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Rationalization of map production and map revision with modern automated and digitized photogrammetric instruments and technologies

Abstract

The instrument makers hold a key position in the further rationalization of surveying. Especially photogrammetry can still make a considerable contribution to the automation and acceleration of map production by new and more advanced techniques and instruments. Along with the development of new instruments and equipment for digital techniques, orthophotography and compilation from photographs taken with space-born cameras, appropriate methods and processes must simultaneously be developed.

By reasonable cooperation and gearing of all activities it will be possible to assist development countries in making headway in cartography and to solve the likewise extremely large tasks in the highly industrialized states.

1. Introduction

To speed up and rationalize map production is a fundamental task in surveying as a whole.
The demand for maps and cartographic data is steadily growing throughout the world. The requirements for quality, accuracy, information content and up-to-dateness of maps increase more and more. It can already be foreseen that with conventional surveying and photogrammetric instruments and techniques the requirements cannot be fulfilled.

It is apparent from latest statistical data compiled by the United Nations /6/ (Table 1) that some areas of the earth's surface have been mapped to a rather large extent -

e.g. Europe with 60 - 80 % at the map scales mentioned

while the cartographic coverage of other regions is completely insufficient -

e.g. Africa and South America with 0.3 to 18 % of their territories.

Assuming a time schedule of ten years and employing conventional techniques (e.g. manual-visual stereoplotting), some ten thousand plotting instruments and operators would be required to make up arrears in mapping. Implementation of plans on this basis is not possible because of the lack of skilled operators and the high investment involved.

Therefore, for solving the world-wide tasks of cartography, novel equipments and techniques have to be employed.

- A method with nearly unlimited possibilities is the taking of photographs from satellites and the use of these pictures for map production and map revision. First experiences gained with the MKF-6 multispectral camera (Fig. 1), / 2/ developed in Jena allow the conclusion that photographs taken with a space-borne MKF-6 can be used for cartographic work at scales of 1 : 50 000 or greater.

- The increased application of aerial triangulation with higher accuracies of coordinate measurement and point transfer and more universal computer programs must and can be realized with the aim of further reducing the rather expensive establishment of control points by ground surveying methods.

- Computer technology is increasingly integrated in the process of stereoplotting. Especially in the production of large-scale town plans and cadastral maps, the compilation of digital data on the stereoplotter, their computerized processing and the subsequent numerically controlled mapping have led to a more favourable organization of work and to economic advantages. The result obtained is a printable original which does not call for additional and expensive cartographic revision.

- The introduction of orthophotography into map production and map revision has already made relatively large strides. The economic advantages and time savings of this technique are unquestioned.

Orthophotography still has untapped potential with regard to

automation by image correlation,
work organization in on-line or off-line systems,
stereoorthophotography, and
colour orthophotography.

In all these domains and many other fields not mentioned here there are possibilities for instrument makers and work organizers to develop and advance systems and methods which will rationalize and accelerate map production.

2. Aerial photography

The internationally standardized cameras with the format 23 cm x 23 cm (9" x 9") and the calibrated focal lengths

9 cm - superwide angle
15 cm - wide angle
30 cm - normal angle (Fig. 2) /7/

have well proven as standard aerial photographic equipment. In Europe, Japan and other regions where preference is given more and more to large map scales (1:2500, 1:1000, 1:500) in cartographic work, normal-angle cameras are increasingly used.

Generally, aerial cameras have in recent years been advanced with regard to their optical and geometrical performance and their degree of automation.

For the planning of mapping work and map revisions at scales from 1:50 000 to 1:250 000 space photography from satellites will have to be considered in future. It can be assumed that already within the next years such photographs will generally be available with the necessary photographic and geometric quality. The application of photographs taken from satellites offers further possibilities of increasing the economy of mapping.

3. Aerial triangulation

In aerial triangulation important strides were made towards an increase of performance which were primarily due to two developments:

- improvement of program technology by eliminating all determinable systematic errors and by using block adjustment
- development of point transfer instruments of higher accuracy.

Referring to the last point we have to mention especially the LASER-TRANSMARK B (Fig. 3). This instrument with a mean coordinate error for point transfer of $\pm$ 2 µm or less is matched to the accuracy of the aerial photographs and the mono- and stereo-comparators, whose accuracy lies in the same order of magnitude. With the point transfer devices mainly used in the past, employing mechanical or thermal marking, the accuracies achieved were considerably lower.

Further and nearly unlimited development possibilities consist in aerial triangulation with photographs taken from satellites. With this technique it will be possible to provide large areas with uniform and homogeneous control networks. Both the required instruments and programs are available, the latter needing possibly an appropriate modification.

