected within the edit procedure. Also during the edit routine a coordinate transformation adjustment occurs wherein the X-Y machine coordinate values of the various map features are converted to project ground coordinates. Special sub-routines within the TAPS software package are dedicated to optimizing selective line work computations and further reducing the computer time that will be required to generate a plot tape. These subroutines include

a procedure for computing vegetation boundaries, one for defining the double lines required for curbs and railroad tracks and one for simplifying computations required for locating simple and complex curves.

2. Storage - The project data base file is constructed from the edited data and stored on a disk. The data file is readily accessible for manipulation such as the generation of a plot tape for obtaining a graphic presentation of map features.
3. Manipulation - The project data base collected by translating photographic imagery to a series of numerics, edited and optimized by the computer software programming and stored on a disk file is readily available to yield a variety of engineering management and planning functions. Manipulative capabilities include total graphics, selective graphics yielding land use information and classification levels, variable scale formats for transportation route analyses, perimeter and area computations and environmental resources for corridor access studies.

The software functions heretofore outlined and shown in Figure 9 are dedicated to the conversion of map data to a computer format for the manipulation of the desired output. Additional software techniques will be designed and developed as the user needs are identified.

Comparison of Mapping Procedures

The production requirements of a mapping project to be prepared using the Automated Mapping System are very similar to the requirements of a project using manual photogrammetric procedures with respect to ground control,

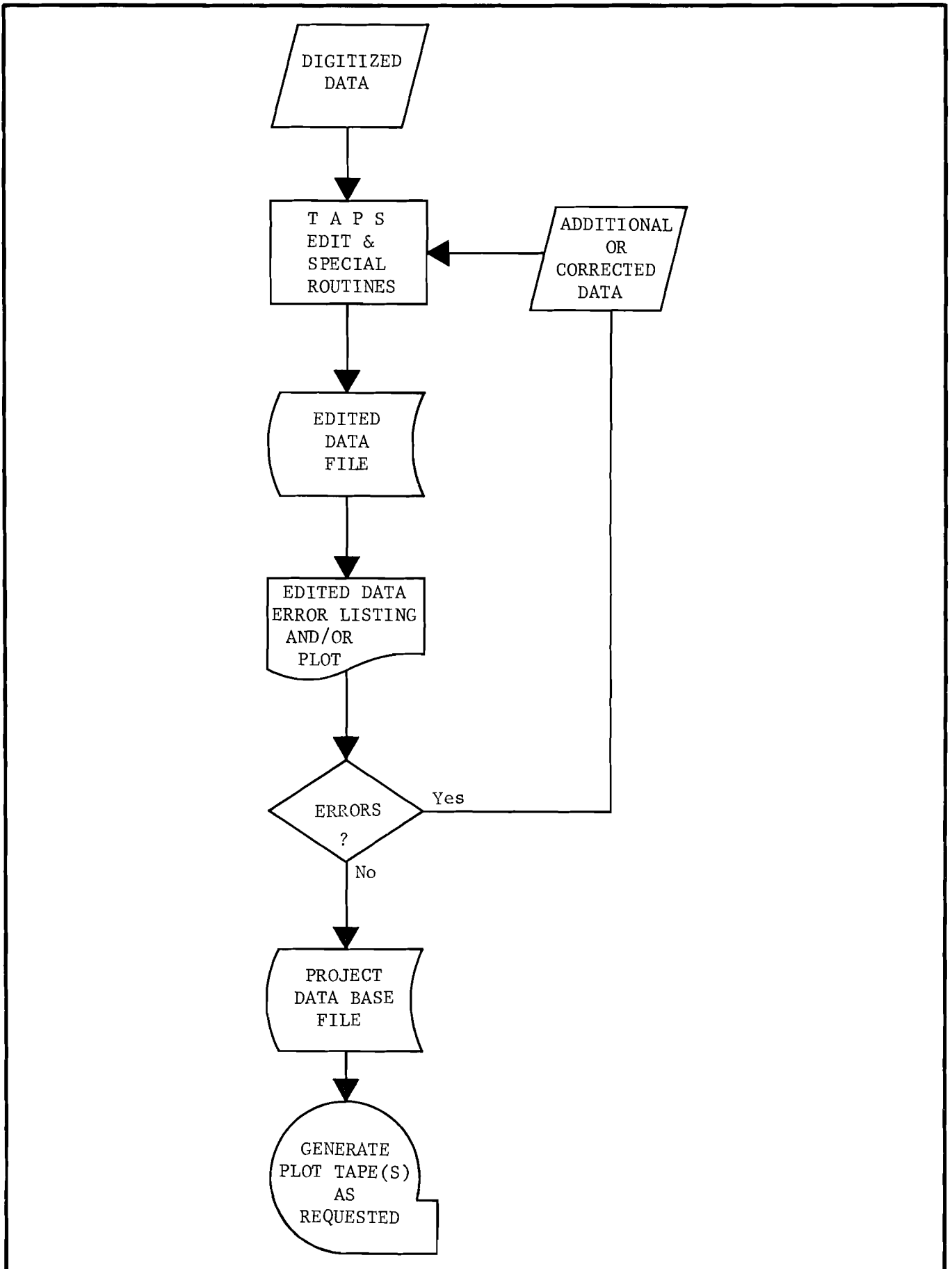


Figure 9. Texas Automated Plotting System (TAPS) Software

aerial photography and aerotriangulation. Beyond the aerotriangulation step, however, the procedures required to complete the map differ considerably and a brief description of the two methods is outlined as follows:

Manuscript Preparation

Manual

Map compilation using manual techniques requires the preparation of a map manuscript on a stable-base scribecoat material. All the ground control points and supplemental control points obtained by aerotriangulation are plotted on the manuscript and oriented to a coordinate grid system. Sheet lengths and widths are also noted on the base manuscript.

Automated

With automated techniques the stereo plotter operator is furnished a film positive sheet with the stereo model's principal points plotted on it. This base sheet is furnished to permit "rough" scaling. The actual precision scaling is done in the computer using software routines similar to those used in the aerotriangulation solution.

Map Compilation

Manual

After the projected photographic control points are adjusted to fit the control points as plotted on the map manuscript, the stereo model is ready for compilation. This procedure is accomplished by optically transferring the photographic imagery to the map manuscript using the stereoplotter tracing table. This line work is then intensified by the operator.

Automated

The stereo model is "roughly" scaled to fit the control points plotted on the film positive base sheet. The project request number and model numbers (constant data) are set for entry onto the punch cards using the remote data switch system described in Figure 5. This constant data information is automatically entered at the beginning of each card when the initial X-Y coordinate values for that card are recorded. The model is now ready for "compilation." Initially the operator will digitize the model principal points and control points to establish the scale factor which is determined from interaction with the Department's aerotriangulation adjustment program. The operator then proceeds to transfer the photographic imagery into a numerical "manuscript" by feature codes as specified in the Digitizing Instructions which are in the Appendix. The recorded X-Y coordinate positions are machine values that will be converted to project coordinates in the

Map Compilation (Continued)

Manual

Automated

computer during the edit routine. The sequence of feature digitizing is determined by operator convenience and imagery transfer efficiencies. Approximately the same amount of time is required to digitize the stereo model data as is required to draw the imagery using manual techniques.

