THE COMPUTER-ASSISTED DZT 90x120/RGS STEREOPLOTTING SYSTEM FROM JENA

Lothar Beier, Dipl.-Ing.
Volker Karnahl, Dipl.-Ing.
Werner Marckwardt, Dr. (Eng.)
VEB Carl Zeiss JENA
GDR
Commission II/1

1. Introduction

The complete automation of work processes associated with intellectual work of man cannot be achieved at present despite the permanently increasing learning capabilities of the automation systems. In such processes the aim of automation is to prepare occurring routine tasks by suitable algorithms and to leave decision finding largely to man. In these cases the term of computer-aided system is used. Especially the concepts of computer-aided design (CAD) and computer-aided manufacturing (CAM) have become well known. Also stereoplotting is a working process, where image interpretation cannot yet be automated by the stereooperator, although first approaches to a solution have been made in worldwide research projects (image correlation, pattern recognition). Computer-aided stereoplotting (CASP) is therefore at present an important trend towards increasing working productivity in stereoplotting.

2. Design of the computer-aided stereoplotting system of VEB Carl Zeiss JENA

The basic principle of computer-aided stereoplotting involves the preprocessing of measured values (model coordinates) obtained in the stereoplotting machine. For this purpose a mini- or microcomputer is arranged between plotter and plotting table. A microcomputer with two diskette drives and a Robotron K 891 terminal are used in the computer-aided stereoplotting system of VEB Carl Zeiss JENA (Figs. 1 and 2). The connection of the computer to the incremental encoders in the model space of the stereoplotter, to the additional controls (foot switch, functional keyboard) and to the peripheral output devices (digital plotting table, magnetic tape unit, printer) is realized via a counter interface which is housed in the electronic cabinet of the digital plotting table. This counter interface has been designed as a modular microcomputer plug-in unit. The program for the microcomputer is stored in the diskettes of the plotting computer and is loaded into the RAM memory after switching on the system. The counter interface solves the following tasks:

- take-over of the coordinate values from the precounters connected with the incremental encoder (IGR),
- interrogation of the functional keyboard and the double foot switch,
- transfer of data between plotting computer and plotting table control,
- output of data to printer, and
- reading and writing of data via a magnetic tape interface card.

The plotting computer with the two diskette drives is housed in a computer cabinet, which serves also for accommodating the K 8911 operating unit (display and keyboard). The modular microcomputer plug-in unit also comprises a RAM memory, i. e. the program is loaded from the diskettes in case of need. The main tasks of the plotting computer are:
- exchange of data and programs with the diskettes,
- data exchange with the operating unit and counter interface, and
- calculations according to selected programs, especially for absolute orientation and making available control data for the digital drawing table.

The K 8911 operating unit is a microprogram-controlled input/output device coupled with the plotting computer by a serial interface (IFSS 20 mA current loop).
The DZT 90x120/RGS digital drawing table contains a control program on PROM. This fixed program permits the operator to call numerous drawing functions with simple commands:
- selection and positioning of the drawing tools,
- allocation of maximum speeds to drawing tools,
- call-up of 9 stored basic symbols and four hardware-generated line types,
- call-up of the complete drawing set of the display keyboard,
- storage of one generated symbol each and one generated user-specific line with the possibility of rapid exchange of these drawing elements,
- scale factors for the complete drawing and the symbols or line types, respectively,
- rotational angle for the complete drawing and texts,
- straight line interpolation,
- circle interpolation including circular arc,
- reading of the current drawing pen position and error status
- admission of manual keyboard for manual setting of the drawing pen,
- viewport, and
- mirror imaging of coordinates, symbols and symbol lines at a defined mirror imaging line

Termed DZT 90x120/RS, this design variant of the digital drawing table (without counter interface) was also developed as a peripheral graphic output device for digital computer with serial interface.

3. Plotting software

The efficiency of the computer-aided stereoplotting system essentially depends on the available software. The program modules available at present can be divided into the following groups:
- operating program (copying of diskettes, work with data files),

- editor (correction of data files, generation of user-specific symbols and lines),
- status (establishment of standard parameters),
- plotting (orientation, mapping, registration)
- off-line (data transfer between peripheral units)
- auxiliary programs (for instance grid plotting) and
- test programs.

Space does not allow us to give a complete description of the comprehensive software. By means of some selected examples the principle of computer-aided stereoplotting shall be explained.

