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THE DZ 7 DIGITAL TRACING TABLE FOR PHOTOGRAMMETRIC AND GEODETIC MAPPING

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1. Introduction

Photogrammetric mapping - still the predominant plotting method in practical photogrammetry - has entered a period of radical change. Conventional mapping, characterized by the sequential activities of measuring and of plotting, is being increasingly replaced by computerized on- and off-line methods. It can be considered as clearly proved that digital mapping methods offer comparatively better quality, higher working speed and higher profitability, the latter improvement being mainly due to a striking reduction of subsequent cartographic work.

In ground surveying we also see systems come to the foreground which allow a continuous data flow from the measuring phase through the plotting phase and up to mapping itself. The definition of linkages between points - which contrary to the case in photogrammetry are not given a priori - plays a crucial role in this respect.

The most important hardware component of both systems is the digital tracing table. Quality requirements and performance characteristics are to a large extent determined by the range of surveying applications; cadastral mapping jobs have been carried out for quite some time already in fair-drawing form.

Computerized photogrammetric mapping can be carried out on different levels. The lowest level is microprocessor control of on-line mapping functions, which is highly efficient as compared with conventional mapping. The highest level is off-line processing of photogrammetric data in large interactive graphic systems. With a view to the considerable financial and organizational consequences it is to be recommended to build up digital mapping systems step by step. With the DZ-7 and the currently available corresponding software Messrs. CARL ZEISS have endeavoured to find a rational solution to fundamental mapping problems and to create at the same time the basis for further developments in the field of computerization.

2. Aims and requirements

The DZ-7 is designed to achieve the following objectives:

- universal use of the tracing table both for on-line and for off-line photogrammetric mappings and for mappings from ground surveying measurements;
- component-by-component system extension starting from the basic unit of the tracing table with possible expansion by additional hardware and software components according to the task to be fulfilled;
- high-quality graphic work and high working speed at comparatively low cost; microprocessor control to relieve the external computer (desktop or minicomputer) from tracing table control and
- supply of an efficient set of macro-instructions to simplify the programming of graphic tasks.

3. Description of the DZ-7 System

The basic unit of the system is the DZ-7 Tracing Table with microprocessor control, vector and pattern generator for basic graphic functions. The additional components - the IEC bus and the V-24 interface as well as the photogrammetric panel and the basic graphic software - are used to configurate the following types of work (Fig. 1):

- DZ 7-A for on-line photogrammetric mapping on analog stereoplotters,
- DZ 7-P for on-line photogrammetric plotting on the PLANICOMP C-100 Analytical Stereoplotter including the off-line mappings pertaining to the C-100 and

- DZ 7-C for off-line mapping on a desktop or minicomputer, mainly for HP computers and ground surveying applications.

Any of these three configurations can be expanded by the two others.

3.1 Tracing table

The DZ-7 Tracing Table (Fig. 2) consists of a base containing the electronic control and amplifier slide-in modules, a frame with a plotting surface, the guide and the two-sided drive of the primary carriage, the primary carriage itself, the secondary carriage with the tracing head as well as a panel for the basic functions. The frame and the plotting surface (932 x 1192 mm) can be inclined between 0° (horizontal) and 70°. To give the operator a good view of the plotting surface the primary carriage moves from front to back or from bottom to top and vice versa. According to the version in question the tracing head can be tipped with 1 or 3 plotting tools (ball point pen, ink-pen holder, scribing tool or pencil) and attains a high damping frequency (max. 30 Hz) mainly for tracing dashes. The main technical data of the basic unit are shown in Fig. 3. The resolution of 0.01 mm is a prerequisite of a high graphic quality as expressed (VS 1 = 100 mm/sec) by a straight line tolerance of ±0.02 mm. Depending on the requirements, the operator can choose between precision mapping at a lower working speed and high-speed mapping (max. 280 mm/sec) of somewhat lower quality.

3.2 Microprocessor control

For all three configuration levels of the DZ-7 the integrated microprocessor is the most important component for table control. The corresponding software packag comprises about 250 individual programs implemented together with the main program on the 32 K byte main memory of the microprocessor. The control functions can be subdivided into two groups:

- general operating programs for internal functions, e.g. controlled acceleration and deceleration of the table carriages and interpolation of straight lines and
- graphic operating programs such as plotting of alpha-numeric data, symbols or the windowing function.

Of direct importance for the user is the second group of functions, the main instructions of which are shown in Fig. 4 and are given in their graphical form in Fig. 5. The instructions are modelled on the HP Graphic Languages and consist each time of an instruction word and a list of parameters, e.g.

IW (x_1, y_1, x_2, y_2) = Input Window

for input and supervision of the mapping area and the terminal positions (see Fig. 6).