By using the various feature codes to enter the planimetric features, later automated manipulation and data analyses are possible. Upon completion of digitizing all planimetric information visible on the aerial photography, the model tie data is entered using the remote data switch system thus insuring a smooth adjustment between adjacent models.

Edit

Manual

Automated

The completed map manuscript is edited to check for omissions and obvious blunders by the stereo operator. This editing is accomplished using aerial photographs identical to the diapositive plates used in the stereoplotter. This edit check is accomplished while the stereo model remains set up in the machine. Corrections are made during this initial orientation to minimize reset expenses.

With the present equipment configuration, the digitized data which has been collected on punch cards is processed through the Automated Map System software on the Department's IBM 370. Certain edit processes take place at this time as described previously under "Software." During this edit run, blunders are detected and adjusted, machine X-Y coordinates are converted to project X-Y coordinates and a plot tape is generated. The plot tape is then loaded onto the Department's CalComp 1136 drum plotter to produce an edit plot. This edit map from the CalComp 1136 plotter is drawn approximately fifty (50) times faster than the map information can be digitized by the stereo operator. Minor discrepancies may be corrected on the

Edit (Continued)

Manual

Automated

edit sheet if no additional plots will be required or deferred for correction on the final sheet. Some major discrepancies require correcting the card data and building a new plot tape with an additional computer run.

Graphics

Manual

Automated

The map manuscript as drawn and edited by the stereoplotter operator is given to the Cartography Section for further processing. This section completes the manuscript by scribing the stereo operator's line work. The scribed manuscript is then copied by standard reproduction techniques to obtain a film positive. This scribing technique offers some flexibility as exemplified by the fact that a film positive of the planimetric data can be obtained prior to scribing the elevation data for the composite map. The scribed manuscript is retained for future reference to the project.

If no significant errors are present, the plot tape generated for use in the edit procedure is also used to generate the final graphics on a CalComp 1136 drum plotter or a precision flatbed plotter.* Frequently the final graphics output is obtained directly from the CalComp 1136 drum plotter since many engineering applications do not require the precision line work and superior accuracies available from a flatbed plotter. If the CalComp 1136 is to be used for the final output, the plot is photographically reproduced immediately onto a film positive to minimize scale deficiencies due to paper instability.

Engineering map graphics requiring superior accuracies and line quality are obtained on a precision Gerber 1232 flatbed plotting system with an optical exposure head. The optical head offers excellent line quality and line weights and also has the ability to "flash" symbols for various planimetric features such as manholes, poles and guard posts. Graphics obtained from the flatbed plotter are drawn directly on a film positive.

*The Department does not own a flatbed plotter at the present time. These plots are obtained through a Service Center.

Graphics (Continued)

Manual

Automated

Graphics from either plotter can be obtained at various scales and line weights.

Figures 10-11 are a typical output from a CalComp 1136 drum plotter; Figures 12, 13 and 14, from a Gerber 1232 flatbed plotter.

Applications of Automated Mapping

Implementation of this Automated Mapping System offers the engineer new dimensions and concepts for graphic presentations and/or data manipulation heretofore unavailable in manually produced maps. Through digitizing methodology and sophisticated computer software routines, the imagery extracted from the aerial photograph is deposited into a "data bank" (project file) for use in multi-disciplinary engineering management applications. Examples of how this data may be manipulated and presented are as follows:

1. Total Map Graphics - The engineer can obtain a photogrammetric map containing all planimetric and topographic features extracted from the aerial photograph similar to maps heretofore obtained using manual photogrammetric techniques.
2. Selective Map Graphics - Differential levels of management information can be extracted from the "data bank" project file. These selective graphics might include separate maps showing only the transportation networks, recreation areas, buildings, utilities or any other classification of land use. Some typical applications