3.1. Dialogue

After switching on the computer-aided stereoplotting system the display shows a survey of the available main programs. The operator selects the desired program and is then led through the program in a dialogue. All further inputs and actions of the stereooperator are supported on the display by appropriate questions and requests. Familiarization with the operation of the system is essentially facilitated.

3.2. Operation with files

Data stored on the diskettes can be identified by a name and thus form a file. By means of operating and editor commands it is possible to perform the following operations with these data:

- copying of complete diskettes,
- display of a survey of the contents of the diskette,
- output of a catalogue of all file names,
- display of all data of a file,
- deletion of files being no longer required,
- transfer of files from diskette Ø to diskette 1,
- input of new files or extension of files already existing
- deletion or exchange of single characters or character strings.

Important files for the operator are:

- control point data,
- generated symbols,
- generated lines, and
- standard assignments of the functional keyboard.

3.3. Absolute orientation of models and drawing table orientation

For calculating the absolute orientation the operator has the option of choosing from three variants:

- calculation of the matrix for the point-by-point transformation of model coordinates into national coordinates,
- calculation of the matrix for the point-by-point transformation with additional height correction (correction of model deformation),
- calculation of orientation data for the stereoplotting machine.

Before the beginning of orientation the control point data by means of the editor have to be entered into a control point file, which will get the name of the project. During measurement in the relatively oriented model, the assignment of the measured point to the control point is made via the control point number entered on the display. For determining the unknowns of absolute orientation two known control points of position and height and another height control point are required in the minimum case. However, for increasing the accuracy it is recommended to use additional control points (up to max. 15).
After calculation, the national coordinates with the determined residual errors as well as the mean positional errors and the mean height error are output. In variant 3 also the orientation data for the stereoplotting machine (φ, ω, $\varkappa$, bx, by, bz) are made available.
In case that no spatial transformation is necessary, the unit matrix is used instead of the transformation matrix, so that the coordinates of the relatively or absolutely oriented model can be output.
The correlation of the drawing table with the model can subsequently be established by the following four possibilities:
- correlation with a common point
- correlation by using control points for position transformation
- display of profiles
- perspective representation

3.4. Mapping

In the subprogram of mapping nine basic functions are realized. The basic functions can be associated with numerous options.

In the following merely the major drawing functions shall be mentioned.

Polygon function
- linear connection of measuring points
- closing the polygon
- connection to polygons measured before
- establishment of an alignment direction
- calculation of area

Rectangle function
- adjustment of a polygon for rectangularity
- adjustment for rectangularity according to the fixed alignment direction
- completion and closing of a rectangular polygon

Curve function
- curve interpolation between the measured points
- transition straight line - curve - straight line

Circle function
- circle interpolation including circular arcs

Track function
- synchronous following of the drawing tool in accordance with fiducial mark movement

Line function
- straight-line joining of measuring points

Duplicate function
- presentation of parallels to open polygons

Area function
- hatching of polygon (hatching distance and angle freely selectable)

Point function
- mapping of points
- recording of height numbers
- recording of the area
- output of character strings(text)
- mapping of symbols

3.5. Registration

With the subprogram of registration data can be output from the measuring system to the magnetic tape device or printer. The data consist of point numbers and coordinates. The coordinates are national coordinates if the absolute orientation was calculated before. However, if the unity matrix was set, then model coordinates will be registered. The output format for the point numbers and the coordinates is fixed in the program module for status. The tabulator (09 H) is used as separating mark between point number and coordinates. With the double foot switch it is possible to control the character-by-character or block-by-block registration.

3.6. Off-line Operation

In off-line operation connections are possible between the peripheral instruments display, drawing table, diskette, magnetic tape and printer. In the following only the important connections will be mentioned:

from diskette (or magnetic tape) to drawing table - automatic mapping

from diskette (or magnetic tape) to printer - listing of a data file

from display to printer - writing of comments

from display to drawing table - map revision

4. Operational tools

In principle it is possible to input all commands via the display keyboard. However, the convenient operation with the

stereoplotting machine requires that the operator primarily concentrates on the interpretation of the image contents and the guidance of the fiducial mark. The interruption of stereoscopic viewing due to the necessary input of several characters via the alphanumeric keyboard must be reduced to a minimum. Therefore, the operator has got a double foot switch and a functional keyboard with 32 key buttons (Fig. 3). With the right foot switch the current model coordinates are stored in the counter interface. By actuating the left foot switch the function EXECUTE is additionally called up and a preset computer program is started which includes all points already recorded by the right foot switch into the calculation of a command sequence for the digital drawing table. The operator compiles the program from single commands of the plotting program. With these commands macros are formed and stored under a macro name. One macro may consist of several command lines. In such a case, each EXECUTE processes one line. The cycle is restarted if all lines of a macro have been processed.
A macro with the following sequence of commands