When an external computer is connected the instructions and the corresponding parameters are transmitted block-by-block as data of the buffer memory of the DZ-7. When a photogrammetric plotter is connected, the operating functions are set on the control panel and the instructions are triggered from the panel or by a footswitch.

3.3 Computer connections

To control the DZ-7 from a desktop computer or a minicomputer a connection to these is necessary. The hardware part consists of a computer interface with its connecting cable and the table interface. As to the software part, data transmission is supported by the driver of the computer. In its standard version the DZ-7 is equipped with

- the serial RS 232 interface (V 24) and the
- IEC interface for byte-serial transmission.

Connections to the following computers have been realized:

- the Hewlett Packard HP 1000 minicomputer,
- Diehl DS 2000 minicomputer,
- the Wang 2200 desktop computer,

- the Hewlett Packard HP 9835/45 desktop computer and
- the Textronix 5054 desktop computer.

3.4 Basic graphic software

To facilitate the establishment of application programs a subroutine library is available for the basic graphic software. It is of a general conception and written in BASIC or in FORTRAN IV, and adapted to the HP 9835/45 desktop computer system or the HP 1000 minicomputer. The basic software corresponds in form to the graphic BASIC instructions used by HP or to the FORTRAN calls of the widely used Calcomp plotting software.

4. Applications

4.1 On-line photogrammetric mapping on analog stereoplotters

For on-line plotting on analog stereoplotters the version DZ 7-A is available. All functions are microprocessor-controlled and are called from the additional photogrammetric panel. We distinguish the operating modes

F Follow
SL Tracing of straight lines and
CU Tracing of curves (Fig. 7).

In the "Follow" mode the motion of the model carriage is transmitted synchronously to the tracing table according to the selected scale; as a rule this mode is used for mapping natural objects. The "Straight Line" mode allows the plotting of straight lines between points, the "Curve Line" mode the plotting of curves between points using a modified spline function. The various operating modes can be concatenated, the tangent condition being respected in case of a combination of SL and CU. The combination of the line types

- continuous,
- broken and
- dot-dash

and of the symbol lines in the SL mode generates a whole variety of different lines permitting a differentiated reproduction of the map contents (Fig. 8). The following additional functions are mainly used for the mapping of buildings (Fig. 9):

M / R for polygon completion,
EC for edge completion and
RA for respecting rectangularity conditions.

The DZ 7-A represents a clear and simple way of partly automating standard mapping tasks.

4.2 Mapping with the PLANICOMP C-100

For mapping with the PLANICOMP C-100 the DZ 7-P version and an expanded software package for computers with RTE IV operating systems are available. The off-line programs for map-sheet preparation, plotting of sets of point, etc. (C 85 - C 88) and the computerized on-line mapping programs (B 80, A 81, 82) are run via the IEC interface, the manual on-line operation takes place via the incremental pulse interface. The following software expansions as compared with the previous version are to be mentioned:

- selectable output of graphic information on the DZ-7, a graphic CRT or on a plotter of the HP series;
- expansion of the symbol set to 32 symbols in a form relevant for cartography, size and rotation of the symbols can be selected (Fig. 10);
- pre-definition of windows and automatic window adaptation for mapping on DZ-7 or graphic CRT when ground or table coordinates of window corners are given in advance;
- preparation and automatic execution of several off-line mapping jobs (batch operation).

As before, the off-line mapping is done in background mode; in that respect reduction of the computer workload by table-internal microprocessor control is particularly efficient.

4.3 Mapping of derived contours

The contours derived from a digital elevation model by means of the HIFI-PC program system (height interpolation by finite elements |1|) can be mapped with the DZ-7. The point series obtained from the computed intersection of grid and contours are filled by interpolation using the already mentioned GRAPH subroutine library and are sent to the DZ-7 in sector form. Interpolation and tracing table control are carried out by the HP 1000 which with adequate memory will at the same time operate the PLANICOMP C-100 Analytical Stereoplotter or the ORTHOCOMP Z-2 Analytical Orthoprojector.

4.4 Mapping from ground survey measurements by means of GEOS

The problems of editing and mapping from ground survey measurements are solved within the framework of the GEOS geodetic computing and mapping system |2|. GEOS functions at desktop computer level and allows a really comprehensive data flow to take place - from the ground survey by means of electronic tacheometers via computing and data management up to the map production itself (Figs. 11 and 12).

Lines between points are defined and edited interactively in the DACA cartographic data bank. Editing is done by menue method through a graphic CRT (Fig. 13). The execution of the mapping job (map frame, point clusters, lines betweem points, etc.) takes place in the MAP program part. With MAP the user can fall back on the following data sources:

- sheet division file,
- DACA Cartographic Data Bank,
- CODA ground survey Data Bank,
- cadastral file or
- general point file (Fig. 14).

