Commission II

Theory, Methods and Instruments

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INTRODUCTION

During the period 1968-1972, Commission II of the International Society of Photogrammetry was awarded to the German Federal Republic. Under the chairmanship of its president, Prof. Dr. H. DEKER, University of Darmstadt, and the secretary, Dr. J. HOTHMER of the Institut für Angewandte Geodäsie, Frankfort, two business meetings and seven technical sessions were held in Ottawa, of which three jointly with Commission IV.

The traditional area of Commission II is "Theory, Methods, and Instruments" and it is the largest of the seven ISP-Commissions. Therefore, the subjects discussed at the seven technical sessions are, to some extent, inconsistent with this. The following problem areas were selected following the intercongressional symposium of the Commission, held in 1970 in Munich.

Development of Instruments from 1968 to 1972
Standard Tests for Photogrammetric Instruments
Automated and Analytical Instruments
Methods and Instruments for Restitution of Space Photographs

The sessions held jointly with Commission IV:

Digitizing and Automation of Photogrammetric Instruments
Methods and Instruments for the Production of Orthophotos
Methods and Instruments for Multi-Media Photogrammetry and Remote-Sensing

This selection of problem areas combines traditional items with a number of new, not to say futuristic, subjects. Studying, however, the programme of all seven Commissions, it is felt that it could have been improved by a more project-oriented rather than the strictly Commission-oriented approach. As an example, although papers on the subjects of Space Photography and Remote Sensing were presented to four different Commissions, coordination existed only between Commissions II and IV. It is hoped that at future congresses, coordination between the Commissions will improve.

The technical sessions were dominated by the Invited Papers since, with a few exceptions, no Presented Papers were read. Although the attendance was in general very good, the absence of lively floor discussions is regretted. It is difficult to voice a general opinion on the activities of Commission II. The accent seemed to lie in sophisticated developments in the field of automation, space photography, and radar, very little attention being paid to photogrammetric practice. This appears to be an over-reaction since these items were somewhat neglected at the previous Lausanne Congress.
An obvious trend towards increased computerization was noticeable in the fields of Commission II such as digitizing, hybrid instrument systems, automated contouring, etc. Forecasts as to the future of automated photogrammetry were very optimistic, although the breakthrough in analytical plotters has still to come.

In the following discussion of the scientific programme of Commission II, the subjects will be treated in the order as indicated above, with the exception of the topics digitizing and orthophotography, which are treated in the report of Commission IV.

INSTRUMENT DEVELOPMENT FROM 1968 TO 1972

The first session of the Commission II was devoted to the topic "New instrument developments". Two invited papers were presented on this topic: MAKAROVIČ reporting on developments in Europe and Asia and BUCCI on developments in North America.

In Europe and partly in Asia, the developments have been typically, optimization of existing instrumentation, trends towards completion of production lines, increased incorporation of digital equipment components, and attachable orthophoto and associated units.

The development has encompassed a wide range of equipment, covering projection type, hybrid, and digital type (analytical) instruments.

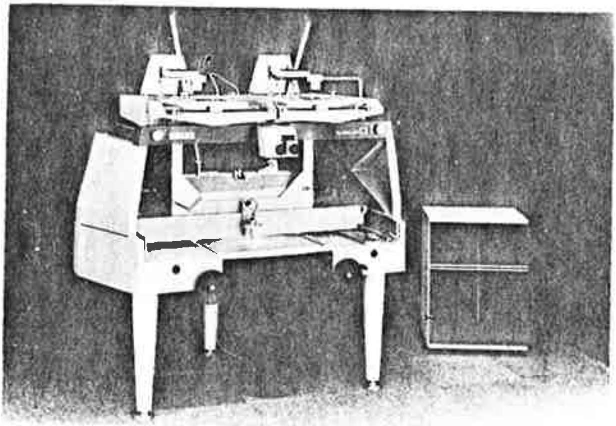

Fig. 1 Zeiss E2 Planicart

In the area of projection type instruments the development was twofold: new instrument types and optimization of the existing ones. Clear limits cannot be drawn between the two categories. The new types are the Zeiss Ob. E2 Planicart, the Matra/SFOM 920 Stereoplotter, and the Sokkisha SP 100 Stereoprojector. The Zeiss E2 Planicart is a simplified version of the D2 Planimat, adapted for the compilation of line maps (at scales 1 : 2,000 - 1 : 50,000) and for map revision.