4. Stereoplotting

To rationalize stereoplotting, great efforts are being made by instrument makers with regard to

- increase of stereoplotter accuracy,
- extension of the range of calibrated focal lengths (superwide angle to normal angle),
- extension of the range of magnification from photo scale to map scale,
- improvement of operating conditions by motor drives, concentrated grouping of controls etc.,
- further accessories for mapping, engraving, recording,
- production of mapping systems with interfaced electronic data processing equipment.

Development of optical-mechanical stereoplotting instruments

- The large and relatively expensive PRECISION STEREOPLOTTING MACHINES are primarily used for aerial triangulations with independent models, for large-scale mapping (town plans and cadastral maps 1:500 to 1:2500) and for numerical compilation of models. The latest design from Jena is the STEREOMETROGRAPH G /4/. To give an example of the efficiency of this instrument in practical use, users in Canada made more than 20 model measurements in one shift of aerial triangulation with independent models.

- A typical representative of STEREOMAPPING STEREOPLOTTERS, a special version of the TOPOCART C was coupled with an electrically controlled DIGITAL DRAWING TABLE (Fig. 4). With this equipment, tried out in USA, large-scale mapping is considerably accelerated.

Parallel to this development, conventional coordinatographs with direct mechanical or electrical connection will certainly preserve their importance for a very long time, especially because of the lower purchase price and higher accuracy.

- For mapping at medium and small scales, for mapping work in forestry, agriculture, water supply, geology, for the training of operators etc., TOPOGRAPHIC STEREOPLOTTERS are used, such as the TOPOFLEX (Fig. 5). These instruments are distinguished especially by simple operation and low cost.

5. Production of orthophoto maps

Orthophoto maps, i.e. orthophotos with imprinted contour lines, grids and other relevant data, can be produced considerably more quickly and more economically than line maps.

According to practical experiences the savings in time and costs are 10 - 90 % depending on the field of application, the equipment and the organization of work flow. Which possibilities for the further rationalization of orthophoto mapping exist at present?

5.1. On-line orthophotography with manual-visual profiling

The publication of the results of a comprehensive international comparison test for orthophoto equipment by the Canadian National Research Council /1/ in 1976 reveals that orthophoto instruments with orthogonal optical projection, such as TOPOCART-ORTHOPHOT (Fig. 7), ensure optimum image quality and optimum accuracy. Therefore, it is instruments of this type from which further rationalization and increase of efficiency will proceed. Most orthophoto equipments used in the world at present operate on the on-line principle. This means, after an operating time of 1 to 4 hours one orthophoto is obtained per model - in most cases directly at the map scale.

5.2. Off-line orthophotography

For the production of large quantities of orthophotos this technique offers the following possibilities for extending application and for rationalization:

- Thanks to the digital storing of profile data the manual-visual profiling can be dispensed with in the case of a repeated production of orthophotos of the same terrain.
- Where terrain surfaces are critical, a better image quality and higher projection speed can be achieved by the digital storing of profiles, mathematical conversion of the data by a computer and orthophoto production by using cross-slope correctors.
- Profile data required for orthophoto production can be taken from data banks or derived from existing maps by digitization of the relief.
- Due to the digital control of orthophoto equipment such as ORTHOPHOTO C and D (Fig. 8) with a DIGITAL CONTROL UNIT, orthophotos can be produced from whole aerial photographs instead of from the model area only.
- Using the digital control unit in conjunction with ORTHOPHOT C or D, STEREO ORTHOPHOTOS can be produced, i.e. the required orthophotos and stereomates.

These manifold combinations allow the adaptation to nearly all practically occurring tasks and an optimal organization of the work flow (Fig. 7).

5.3. Orthophoto production with automatic image correlation

Of the numerous efforts made with the aim of achieving a maximum automation of photogrammetric plotting, only the profile scanning of stereo models with electronic image correlators has so far led to practicable solutions. A highly economic instrument equipment with automatic image correlation for the production of orthophoto maps is the TOPOMAT designed in Jena /5/, (Fig. 9). In this instrument system the profile scanning of the stereo model, the exposure of the orthophoto, and the graphical representation of the relief by dropped lines or the numerical recording of the profiles are performed fully automatically. In comparison with the manual-visual differential rectification, the most remarkable difference is that the automatic system is capable of speeding up operation by a factor of 2 to 2.5.

The TOPOMAT is a universally applicable equipment (stereo plotting, manual-visual orthophoto production, automatic orthophoto production, digital recording) which satisfies to a remarkable degree the requirements for automation and economy.

6. Map revision

With the steadily increasing amount of existing maps the requirement for a revision of such maps grows proportionally. Besides, the economic growth in all countries is accompanied by increasing demands for higher quality and up-to-dateness of the cartographic material. From all this finally results an overproportional accretion of the tasks for map correction and revision.