PO
D

has for instance the effect that with the first actuation of the left foot switch a polygon is drawn, the corner points of which were already recorded with the right or left foot switch. The operator can check the form drawn, set a new point and draw a parallel to this polygon through the new measuring point by another actuation of the left foot switch. The plotting computer is capable of storing a great number of macros. The frequently used macros are reasonably assigned to the key buttons 1 - 30 of the functional keyboard. The key buttons 31 and 32 are reserved for the functions VIEW (release of the drawing by the drawing head) and EXECUTE (corresponds to the left foot switch).
The macro call-up is effected by pressing the respective key button. Thus the command memory is deleted and the new command sequence of the selected macro is entered. For less frequently used macros the call-up can be realized by writing the macro name on the display key-board. The scope of delivery includes a standard set of macros which corresponds to a standard assignment of the functional keyboard. The individual macros are symbolically represented on a pattern.

5. Examples

Figures 4 and 5 show examples of generated symbols and generated line types. When the symbol name is called up, the respective sequence of drawing commands is loaded into the RAM space of the drawing table control. Then the symbol or the line type can be drawn as often as is desired.

Figure 6 shows a section of large-scale map. In addition to alphanumeric characters, generated symbols and line types also the polygon, rectangle, area, duplicate and curve functions were used.

6. Summary

The computer-assisted stereoplotting system from Jena is on-line connected to incremental encoders in the model space of a stereoplotter. A microcomputer between the stereoplotter and the drawing table calculates from the measuring values sequences of drawing instructions under consideration of rectangularity, parallelism and many other functions. In addition, the computer supports absolute orientation and enables mapping, when the drawing instructions come from external data media (off-line). Model coordinates can be output via printer or magnetic tape. The existing software packet allows a variety of possibilities for a further increase of working productivity in photogrammetric stereoplotting.