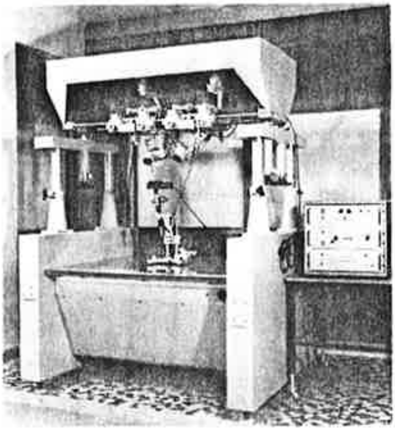

Fig. 2 Matra/SFOM 920 Stereoplotter

The Matra/SFOM 920 Stereoplotter is an improved model of the earlier Kelsh type plotter made by SFOM. Improvements concern the illumination, projector lenses, and the attachable SIA (Stereo Image Alternator) kit for observation. A digital output system (in three versions) and an orthophoto printer can be attached.

The Sokkisha SP 100 Stereoprojector, which is similar to the Zeiss Ob. DP-1 Double Projector, is intended mainly for plotting line maps at scales 1 : 20,000 - 1 : 50,000. The tracing table is provided with an electric motor drive for tracking in height, and the observation is in polarized light.

The reasons for modifying the existing instrument types have been: to improve the performance, reliability, operational and human engineering characteristics, and to increase their internal and external compatibility.

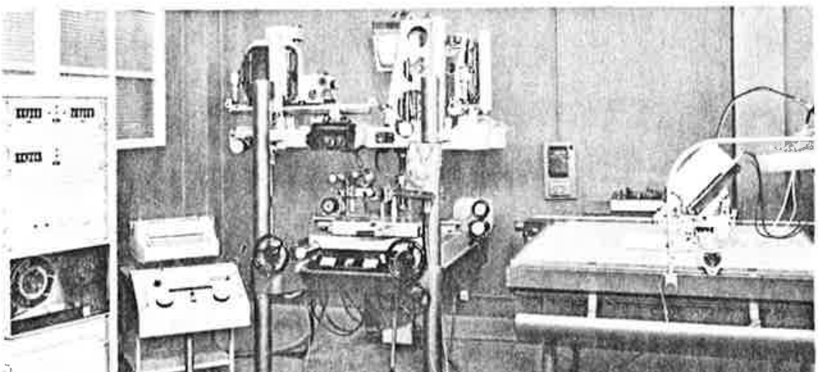

Fig. 3 SOPELEM Presa 225 RC

Improvements to the Wild A 10 Autograph concern mainly the drawing table and its connection with the instrument. The Zeiss Ob. D2 Planimat has been adapted to enable plotting from terrestrial photographs. The SOPELEM Presa 225 RC is equipped with absolute linear digitizers, digital displays, an electronic height computer, and remote controls for K-rotations.

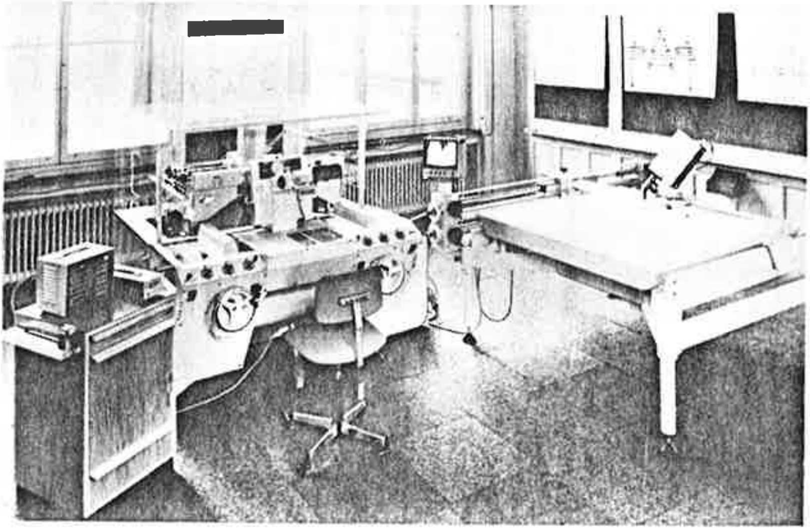

Fig. 4 Kern PG 3

The Kern PG 3 has been adapted for terrestrial and narrow angle photographs, and enables coupling of some orientation parameters. The measuring device remains active during fast free-hand tracking. A closed circuit TV set can be attached to the drawing table. The Zeiss Jena Stereometrograph F can now also use narrow angle photographs. The driving agents X, bx, and Y, by are arranged symmetrically on the panel, and are equipped with digitizers (for comparator operation). Special X, Y-gears are provided for large transmissions from model to map.