The present situation in this field and the possibilities for rationalization of work can be analyzed as follows:

- Map revision by field comparison and subsequent ground surveys: possible only in exceptional cases and with small objects because of the high costs.
- Magnification or rectification of aerial photographs to the map scale and graphical transfer of changes into the map originals: applicable only for relatively flat terrain, in which case the method is extremely economical.
- Stereoplotting: economical only for revisions on a large scale with specialized stereoplotters. To satisfy these conditions the TOPOFLEX (Fig. 4) was developed.
- Differential rectification: The orthophoto technique which is favourable with regard to the expenditure of time and cost compared with stereoplotting finds practical application for map revision in regions with numerous or comprehensive changes in nature.
- Map revision on the basis of data banks: A further rationalization of map updating is made possible by the ecological data banks projected for the future to be used for towns and countries.
- Map revision with photographs taken from satellites: If in the near future such photographs taken at regular periods will be available, possibilities will be provided by magnification, rectification or differential rectification to produce maps quickly, comprehensively, and economically at a scale of 1:50 000 or perhaps even larger.

Table 1

State of mapping of the earth's surface, 1976 /8/

Region	Mapped area (%)			
	1:1250-1:31680	1:40000-1:75000	1:100000-1:126720	1:140000-1:253440
Africa	0.3	24	10	75
North America	23	51	8	90
South America	9	6	18	18
Europe	75	70	63	88
Asia	12	55	13	88
USSR		40	100	100
Oceania	18	32	20	100
World	12	36	35	80

References

/1/ Blachut, T.J., van Wijk, M.C., Results of the International Orthophoto Experiment 1972-76. Presented Paper, XIIIth ISP Congress, Helsinki 1976, Commission II, NRC-Publication 15362

/2/ Joachim, R., Some information from the common space-experiment USSR/GDR with "Soyuz 22" 24 Rassegna Internazionale Elettronica, Nucleare ed Aerospaziale, Roma 1977

/3/ Marckwardt, W., The production of stereo orthophotos with the TOPOCART-ORTHOPHOT C instrument system from Jena
Jena Review 22 (1977), No. 2, p. 64-69

/4/ Starosczik, H., Advanced Stereometrograph Model G with novel fast motion. Jena Review 22 (1977), No. 2, p. 76-78

/5/ Szangolies, K., Kunze, W., TOPOMAT - a New Fully Automatic Photogrammetric Restitution System. Presented Paper, XIIIth ISP Congress, Helsinki 1976, Commission II.
Jena Review 22 (1977) No. 2, p. 55-63

/6/ UN ECOSOC, The Status of World Topographic Mapping. 8th UN Regional Cartographic Conference for Asia and the Far East, Bangkok 1977

/7/ Würtz, G., New developments of equipment for aerial photography of JENA works from 1972 to 1976.
Jena Review 22 (1977 No. 2, p. 79-83