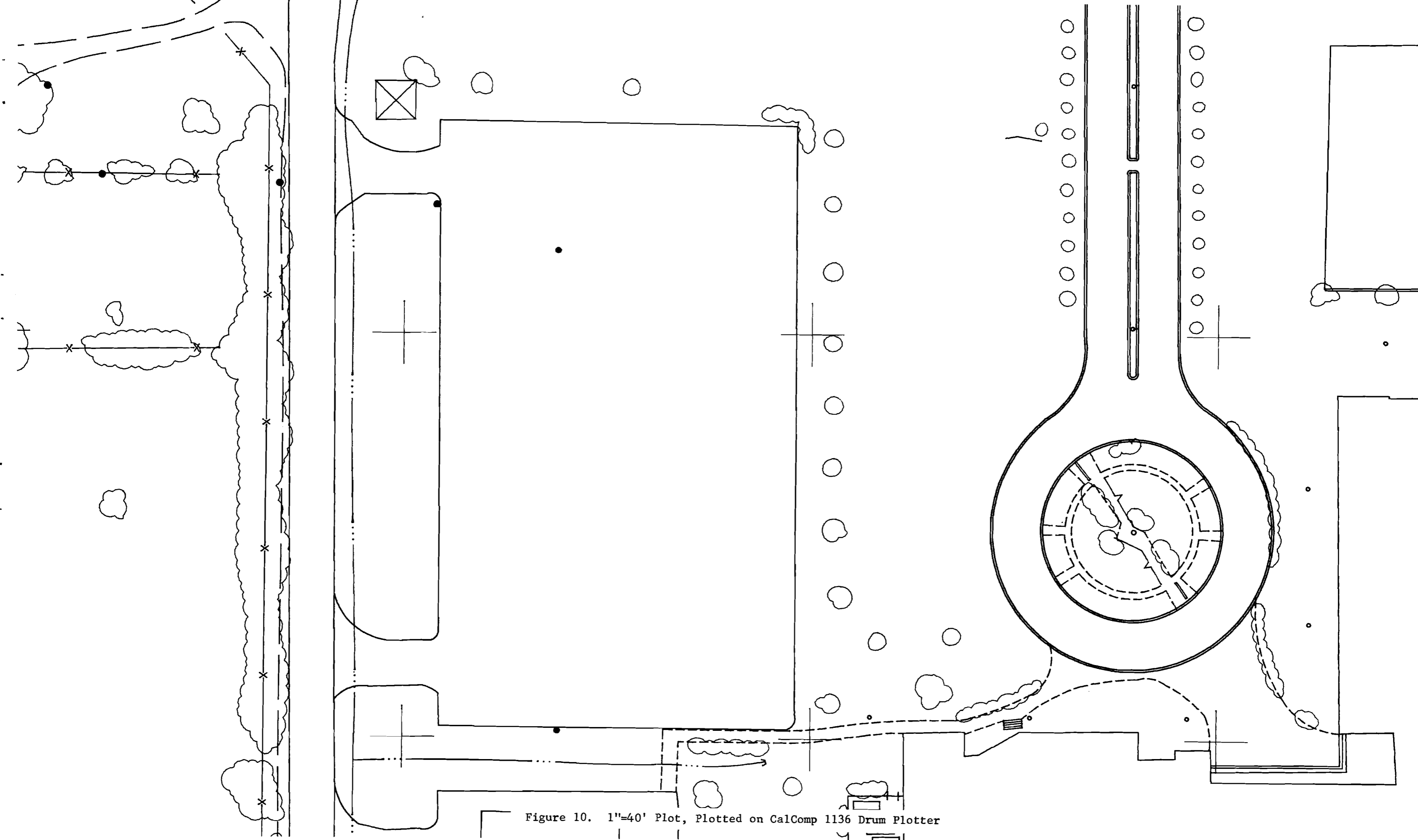


Figure 10. 1"=40' Plot, Plotted on CalComp 1136 Drum Plotter

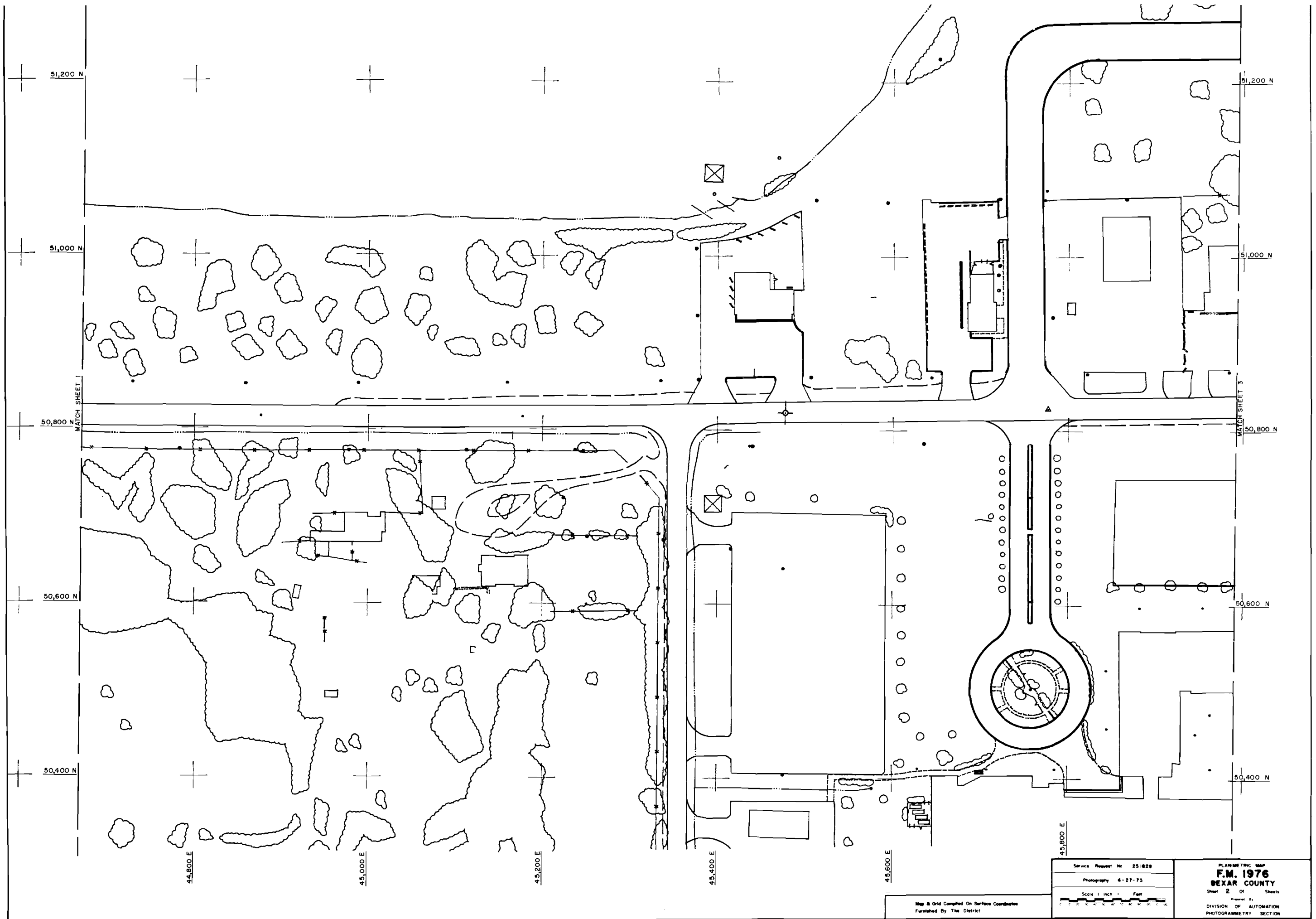


Figure 11. 1"=100' Plot, Plotted on CalComp 1136 Drum Plotter

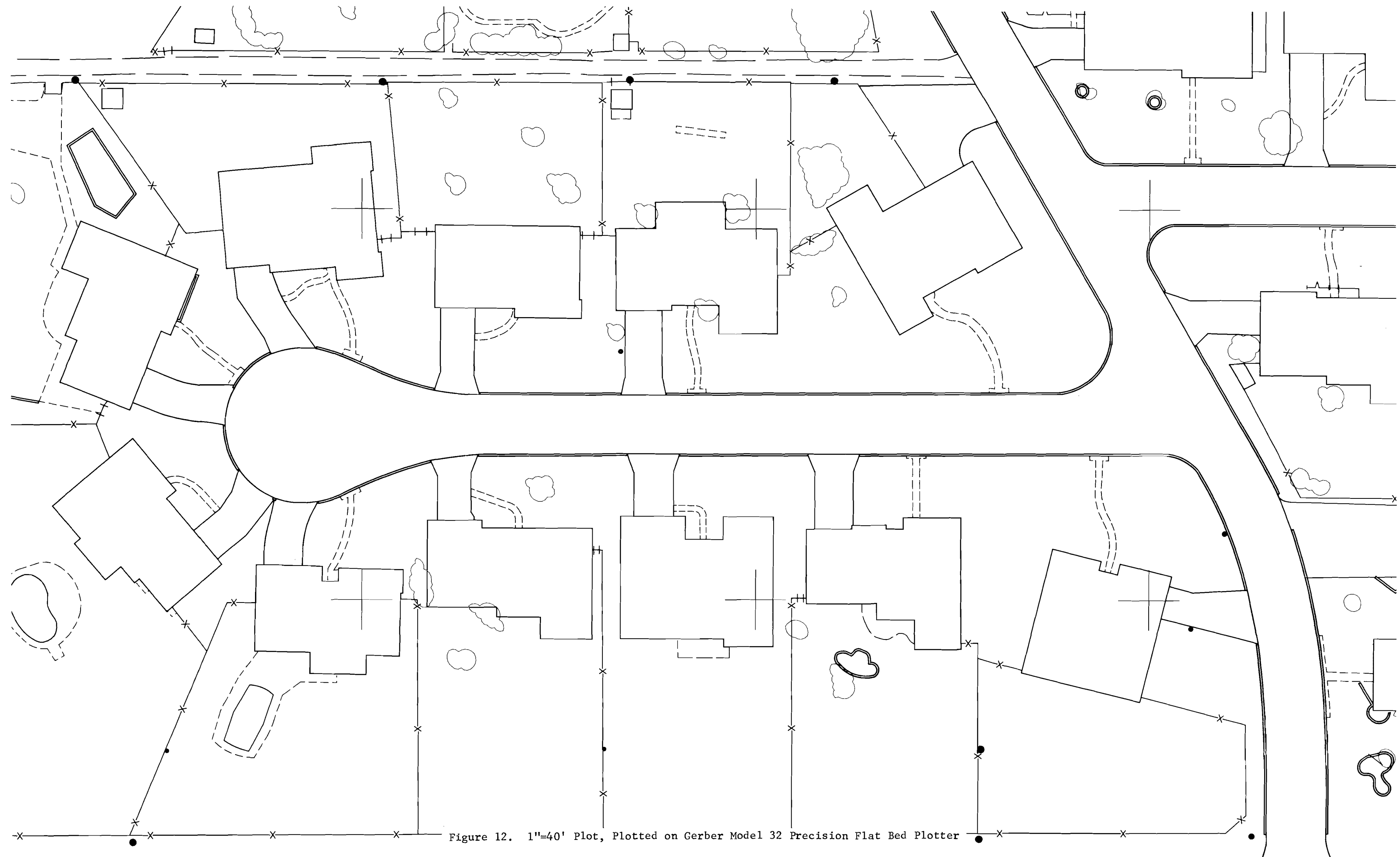


Figure 12. 1"=40' Plot, Plotted on Gerber Model 32 Precision Flat Bed Plotter

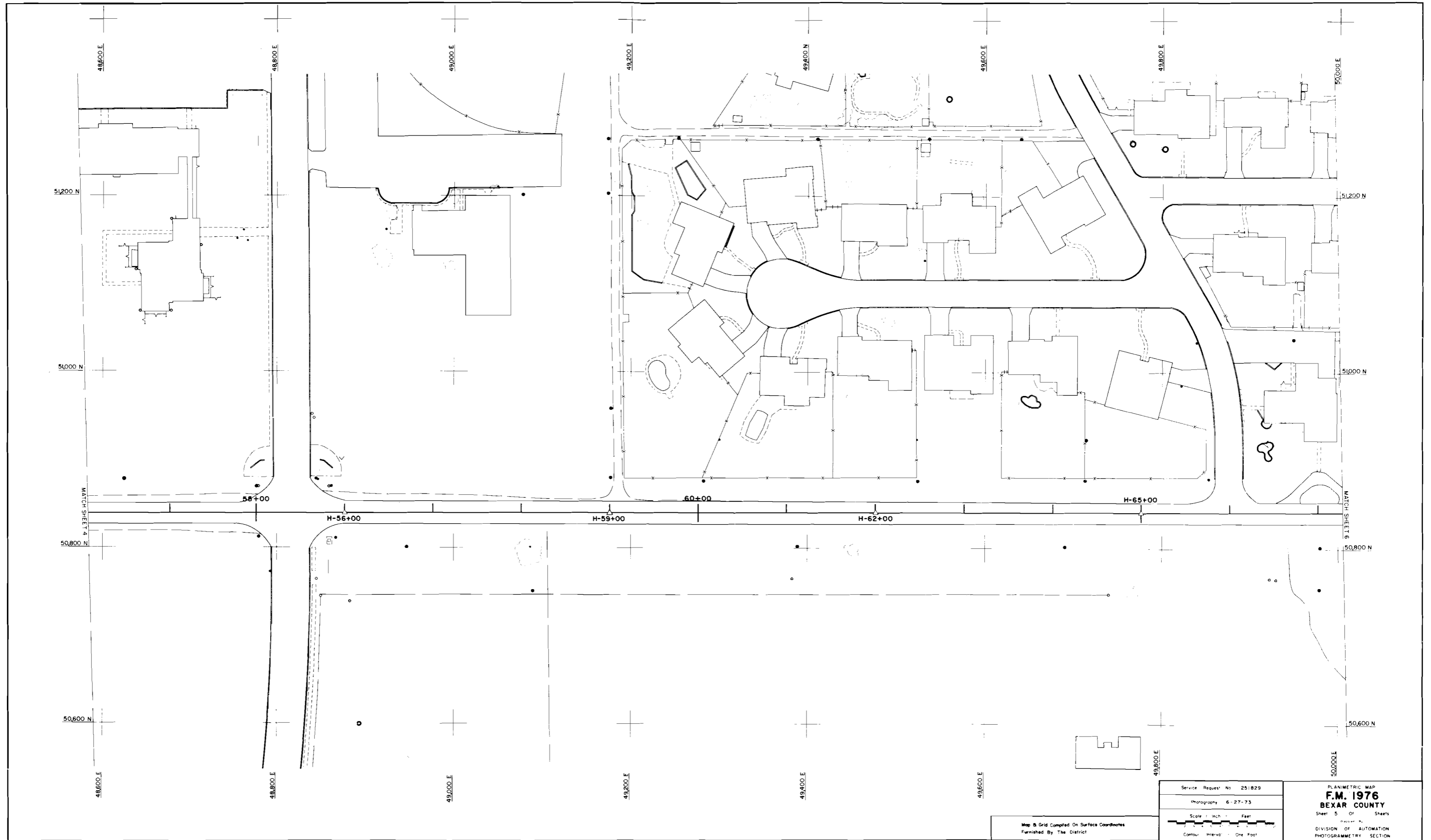


Figure 13. 1"=100' Plot, Plotted on Gerber Model 32 Precision Flat Bed Plotter

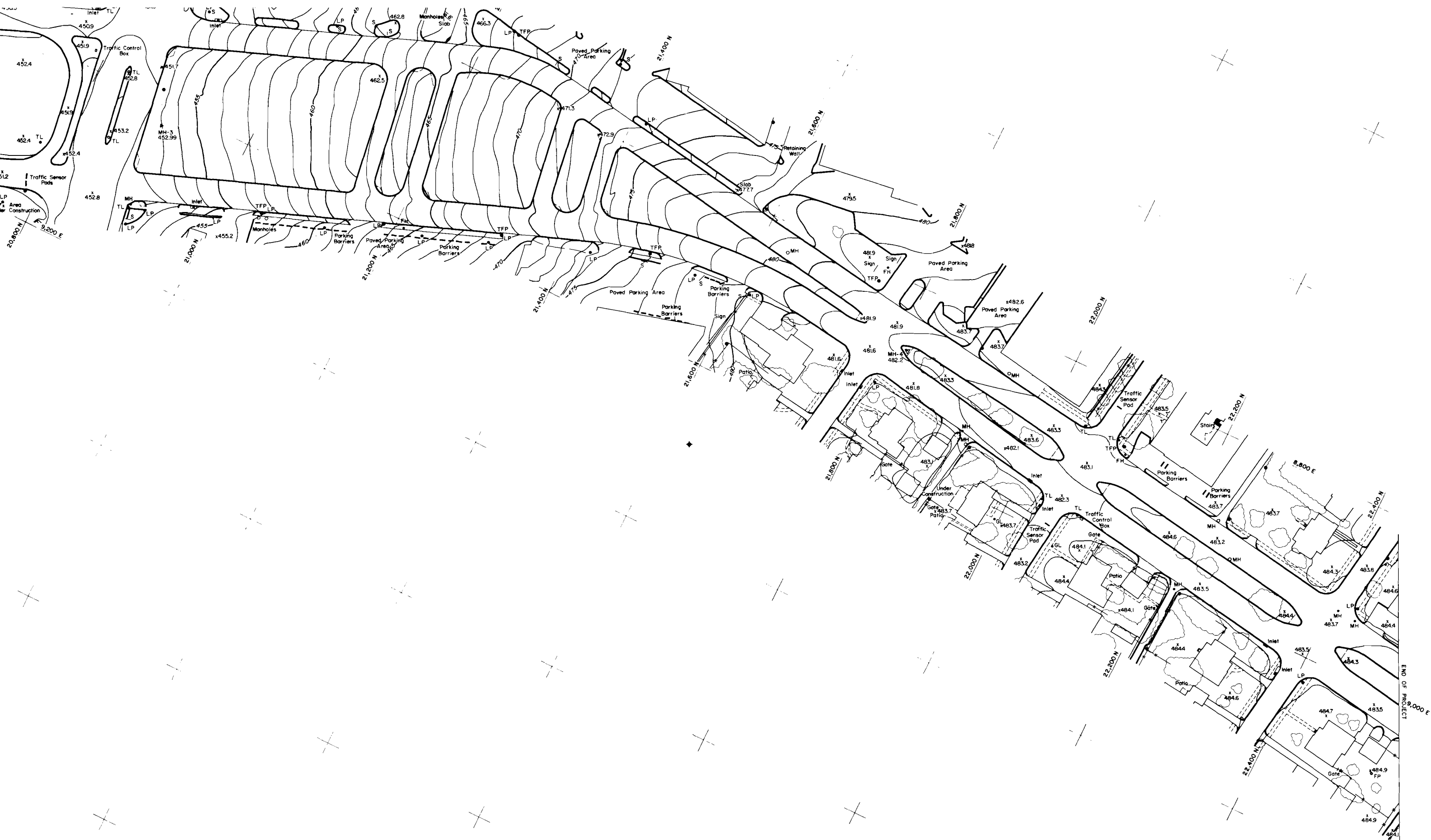


Figure 14. 1"=100' Plot, Plotted on Gerber Model 32 Precision Flat Bed Plotter

Map & Grid Compiled On Surface Coordinates Projected From The State Plane Coordinate System, North Central Zone.	Service Request No. 247298	TOPOGRAPHIC MAP M.H. 5386 DALLAS COUNTY