The Nikon M5 Plotter, employing a two stage mechanical projection system (i. e. rectification, projection), has increased ranges for the orientation parameters, control parameters, and for the drawing table.

The Wild B8 S Aviograph has an improved stability, increased Z-range, and provides for better comfort of operation.

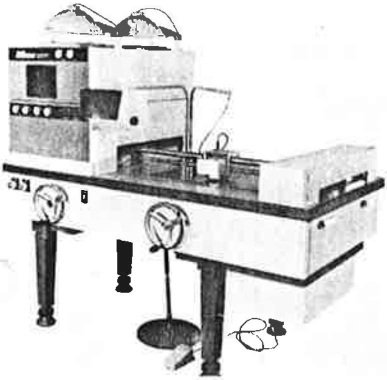

Fig. 5 Nikon M5 Plotter

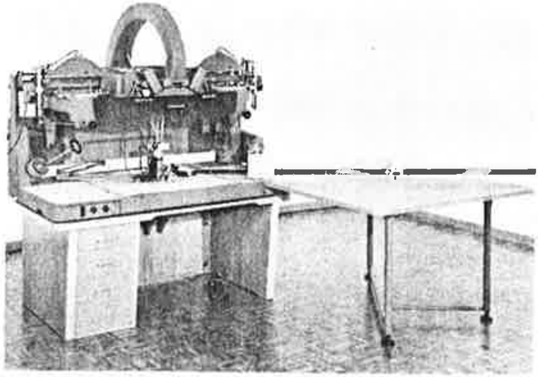

Fig. 6 Wild B8 S Aviograph

The Zeiss Ob. D. P. Double Projectors are made in different versions. The DP-16 is a van-mounted version of the DP-1, the DP-2 is equipped with X, Y-driving agents, cross-slides, and digitizers, and the DP-3 has in addition an external drawing table (with electrical transmissions).

The first instrument type, belonging to the class of hybrid plotters, was made by Messerschmidt-Bölkow-Blohm. The MBB HO-1 Plotter was designed by O. HOFFMANN. It is intended for plotting from 9"x9" near vertical and terrestrial photographs with principal distances ranging from 50-3276 mm. The HO-1 Plotter is applicable to the continuous restitution of strips, as an ordinary stereocomparator, to the compilation of planimetric line maps and orthophotographs,and to digitizing models.

The system employs a simple, spatial, mechanical projection system and an on-line, special purpose, digital computer. The computer controls the rectification and various corrections of each photograph, while the projection system solves the collinearity equations in a simplified form. The photo stages are horizontal and coplanar; their movements are fed into the computer in a digital form.

The projection system uses, in general, affinely distorted bundles. Therefore the principal distance (of the instrument) can be kept constant. The heights are scaled accordingly by the computer. The instrument can be supplemented by an on-line orthophoto printer with computer controlled optical units. The computer and plotting coordinatograph may also operate independently, e. g. for plotting contour lines or profiles from a D. T. M.

In the area of computer type instruments (analytical plotters) two significant development lines have been apparent, namely:

- complex, versatile, and high precision systems, incorporating an on-line digital computer;
- simple analogue plotters, employing mechanical computers (or correction devices) and usually implementing an approximate metric transformation. The O. M. I. Nistri AP/C-3 Analytical Stereoplotter and the Galileo D. S. Digital Stereocartograph belong to the first class, whereas the Thompson CP-1 Plotter represents the second class.

The AP/C-3 Analytical Stereoplotter is the successor of the AP/C. The Bendix special purpose AP/C computer has been replaced by the IBM 1130 computer, and the Multiplex Control Enclosure, with the corresponding interface and peripheral units. The improvements concern: reducing the time for loading programmes and for orientation computations; the performance of the servo-motors; the ease of programming, the facilities for the permanent storage of programmes, the feasibility of recording coordinates on magnetic disc (or tape), and the direct processing of the D. T. M. -data.

The D. S. Digital Stereocartograph, designed by INGHILLIERI, consists of the Galileo M. S. Stereocomparator, the Laben 70 mini-computer with corresponding interface and peripheral units, and the Galileo electrical plotting coordinatograph. Typical properties of the D. S. are the simple programming, the permanent storage of the main programmes, and the expandable storage capacity. The need for interface equipment is minimum.