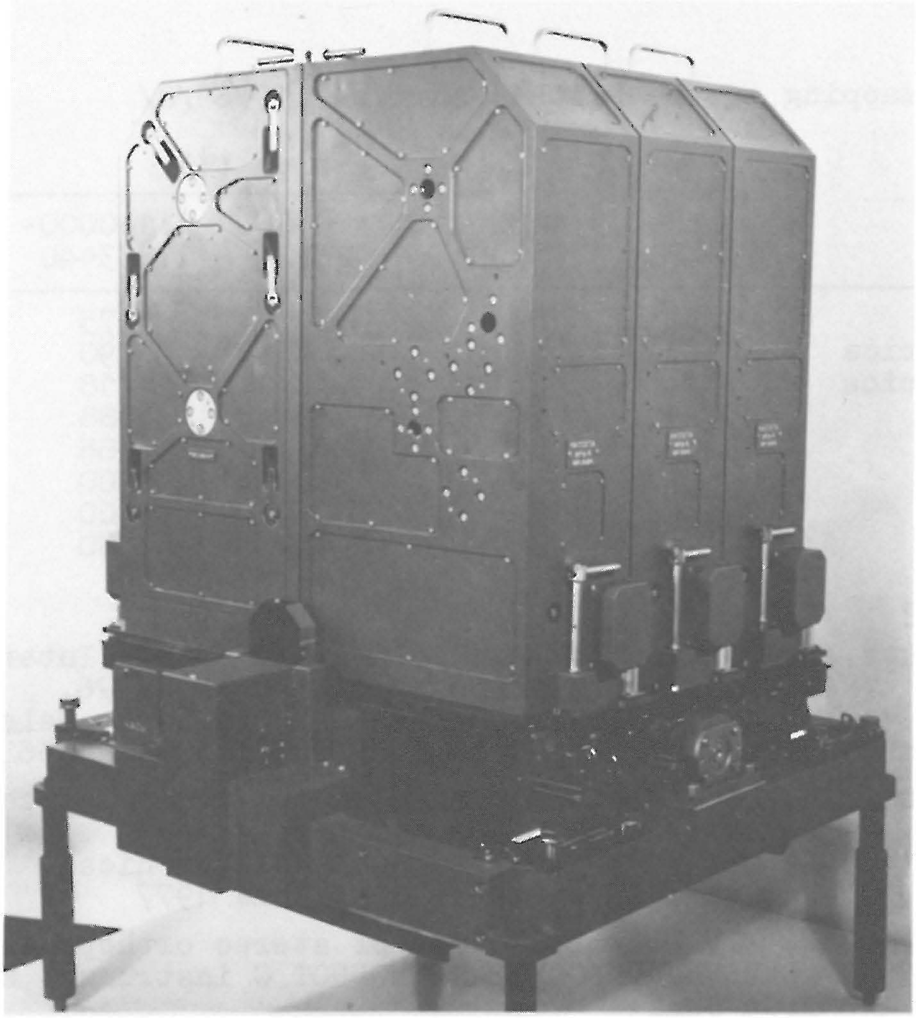

Fig. 1 MKF-6 Multispectral Camera

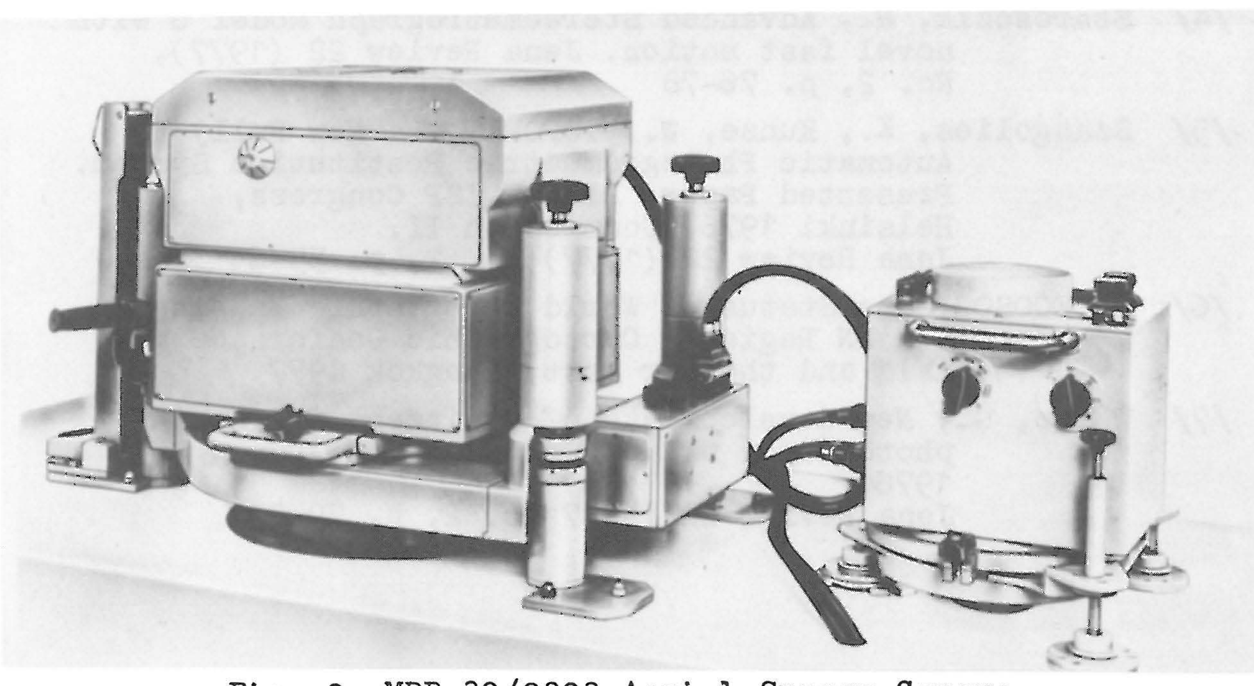