State Plane Coordinates - Surface Coordinates - 1.000120000	Photography 5-80-73	Sheet 2 of 2 Sheets
Graphic Azimuth - Grid Azimuth - Angle	Scale 1 inch = 100 Feet	Prepared By DIVISION OF AUTOMATION PHOTOGRAMMETRY SECTION
	Contour Interval - One Foot	

3. Selective Area Graphics - Specific areas can be extracted from the project file and plotted without requiring a plot of the entire area. This "windowing" feature will be very useful to the traffic engineer for extracting selective interchanges for signalization studies and design, and to the safety engineer for accident site evaluations.
4. Additions and Deletions - The project file can be accessed to update land use applications as new subdivisions, parks, transportation routes or industrial changes occur.
5. Differential Scales - The system offers the engineer the flexibility of selecting the scale of the graphic presentations within the accuracies as dictated by the photographic scale at the point of data entry. Several areas from the same project file can be obtained at varying scales.
6. Data Analysis - The engineer will be able to analyze environmental and economic problems through combining the selective areas and feature uses. This would display a certain area, the type of improvements and transportation routes available.

These are only a few examples of how the stored data can be manipulated. The implementation of this system opens the possibility of developing capabilities that will permit engineers and managers (1) to obtain information heretofore unavailable or in an undesirable form and, (2) to make decisions based on this information.