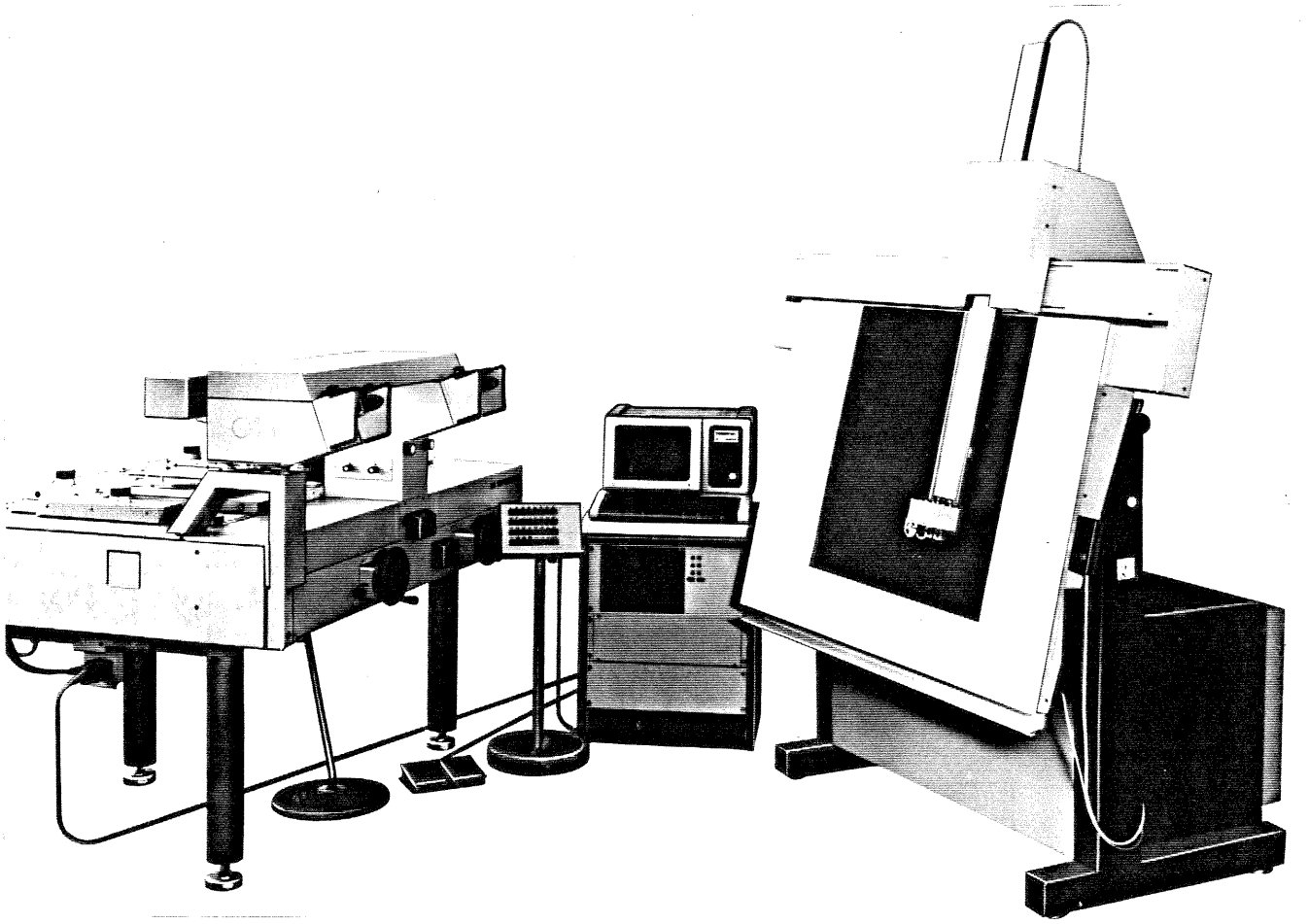

Fig. 1 Computer-assisted DZT 90x120/RGS stereoplotting system from Jena