Fig. 2 MRB-30/2323 Aerial Survey Camera

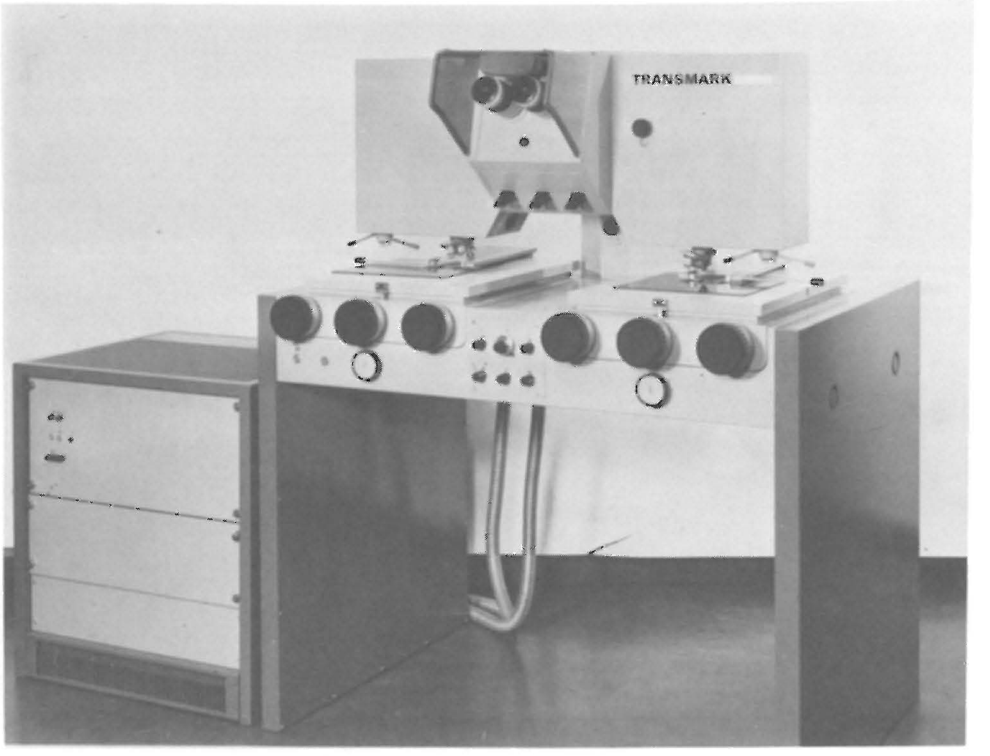

Fig. 3 TRANSMARK-B Point Transfer Machine

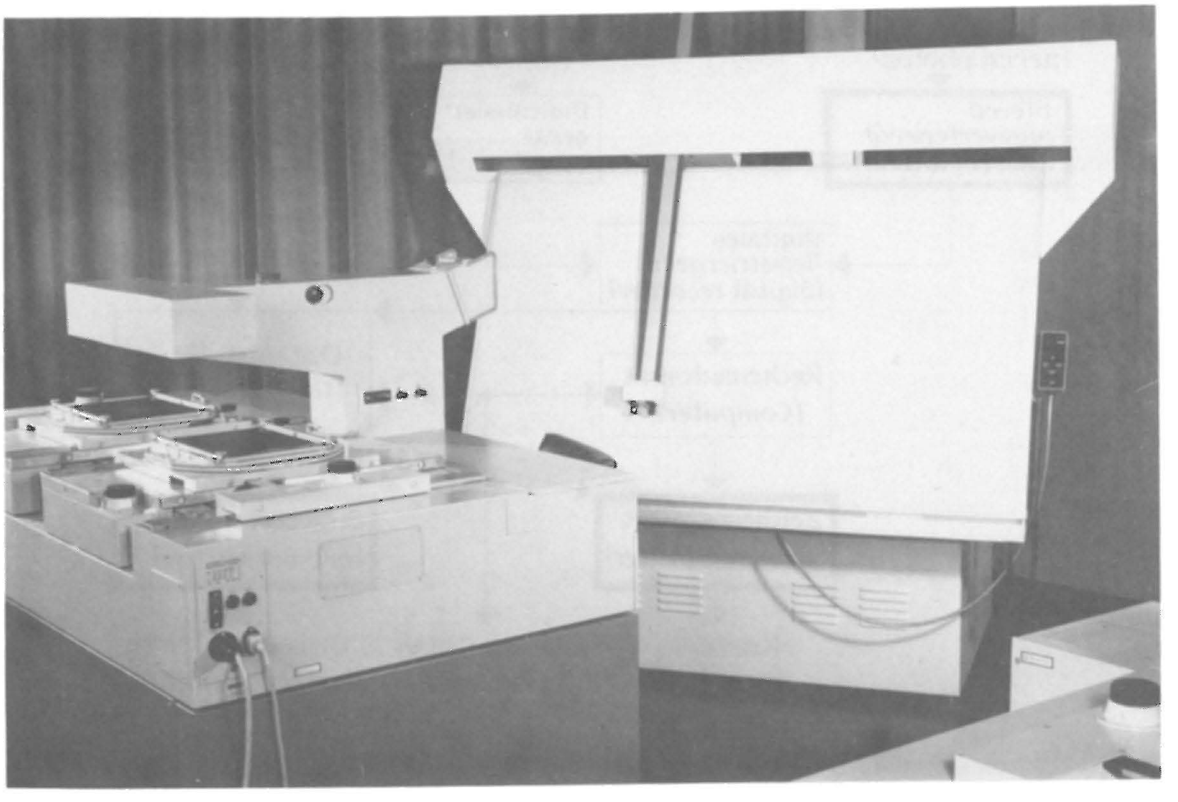