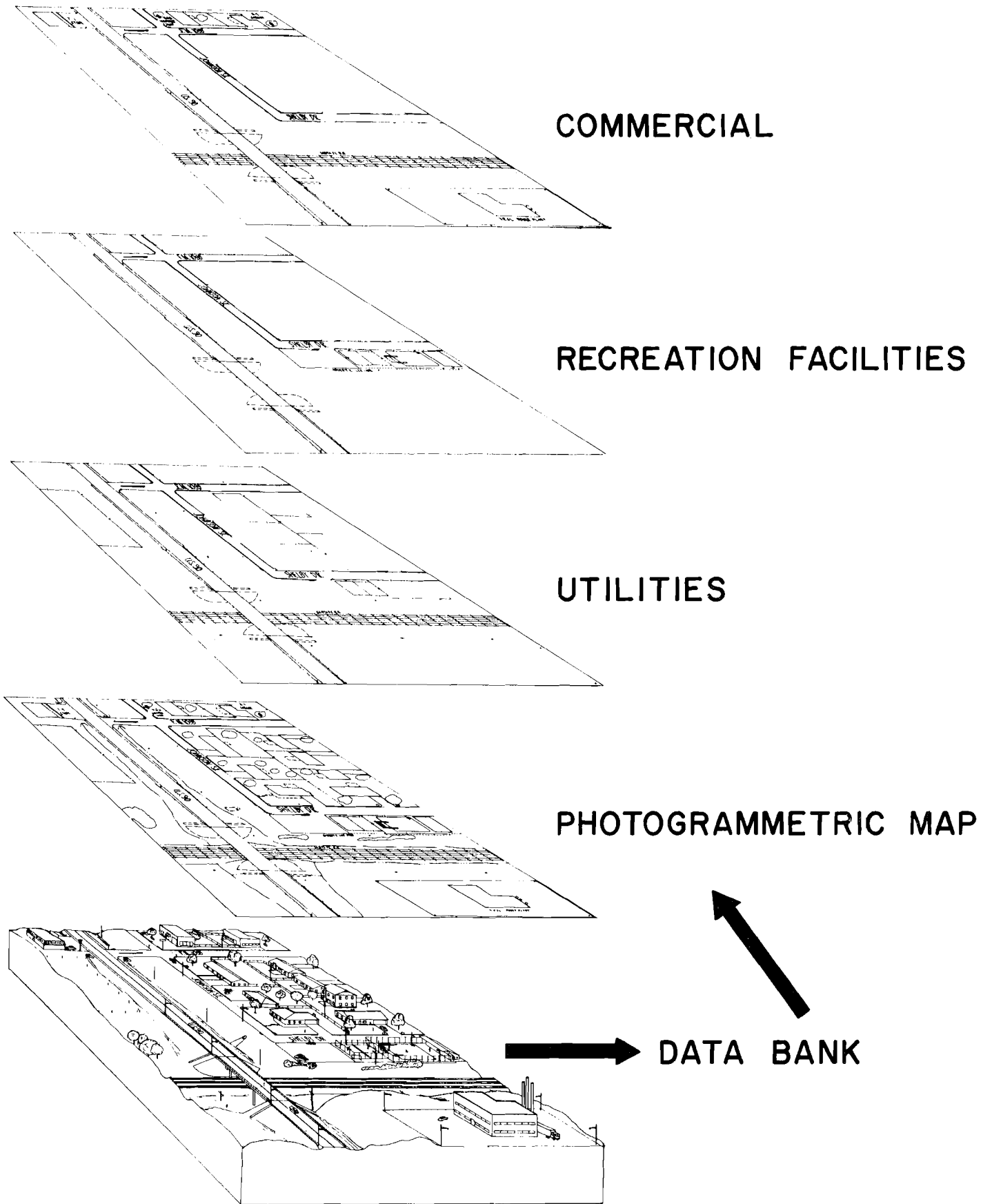


Figure 15. Automated Mapping System Selective Map Graphics

III. Conclusions and Recommendations

Conclusions

Implementation of the Automated Mapping System into the production environment of the Texas Highway Department provides an effective method for collection, storage and retrieval of large volumes of map data, and offers the engineer flexibility for automated manipulation of the map data heretofore unavailable.

The cost involved in obtaining map data using automated methodology is comparable to the cost of maps produced using manual techniques. The added expenses of equipment depreciation for the digitizing accessories, computer time, editing and precision plotting are offset by the substantial reduction in the number of man hours required to complete the job manually.

Attempting to compare the economics of an Automated Mapping System to conventional mapping techniques is similar to comparing photogrammetric mapping to conventional field mapping. Appraisal values for the advanced methods depend on the resourcefulness of the user in performing the variety of manipulative processes available.

Graphics produced by automated manipulation of map data offer new concepts and dimensions for presentation. These plots can be obtained at different scales, line weights and line types in a time frame much faster than an identical map manuscript can be scribed using standard cartographic techniques. This time comparison ranges from ten (10) times faster using a precision flat-bed plotter with the optical exposure head to fifty (50) times faster for edit plotting on the CalComp 1136 drum plotter.

The limited amount of manual drafting used with automated graphics permits personnel previously restricted to drafting duties the opportunity to be trained

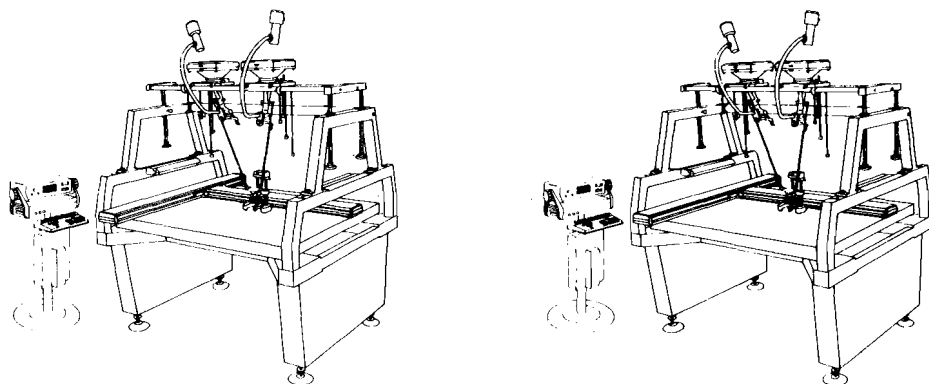
To overcome edit deficiencies and optimize the overall system, it is the Department's intent to replace the individual keypunch data collectors with multiple automated stations. The automated stations would permit the use of all existing digital hardware with the exception of the keypunch interface which would necessarily be replaced with a computer interface. Each automated station could consist of three to five stereoplotter units with digitizing accessories, a cathode ray tube (CRT) display with a hard copy unit and a mini-computer as shown in Figure 16.

This equipment configuration will permit each stereoplotter operator interaction between the digitizer, mini-computer and the CRT display. In congested areas hard copies of the digitized data can be obtained by the operator for editing purposes. This will avoid extended use of the display tube by any one operator. The edited data will be transmitted by the stereo operator to the host IBM 370 computer for final processing, disk storage and further manipulation as required. The use of several automated stations with smaller mini-computers is preferable to having a total system with one larger computer since this will minimize production delays caused by the inevitable down time of electronic equipment. Figure 17 represents the proposed multiple automated stations which will utilize the host IBM 370 computer, disk files, magnetic tapes and a precision flatbed plotter for graphics.

The Texas Highway Department is presently preparing specifications to purchase or lease a precision flatbed plotter for use in conjunction with the CalComp 1136 drum plotter purchased by the Department several months ago.

Considerable work remains to be accomplished in the field of automated mapping and the Texas Highway Department will continue to investigate means and methods to adjust their automated mapping system to this rapidly expanding field.