The graphic information is output alternatively on the DZ-7, the graphic CRT or (for subsequent background mapping) on a plotfile.

5. Conclusion

With the DZ-7 Digital Tracing Table an efficient and flexible medium-priced instrument is available. Its use will reduce the workload of both the operator of a photogrammetric plotter during on-line mapping and that of the external control computer in the off-line mapping process. The DZ-7 is an important element of computerized digital mapping.

Literature:

|1| Ebner, H.: HIFI - Ein Minicomputer-Programmsystem für Höheninterpolation mit finiten Elementen (HIFI - A minicomputer program system for height interpolation by finite elements), Presented Paper, 14th ISP Congress, Hamburg, 1980.

|2| Schwebel, R.: Auswertung und Kartierung im Rahmen eines integrierten Gesamtsystems (Plotting and mapping within an integrated overall system), 4th GEODETIC INSTRUMENTS COURSE, Oberkochen, 1981.

Abstract

With the DZ-7 Messrs. CARL ZEISS of Oberkochen present a new digital tracing table for computerized mapping. In view of its maximum coordinate error of 0.1 mm, the graphic quality achieved and its high working speed, the table lends itself to photogrammetric, ground survey and technical engineering mapping. The built-in microprocessor control of the table comprises a vector generator, a generator for alphanumeric characters and symbols, windowing functions as well as an IEC and V-24 interface for buffered data traffic with an external control computer. Depending on the range of application, the table is supplied in different versions and combined with application-specific software:

DZ 7-A for on-line photogrammetric mapping on analog instruments for microprocessor-aided plotting of lines, straight lines and curves;

DZ 7-P for on-line and off-line photogrammetric mapping with the PLANICOMP C 100;

DZ 7-C for connection to desktop and minicomputers, the connection to selected computers being supported by Messrs. CARL ZEISS supplying both software and hardware.

The problems of ground survey mapping are solved within the GEOS integrated system. The editing of plotting data takes place via graphic CRT, mapping itself being done on the DZ-7. Finally a description is given of the plotting on the DZ-7 of contours obtained from a general digital elevation model.

Der Digitalzeichentisch DZ-7 für photogrammetrische und geodätische Kartierung

Zusammenfassung

Mit dem DZ-7 stellt die Fa. CARL ZEISS, Oberkochen, einen neuen Digitalzeichentisch für rechnergestützte Kartierung vor. Mit einem maximalen Koordinatenfehler von 0,1 mm, der erzielten graphischen Qualität und einer hohen Arbeitsgeschwindigkeit eignet sich der Tisch für photogrammetrische, geodätische und ingenieurtechnische Kartierungen. Die tisch-interne Mikroprozessorsteuerung umfaßt einen Vektorgenerator, einen Generator für alphanumerische Zeichen und Symbole, Windowing-Funktionen sowie eine IEC- und V 24-Schnittstelle für den gepufferten Datenverkehr mit externem Steuerrechner. Entsprechend den Einsatzbereichen wird der Tisch in verschiedenen Versionen und kombiniert mit anwendungsspezifischer Software angeboten:

DZ 7-A für photogrammetrische on-line-Kartierung mit Analoggeräten zum mikroprozessor-gestützten Zeichnen von Linien, Geraden und Kurven;

DZ 7-P für photogrammetrische on- und off-line-Kartierung mit PLANICOMP C 100;

DZ 7-C für den Anschluß an Tisch- und Minicomputer, wobei der Anschluß an ausgewählte Computer soft- und hardwaremäßig von der Fa. CARL ZEISS unterstützt wird.

Die geodätische Kartierung wird innerhalb des integrierten Gesamtsystems GEOS gelöst. Die Aufbereitung der Kartierdaten erfolgt über graphischen Bildschirm, die Kartierung selbst mittels DZ-7. Abschließend wird auf die Kartierung von Höhenlinien hingewiesen, die mit dem Programmsystem HIFI aus einem allgemeinen digitalen Höhenmodell gewonnen und für den DZ-7 aufbereitet werden.