Fig. 4 TOPOCART-C with Data-Tech drawing table

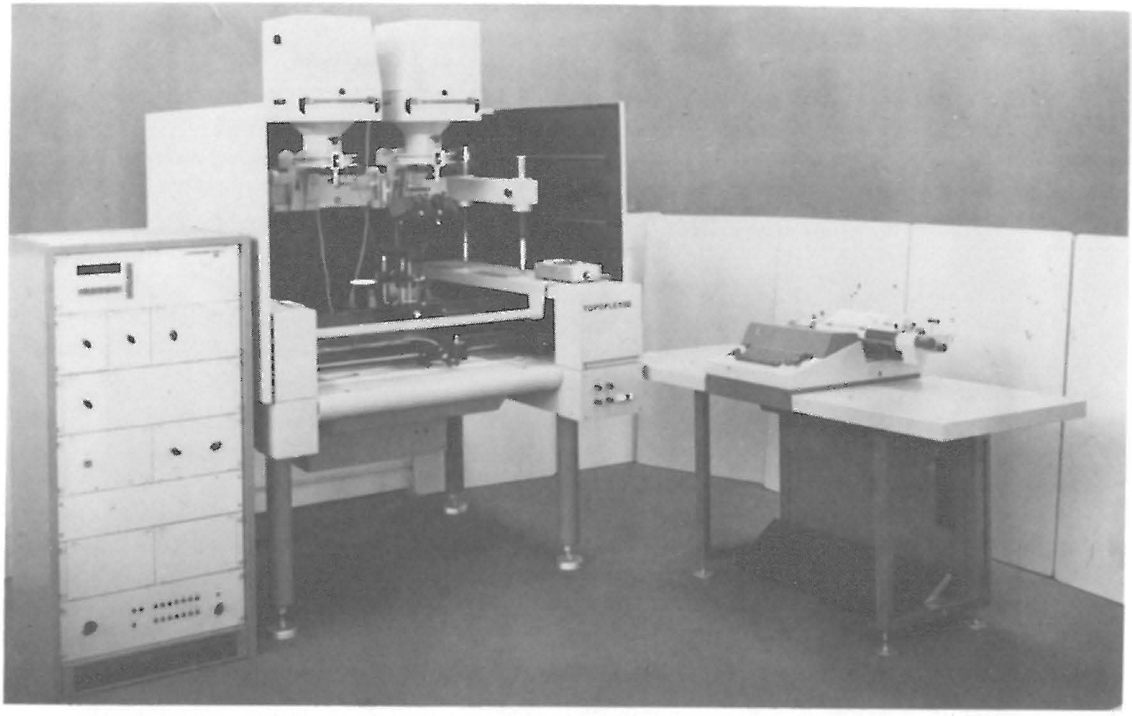

Fig. 5 TOPOFLEX Topographic & Map Revision Plotter