AUTOMATED STATION



STEREO PLOTTER UNITS

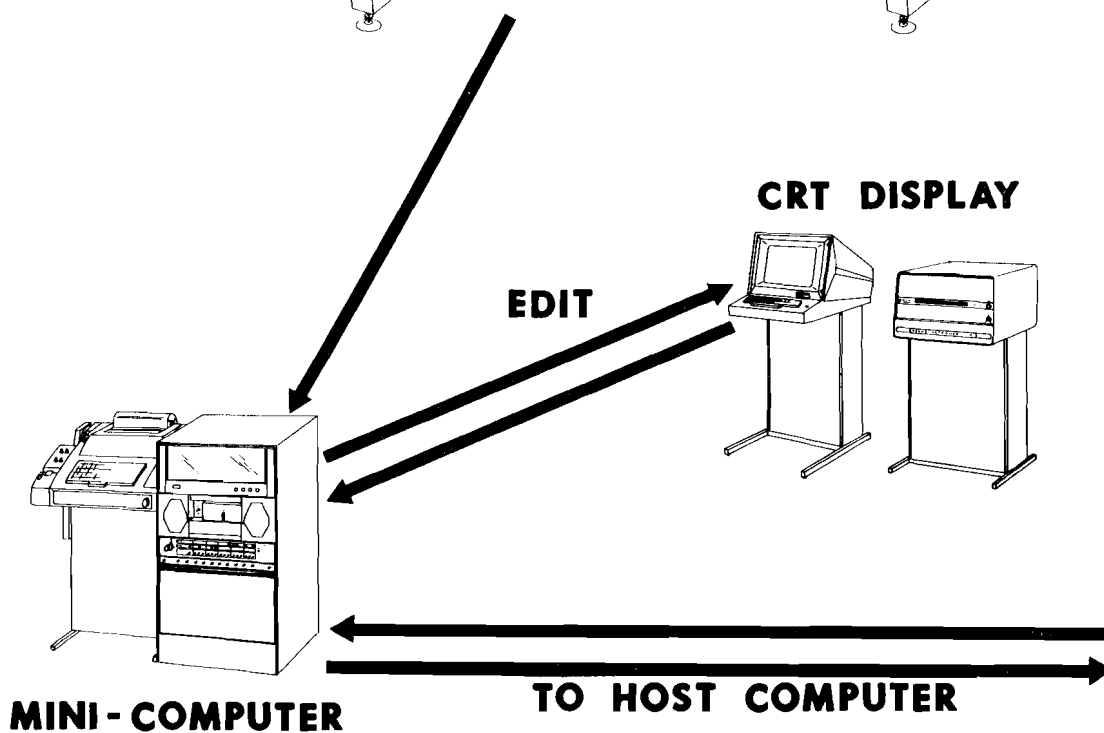
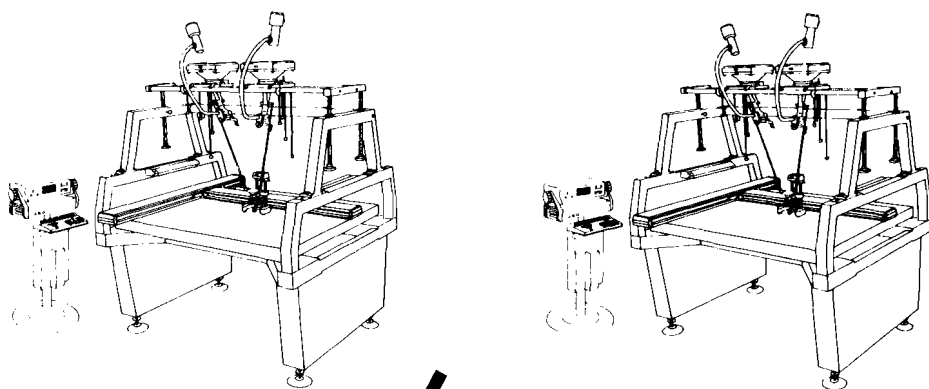