La table traçante numérique DZ 7 pour l'établissement de cartes photogrammétriques et géodésiques

Résumé

Avec la DZ 7 la maison CARL ZEISS, Oberkochen, présente une nouvelle table traçante numérique pour la restitution assistée par ordinateur. La table se prête particulièrement à des restitutions photogrammétriques, géodésiques et à des restitutions d'ingénieur vue l'erreur maximale de coordonnées de 0,1 mm, la qualité graphique obtenue et la grande vitesse de travail. La commande par microprocesseur qui est incorporée dans la table comprend un générateur vectoriel, un générateur pour les symboles et les caractères alphanumériques, des fonctions "windowing" ainsi qu'un interface IEC et V 24 pour la transmission des données à mémoire tampon à l'ordinateur externe. Selon la mise en service, la table est offerte en différentes versions et l'ordinateur y relatif dispose d'un logiciel spécifique, à savoir:

DZ 7-A destinée à la restitution photogrammétrique on-line avec des appareils analogiques pour le tracé de lignes, de lignes droites et de courbes assisté par microprocesseur;

DZ 7-P destinée à la restitution off-line et on-line avec le PLANICOMP C 100;

DZ 7-C destinée au raccordement de calculateurs de table et de miniordinateurs, le raccordement aux ordinateurs sélectionnés étant effectué par le soutien de la maison CARL ZEISS en ce qui concerne le software et le hardware.

La tâche de la restitution géodésique est résolue dans le cadre du système global intégré GEOS. L'élaboration des données de restitution s'effectue par l'intermédiaire de l'écran graphique, la restitution elle-même au moyen de la DZ 7. En conclusion, l'auteur traite la restitution des courbes de niveau qui sont obtenues à partir d'un modèle numérique d'altitude au moyen du système de programmes HIFI et qui sont élaborées pour la DZ 7.

La mesa de dibujo digital DZ 7 destinada a la confección de mapas obtenidos por levantamientos fotogramétricos y terrestres

Resumen

Con el DZ-7, la casa CARL ZEISS, Oberkochen, Alemania Occidental, presenta una nueva mesa de dibujo digital para el trazado de mapas, asistida por computador. Por el error máximo de coordenadas de 0,1 mm, la calidad gráfica obtenida y la elevada velocidad de trabajo, se presta esta mesa para trazados de mapas fotogramétricos, geodésicos y de ingenieria. El mando por microprocesador incorporado en la mesa incluye un generador de vectores, un generador para caracteres y símbolos alfanuméricos, funciones "windowing" así como sendos interfaces IEC y V 24 para la comunicación de datos por memoria intermedia con una calculadora de mando externa. En función de su empleo, se ofrecen varias versiones de la mesa de dibujo digital, combinadas con el software específico de aplicación:

DZ 7-A para el trazado de mapas fotogramétricos on-line con ayuda de instrumentos analógicos para el dibujo, asistido por microprocesador, de líneas, rectas y curvas.

DZ 7-P para el trazado de mapas fotogramétricos on-line y off-line con ayuda del PLANICOMP C 100.

DZ 7-C para la conexión a calculadores de sobremesa y minicomputadores; la casa ZEISS apoya por hardware y software la conexión a los computadores elegidos.

El trazado de mapas geodésicos se resuelve dentro del sistema total integrado GEOS. La preparación de los datos de trazado se realiza por pantalla gráfica, el trazado como tal con ayuda del DZ-7. Se concluye la conferencia mencionando el trazado de curvas de nivel que se consigue con ayuda del sistema de programas HIFI a partir de un modelo digital altimétrico de tipo general y que se preparan para el DZ-7.

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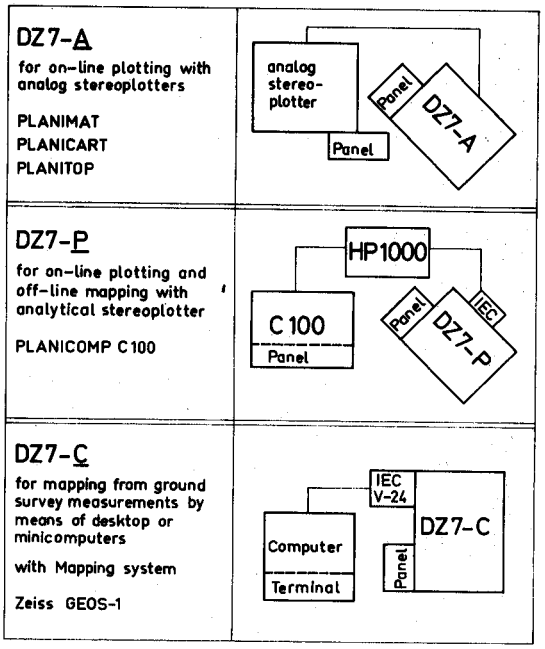