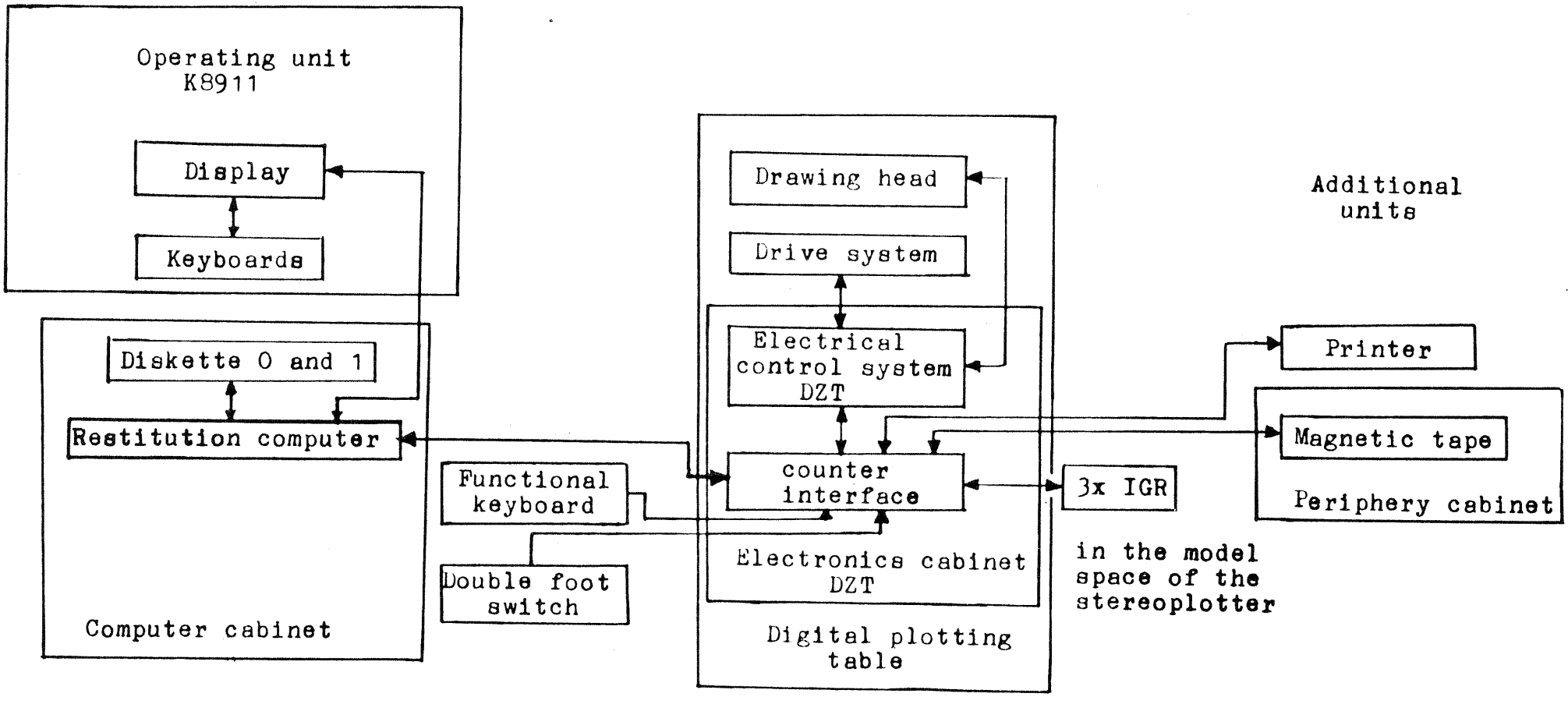

Fig. 2 The computer-assisted DZT 90x120/RGS stereoplotting system from JENA, schematic