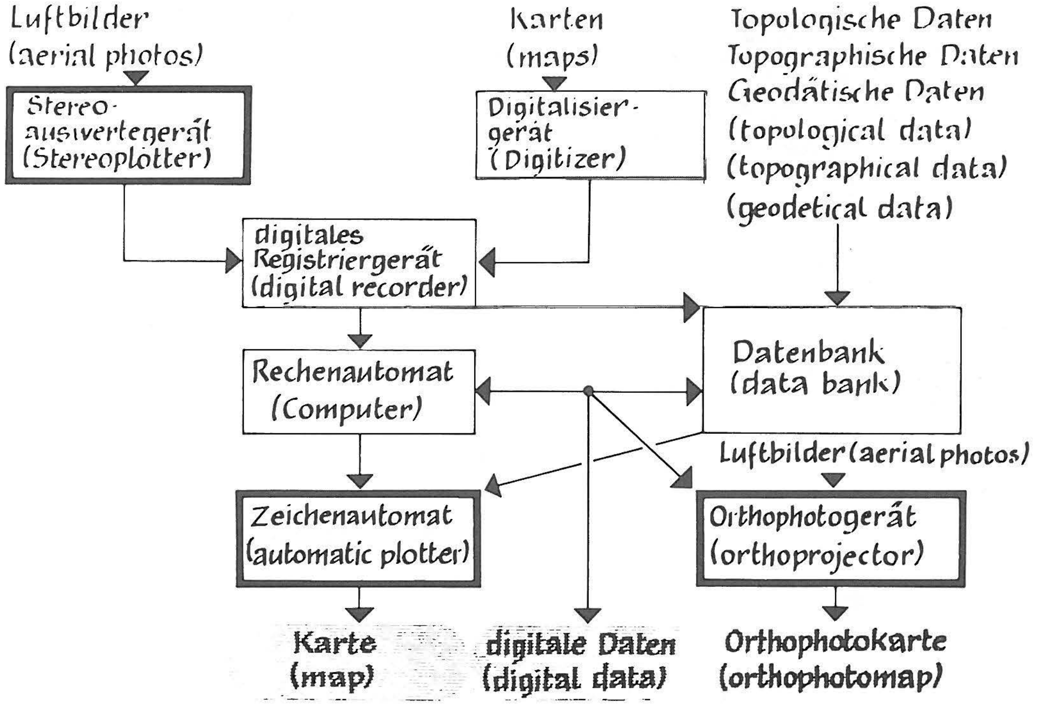

Fig. 6 Digital stereomapping

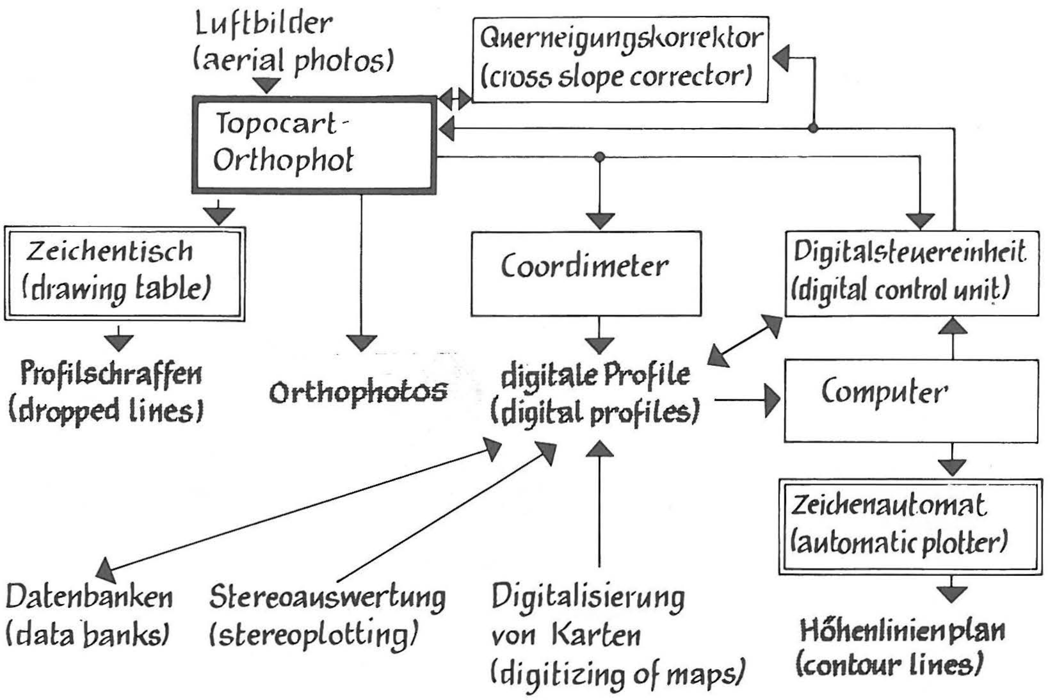

Fig. 7 Orthophotography