Fig.1: Configuration levels and applications of DZ 7

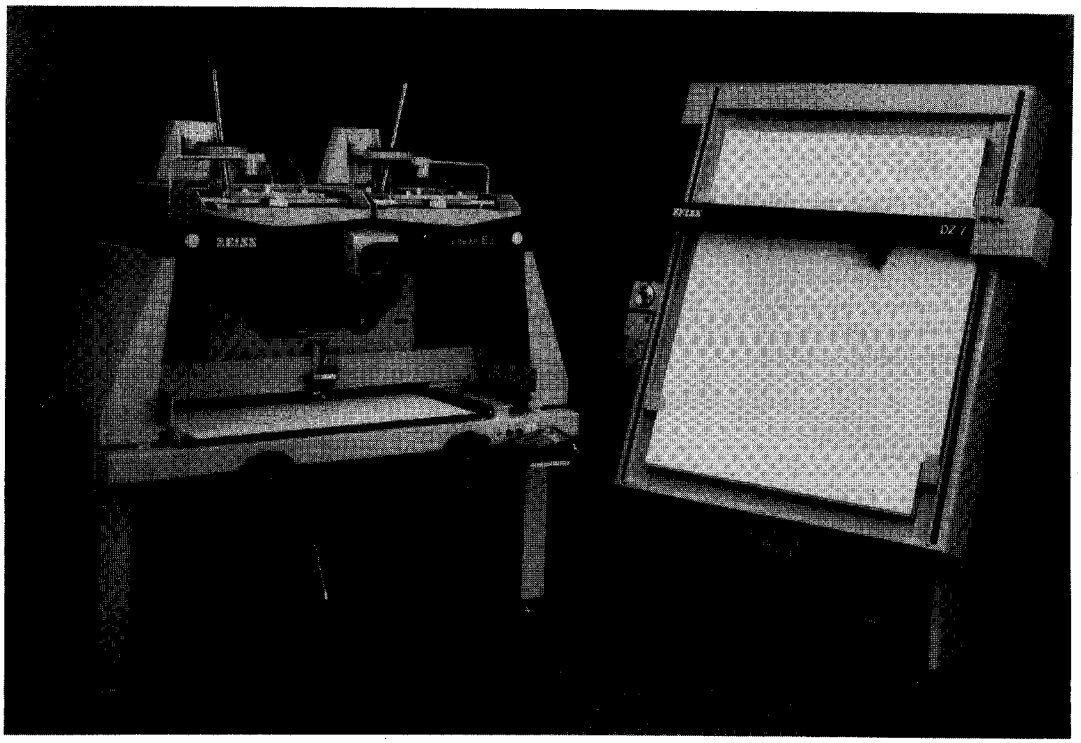

Fig.2: DZ 7-A with PLANICART E-3

MAPPING FORMAT: 932 MM (X), 1192 MM (Y)
RESOLUTION: 0.01 MM
AVERAGE MAPPING ERROR $\leqq \pm$ 0.05 MM
DEVIATION FROM RECTILINEARITY $\leqq \pm$ 0.02 MM
MAXIMUM MAPPING SPEED DURING VECTOR OPERATION:
100, 140, 280 MM/SEC
MAXIMUM ACCELERATION: 0,7 M/SEC^2
TRACING HEAD: A MAXIMUM OF 3 PLOTTING TOOLS, MAX.
LOWERING FREQUENCY 30 HZ
EVENNESS OF PLOTTING SURFACE: $\pm$ 0.2 MM
INCLINATION OF TRACING TABLE: 0 - 70^0

Fig.3: Technical data of DZ-7

STANDARD OPERATING FUNCTIONS

IN	INITIALISATION	INITIATING STANDARD PARAMETER
PU	PEN UP	TRACING TOOL UP
PD	PEN DOWN	TRACING TOOL DOWN
SP (I)	SELECT PEN	SELECTION OF TRACING TOOL I
VS (I)	VELOCITY SELECTION	SELECTION OF MAPPING SPEED I
IW (X_1,Y_1,X_2,Y_2)	INPUT WINDOW	INPUT AND SUPERVISION MAPPING AREA AND STOP POSITIONS
OD (X,Y,P)	OUTPUT DIGITALIZATION	TRANSFER OF POSITION X, Y AND THE STATE P OF THE TRACING TOOL TO THE COMPUTER

MOVEMENT INSTRUCTIONS

PA (X, Y)	PLOT ABSOLUTE	MAPPING OF A POINT; X, Y RELATED TO REFERENCE POINT
PR (ΔX,ΔY)	PLOT RELATIVE	MAPPING OF A POINT; ΔX,ΔY RELATED TO THE LAST POINT
PS (ΔX,ΔY)	PLOT SHORT	AS FOR PR BUT WITH START-STOP OPERATION