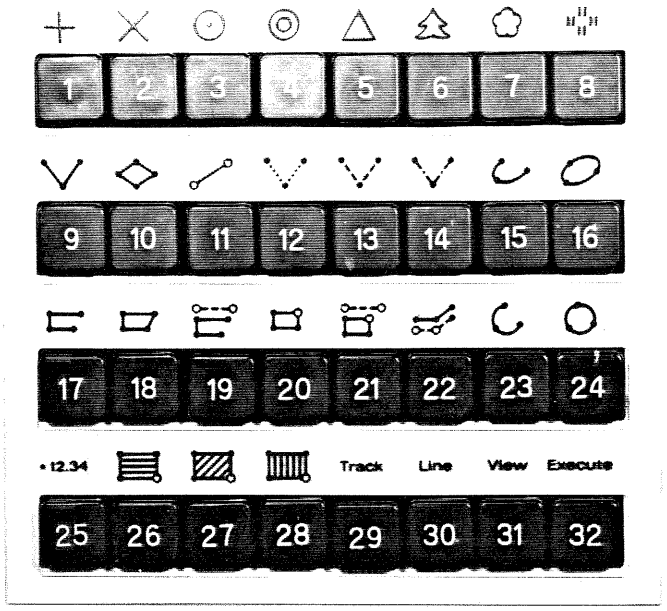

Fig. 3 Functional keyboard with pattern mask for standard assignment of keys

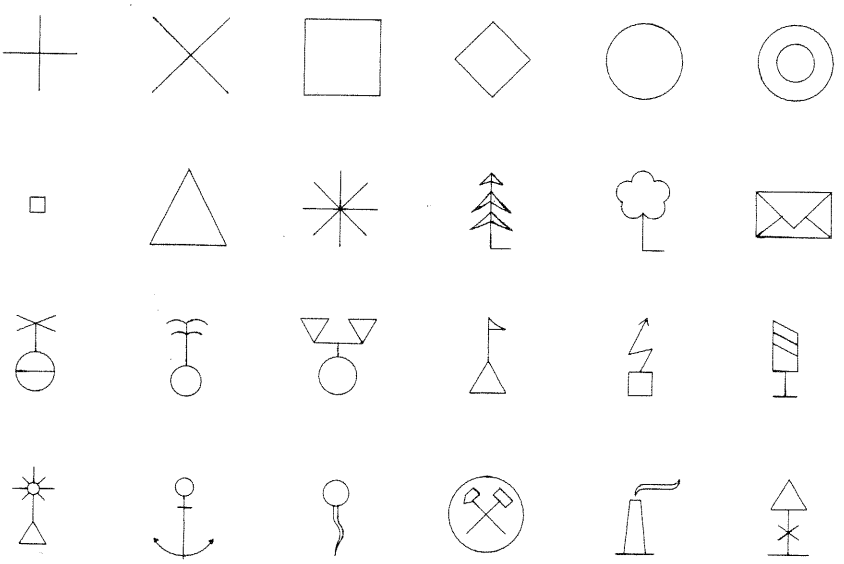

Fig. 4 Standard symbols and examples of generated symbols

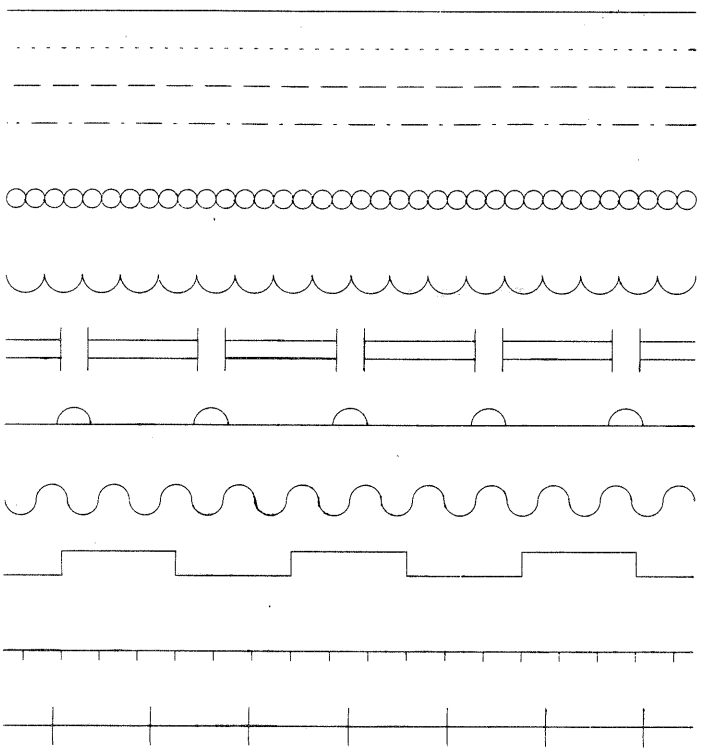

Fig. 5 Standard line types and examples of generated line types

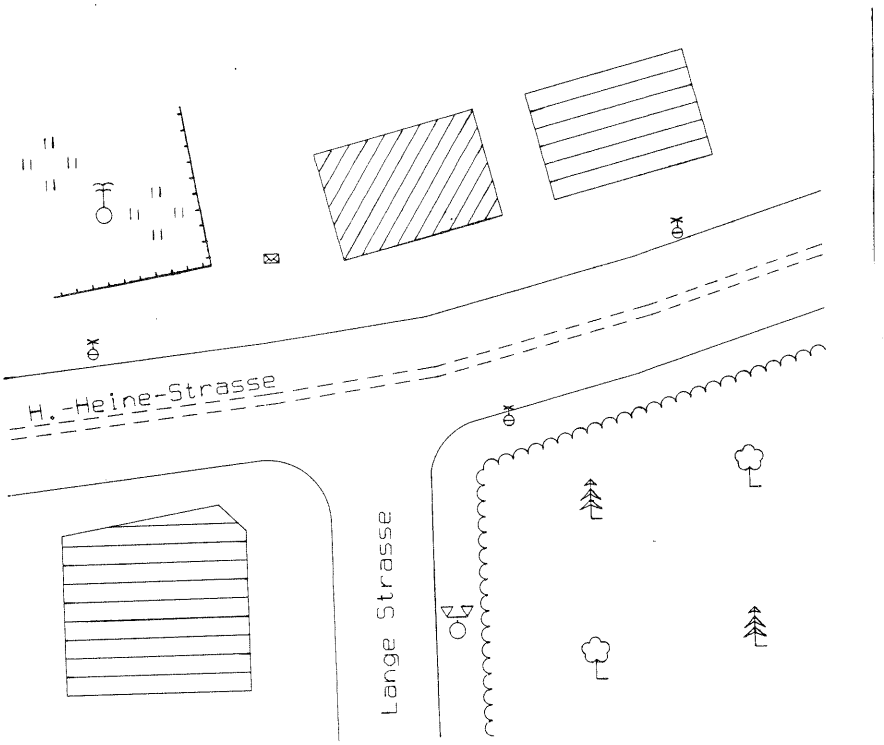

Fig. 6 Section of a large-scale map