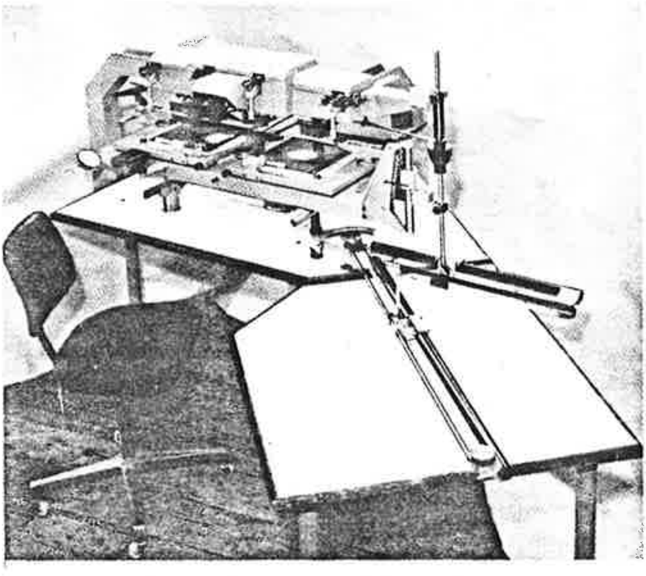

Fig. 7 Thompson CP-1 Plotter

The Thompson CP-1 Plotter, made by Cartographic Engineering, Salisbury, was designed for the compilation of line maps at small and medium scales, from 9"x9" and smaller format near vertical photographs (of any principal distance).

The mechanical computation is carried out simultaneously in two stages:

- rectification of each photograph, separately for the x and y direction (implementing a first order approximation);
- corrections for the terrain relief and transformation of scale.

The CP-1 incorporates a parallax converter. The plotting process is essentially an interpolation between given control points. The height measurements are not significantly affected by the mechanical imperfections in the tracking device, or by the magnitude of the height differences in the model. The y-parallaxes are cleared sufficiently by the relative orientation for an undisturbed stereoscopic viewing. The image quality of the observation system is high.

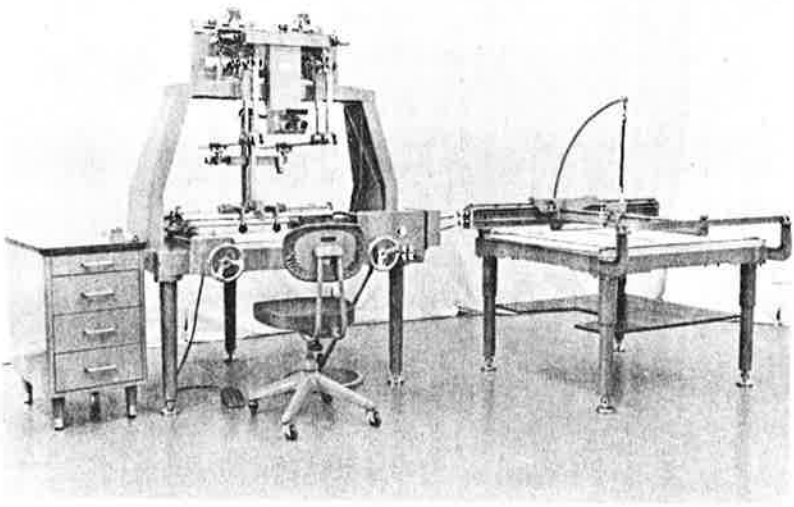

Fig. 8 Sokkisha ST-65 Terrestrial Plotter

For plotting from terrestrial photographs new instrument types were developed in Japan and Europe. These new types are: Sokkisha ST-65 Terrestrial Plotter (similar to the Wild A40 Autograph), Nikon TR-2 Plotter (similar to Zeiss J. Stereoautograph), and the Zeiss J. Technocart (simplified Topocart). They all employ a mechanical projection system with horizontal, co-planar photo-stages, and are adapted for plotting from photographs taken by terrestrial stereocameras. The latter two instrument types can employ attachments for plotting from oblique photographs with parallel principal axes.