LINE TYPES, CHARACTERS AND SYMBOLS

LT (I,L,G)	LINE TYPE	SELECTION OF LINE TYPE I, DETAILS OF LINE GAP LENGTHS L RESPECTIVELY G
SM (I)	SYMBOL-MODE	TRACING OF LINES WITH SYMBOL I
LB (ASCII	LABEL	TRACING OF ALPHANUMERICAL CHARACTERS AND SINGLE SYMBOLS
SL (α)	SLANT	SLANT α OF THE CHARACTER
SI (H,B)	SIZE	HEIGHT H AND WIDTH B OF THE CHARACTER
DI (R,R)	DIRECTION	INCLINATION OF THE CHARACTER SEQUENCE
SY (S)	SYMBOL SIZE	SIZE S OF THE SYMBOL
SD (R,R)	SYMBOL DIRECTION	DIRECTION OF SYMBOL

Fig.4: DZ-7 instruction set for graphic functions

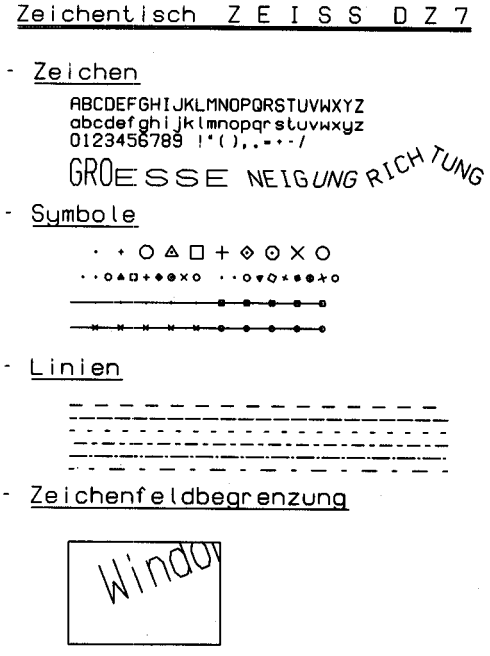

Fig.5: DZ-7 Graphic functions

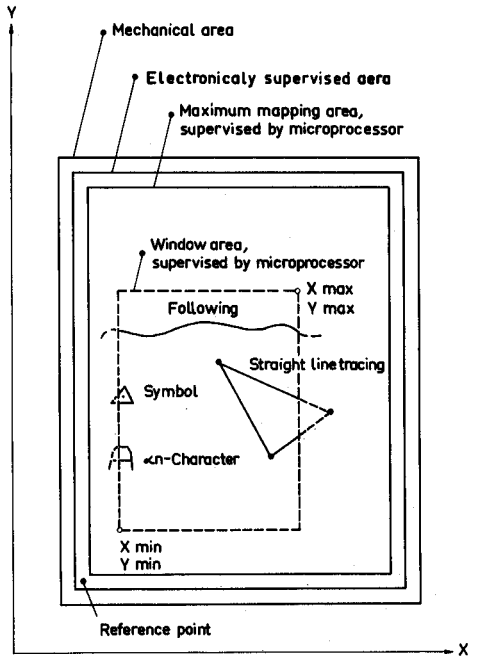

Fig.6: Terminal position system and windowing function

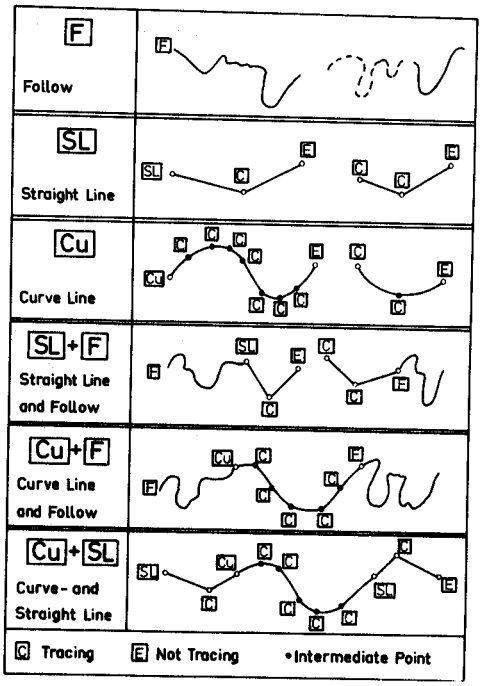

Fig.7: DZ 7-A Operating modes

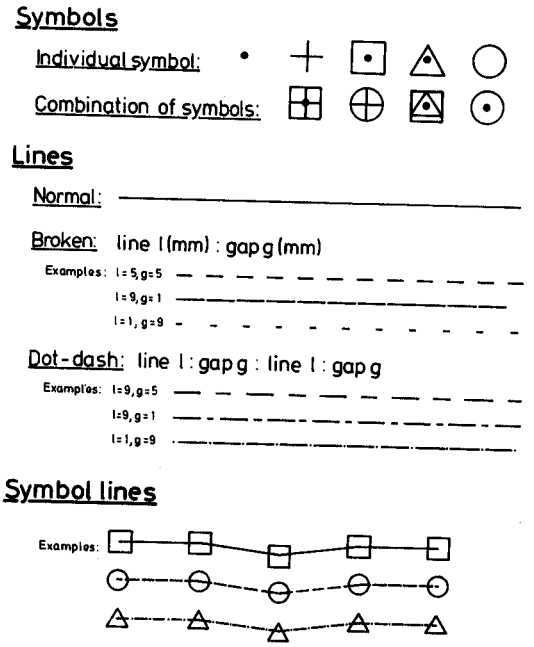

Fig.8: DZ 7-A Symbols and Types of Lines

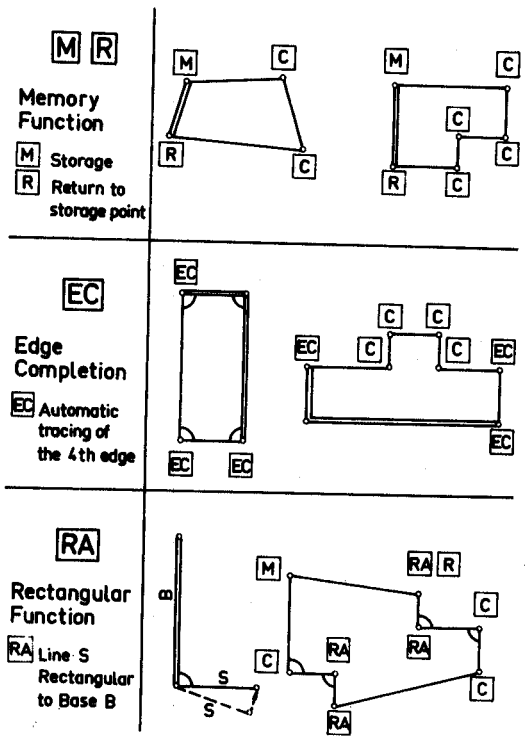