Figure 16. Automated Station

TOTAL AUTOMATED INFORMATION MANAGEMENT SYSTEM

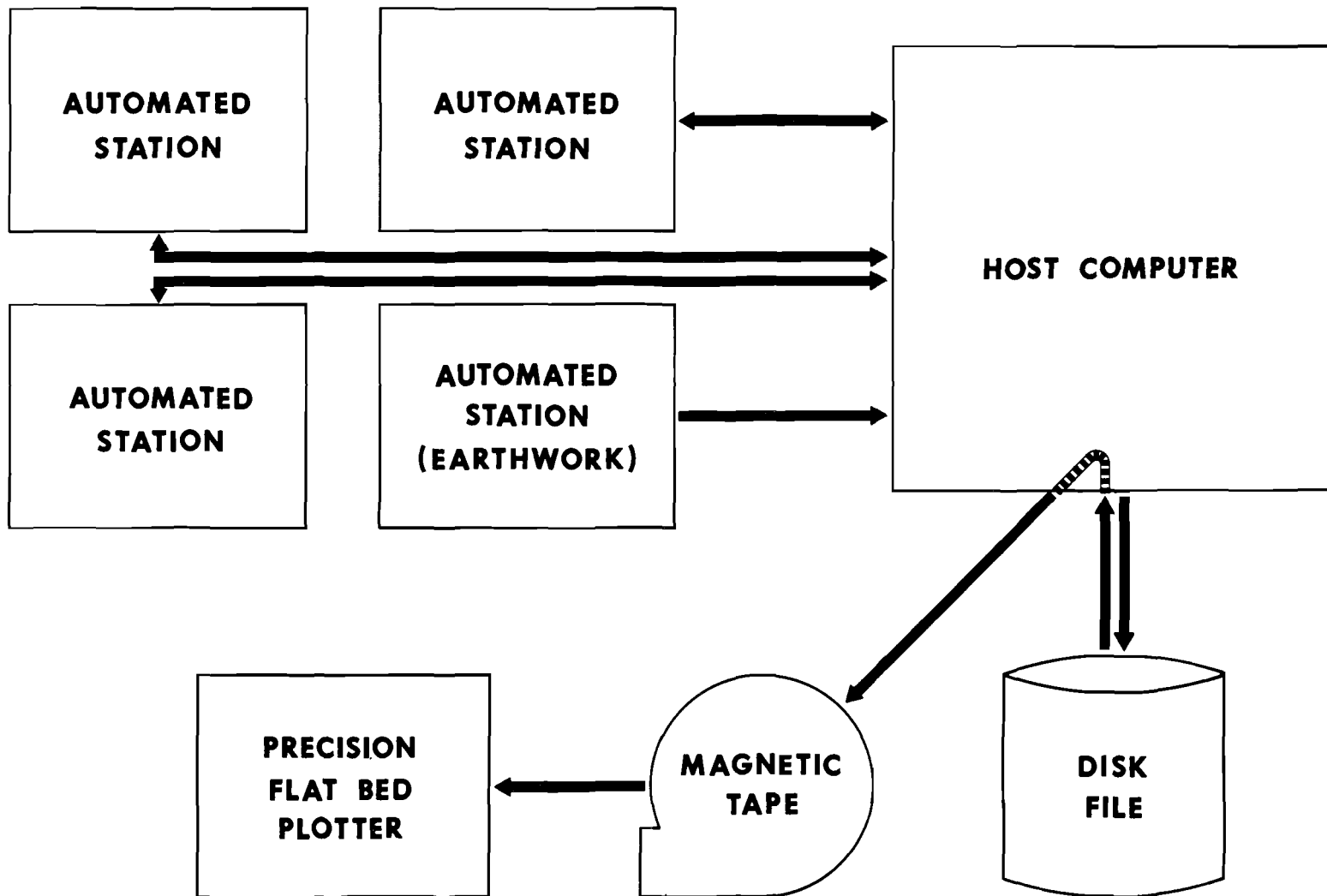


Figure 17. Total Automated Information Management System

APPENDIX
DIGITIZING INSTRUCTIONS

CODE	FEATURES DIGITIZED	LINE TYPE	LINE SIZE	SYMBOL SIZE	CLOSURE FACTOR	METHOD OF DIGITIZING
1	Pass Points Principal Points Control Points			Special		Base index is left principle point. Digitize lowest model line first. Digitize in a clockwise direction. Digitize control points from left to right.
2	Buildings (Square)	Point To Point	.014 Solid		1.0'	Areas obscured by trees are not digitized.
3	Curb I	Smooth Curve	.012 Double			Digitize right side in direction digitized. Digitize twice at square corners. Curb ends are closed.
4	Paved Roads and Driveways	Smooth Curve	.012 Solid		1.0'	Two points only are plotted point to point. More than two points are plotted smooth curve. Double digitize square corners.
5	Sidewalks	Plotted Curve	.008 Dash SW		1.0'	
6	Steps (Square) Stairs Fire Escapes	Point To Point	.008 Special			Start at top left corner and digitize clockwise. Two points indicate a single step Three (3) points only.
7	Fences and Gates Irrigation Gates Misc. Gates	Point To Point	.010 Special		1.0'	Digitize twice at each end of the gate.
8	Slabs Concrete Dams Concrete Drains, Rip Rap Concrete Irrigation Ditch	Plotted Curve	.008 Dash Slab		1.0'	
9	Water Irrigation Canals	Smooth Curve	.010 Special		2.0'	Digitize bodies of water clockwise. Digitize centerline of drainage.
10	Poles Transformer Poles			.095		Digitize once for each pole.
11	Light Poles Traffic Lights			.080		Digitize once for each pole.

CODE	FEATURES DIGITIZED	LINE TYPE	LINE SIZE	SYMBOL SIZE	CLOSURE FACTOR	METHOD OF DIGITIZING
12	Buildings (not square)	Plotted Curve	.014 Solid		1.0'	
13	Walls Retaining Walls	Plotted Curve	.010 Special		1.0'	Digitize centerline. Symbol (—) is left of direction digitized.
14	Guard Rails	Smooth Curve	.010 Special		1.0'	Digitize the rail so the posts are on the left in the direction digitized.
15	Guard Fences	Smooth Curve	.010 Special		1.0'	Digitize centerline.
16	Dirt Road	Smooth Curve	.010 Dash		2.0'	
17	Ruins Foundations, Framework Areas under Construction	Plotted Curve	.014 Dash		1.0'	Digitize clockwise.
18	Earthen Dams Earthen Levees	Smooth Curve	.010 Special		2.0'	Digitize centerline. Symbol (—) is left of direction digitized.
19	Inlets Culverts Bridge Ends	Plotted Curve	.008 Solid		1.0'	
20	Transmission Line Towers Windmills	Point To Point	.010 Special		1.0'	Digitize corners, 'x' symbol is put in automatically.
21	Tanks		.010 Special		1.0'	Circular tanks - digitize 3 points on circle. Butane tanks - digitize 4 points (sides first). Rectangular tanks - digitize 5 points.
22	Surface Pipeline - Oil Well	Plotted Curve	.010 Solid		1.0'	

CODE	FEATURES DIGITIZED	LINE TYPE	LINE SIZE	SYMBOL SIZE	CLOSURE FACTOR	METHOD OF DIGITIZING
23	ROW Marker			.075 Square		Digitize once for each marker.
24	Manholes (Not on Inlets)			.095		Digitize once for each manhole.
25	Sign Post Posts Flag Poles			.070		Digitize once for each feature.
26	Fire Hydrant Manholes (On Inlets) Gas Lights Meters			.060		Digitize once for each feature.
27	Guard Posts Vent Tank Caps Parking Meters Traffic Buttons			.050		Digitize once for each feature.
"	Speaker Posts Pipeline Marker Cable Marker					
28	Orchard (Interior Trees)			.035 Dot		Digitize once for each tree.
29	Small Trees Orchard (Outline Trees) (Symbol)		.006 Bush	10' To Map Scale		Digitize once for each tree.
30	Trees	Smooth Curve	.006 Bush		5.0'	Digitize perimeter clockwise. Digitize clearings counter clockwise.
31	Palm Trees		.006 Special			Digitize at two points to show limits of tree. Digitize once to indicate base of tree.
32	Tree Farm	Smooth Curve	.006 Special		5.0'	Digitize perimeter clockwise.

CODE	FEATURES DIGITIZED	LINE TYPE	LINE SIZE	SYMBOL SIZE	CLOSURE FACTOR	METHOD OF DIGITIZING
33	Curb II	Plotted Curve	.012 Double			Use for enclosed curbs or curbs on the model line. Curb ends are not closed.
34	Marsh Pits	Smooth Curve	.010 Stream Dash		2.0'	Digitize Perimeter.
35	Railroads I Workcar Sidings	Smooth Curve	.008 Special			Digitize right track in direction digitized.
36	Railroad Switch		.008 Special			Digitize once at switch to track connection. Digitize switch extremity second as the final reading.
37	Railroad Signal		.008 Special			Digitize once to show direction of the signal. Digitize once to indicate base of the signal and the final reading.
38	Railroad Standard		.008 Special			Digitize once for each standard.
39	Barricades Large Signs Parking rails	Smooth Curve	.012 Solid		1.0'	Two points only are plotted point to point. More than two points are plotted smooth curve. Digitize twice at square corners.
40	Cemetery	Plotted Curve	.010 Special		1.0'	Digitize perimeter.
41	Paved Shoulder	Smooth Curve	.012 Dash Road		2.0'	
42	Guard Fence II	Plotted Curve	Special		1.0'	Digitize Centerline.
43	Railroads II	Plotted Curve	Special			Digitize right track in direction digitized.

CODE	FEATURES DIGITIZED	LINE TYPE	LINE SIZE	SYMBOL SIZE	CLOSURE FACTOR	METHOD OF DIGITIZING
44	Railroad II (Single Line)	Plotted Curve	Special			Digitize centerline.
45	County Line	Smooth Curve	.02 Special		2.0'	
46	Match Line	Point To Point	.01 Special			
47	Parking Barriers					Digitize right side in direction digitized. Digitize twice at square corners.
48	Scales, Bleachers, Arbors, Awnings, Boat Docks, Drive-in screens, "no stereo coverage".	Plotted Curve	.014 Solid		1.0'	
49	Dirt Shoulder Stock Pile Golf Greens, Tee Box	Smooth Curve	.010 Dash		2.0'	
50	Culverts Bridge Ends Syphon Traffic Sensor Pad	Plotted Curve	.008 Solid		1.0'	
"	Irregular Shaped Steps					
51	Grease Rack Utility Box Catwalk Storm Cellar	Plotted Curve	.010 Solid		1.0'	
"	AC Units Crosswalk Water Tower Monuments	Pool Incinerators				