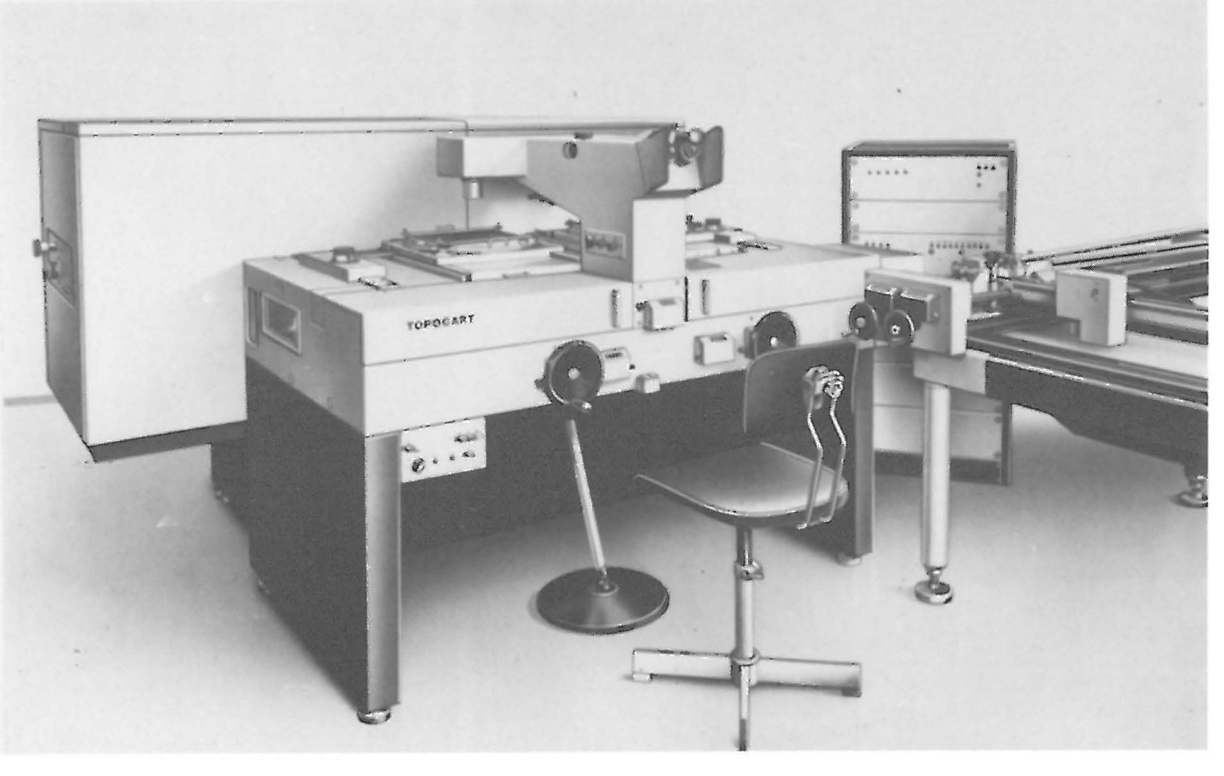

Fig. 8 TOPOCART/ORTHOPHOT-B

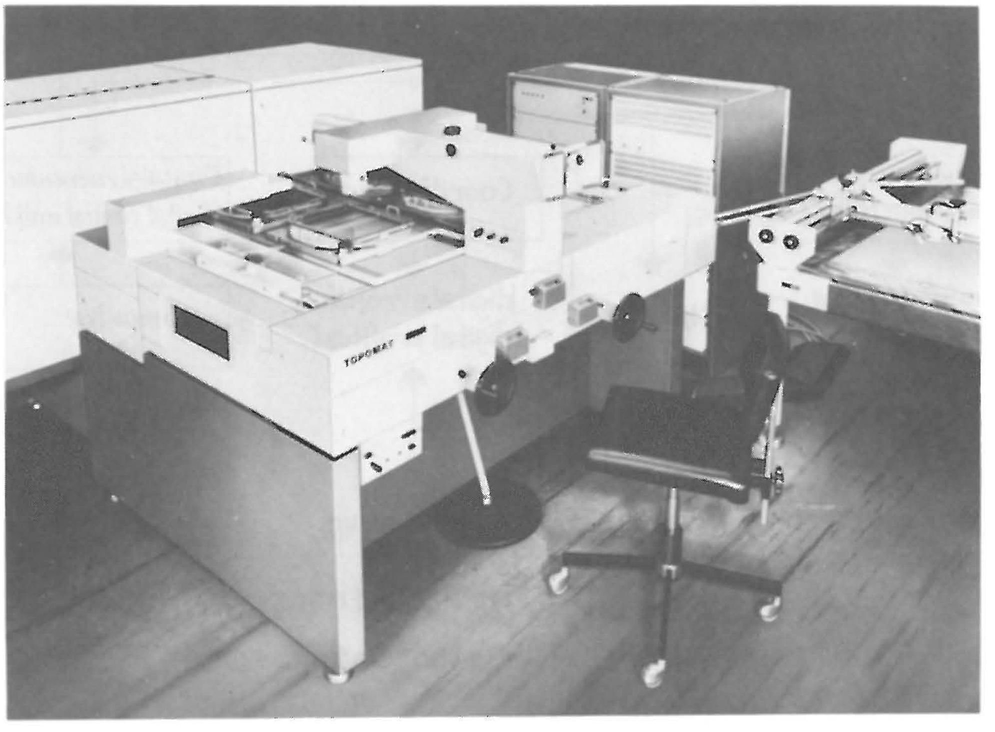

Fig. 9 TOPOMAT