Fig.9: DZ 7-A Building functions

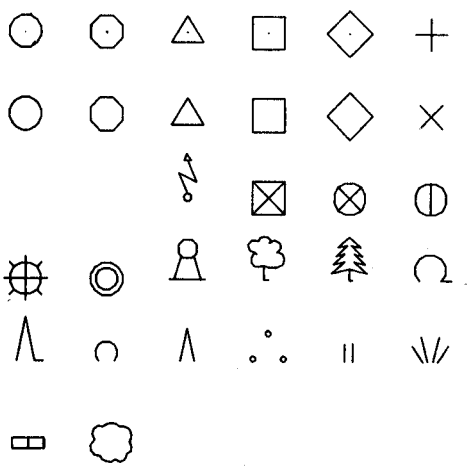

Fig.10: C-100/DZ 7-P Symbol set

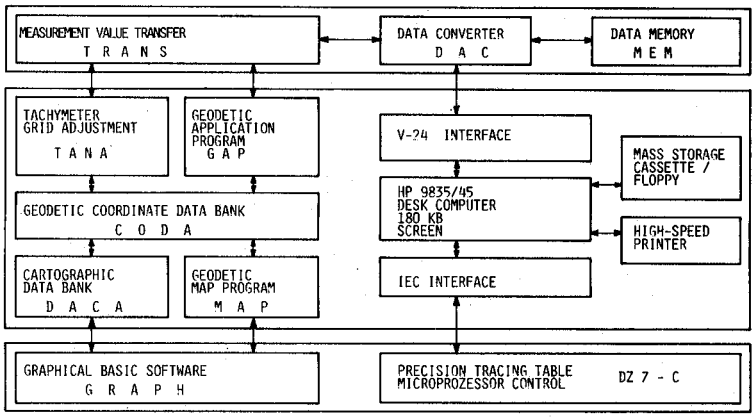

Fig. 11: Software diagram, GEOS-System

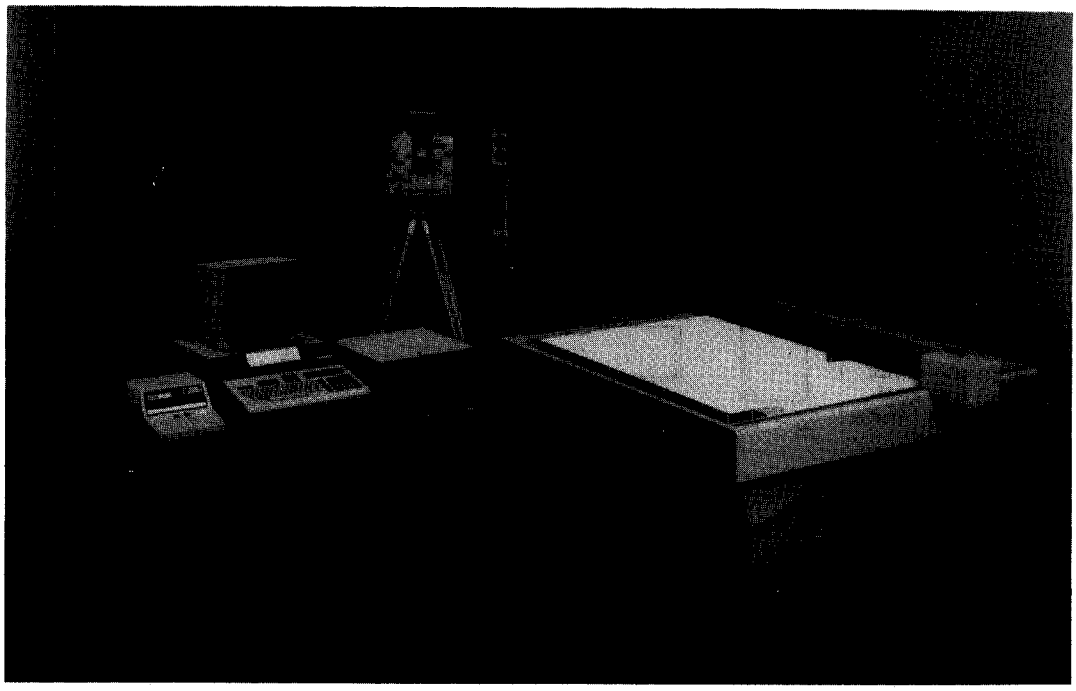

Fig.12: GEOS-System (hardware) with ELTA 2

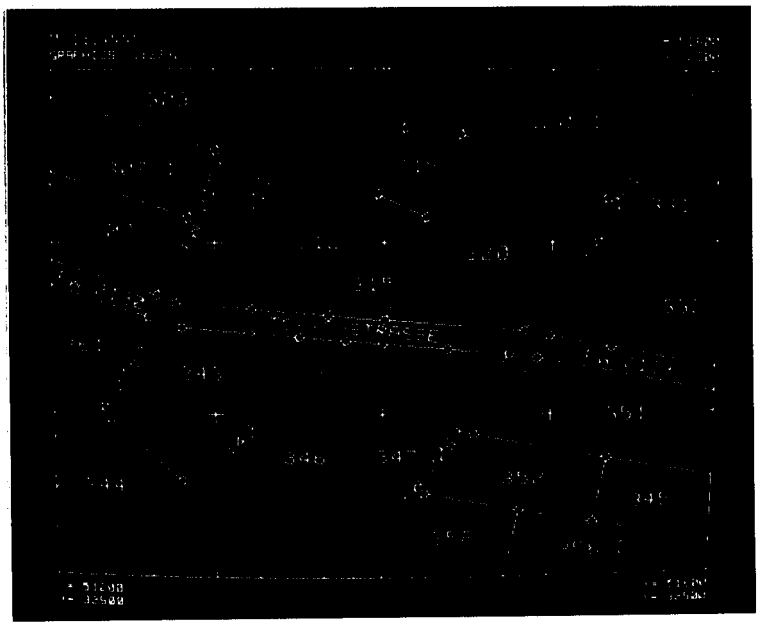

Fig.13: GEOS: Edition of mapping datas by means of graphical CRT

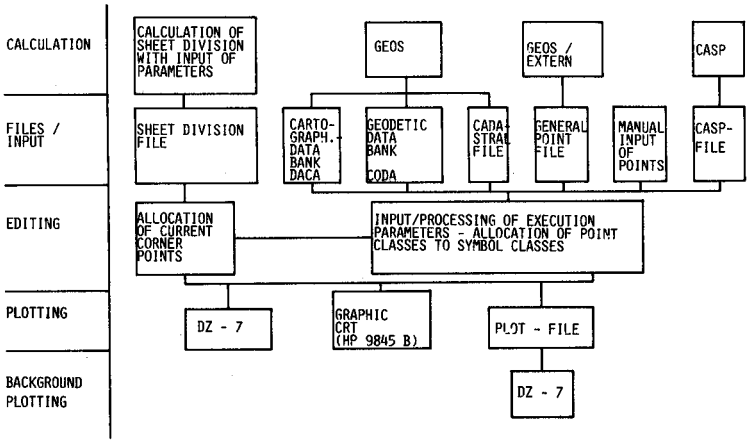

Fig.14: GEOS: Structural diagram of MAP