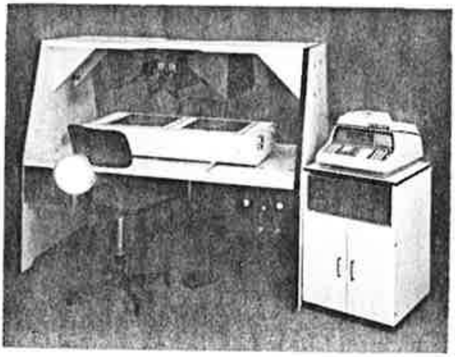

Fig. 9 Zeiss St R3 Stereo X-ray Comparator

In West Germany two new instrument types were developed for restitution from X-ray photographs, namely the Göttingen Reomat and the Zeiss Ob. St R 1-3 Stereo X-ray Comparator. In both a simple stereo-comparator can be interfaced with an off-line or on-line digital computer for sequential processing of the output data.

The development trends in Europe and Asia can be summarized as follows:

- systems approach and modular organization of equipment;
- increasing the impact of digital equipment components;
- growing diversity of instruments and peripherals, and their adaptation to specific applications;
- further optimization, particularly of operational and human engineering characteristics.

-` North America the emphasis has been laid on the development of digital and automated equipment.

Dell Foster Co. developed the R SS 600 Mono-Digital Comparator. Its measuring area is 10"x19" and accuracy $\sigma_0 = 1\ \mu m$. The measuring device uses scales with precision gratings. Granite ways and an air bearing stage are employed for tracking. Observation is done by means of binoculars or on a projection screen (or both). A zoom system enables the magnification to be varied between 5.3x and 31.5x.

Mann Co. made the Type 2405 automatic precision monocomparator. The measuring area is 9"x18"; positioning on symmetric images may be manual or automatic. The automatic control system comprises a photo-electric detector, corresponding circuit, and servo-mechanism for positioning to symmetric images (e.g. stars, signal points), drilled holes, and reseau crosses. Approximate positioning can be computer controlled.

N.R.C. Canada (MAKOW) developed a precision linear measuring device "LINCAP", which uses the electrical capacity as the measuring parameter. The accuracy is about 1 μm.

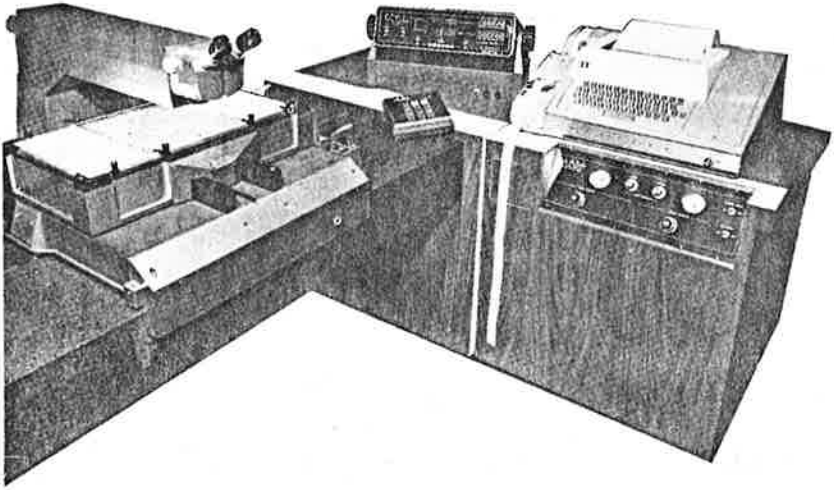

Fig. 10 Dell Foster R SS 600
Mono Digital Comparator

Ohio State University (MERCHANT) developed a new stereocomparator, the "P-CATS". This is essentially a Point-Comparator and Transfer System, suitable for point selection, measurement, recording coordinates, and for point transfer.

The U.S. Geological Survey in collaboration with the B.A.I. Corp., developed the "Image Correlator and Measuring System". A scanner generates the video signal (i.e. image signature), which is recorded in digital form on a punched card. When the conjugate image is scanned, the stored signature is regenerated and correlated with the new signature. The scanner is an annular ring with a varying diameter which can also be distorted into an ellipse for adaptation to the terrain slope.

The development of orthophoto equipment will be outlined elsewhere in this report. Some attention will be paid here only to the Hobrough G. P. M. Gestalt Photo Mapper. The G. P. M. is an automatic orthophoto printer encompassing four basic modules: the tracking and measuring module, the correlator module, the printing module, and the control module. The latter includes a console, TV-monitor, control electronics, and the Nova mini-computer. The system is an automatic orthophoto printer operating incrementally by patches. The speed of operation under normal circumstances is very high. The correlator generates heights for a multitude of points in each patch. It is intended to exploit these heights in future for the extraction of contour lines.

Bausch & Lomb introduced the Zoom Transfer Scope ZTS, a modular system adaptable to varying requirements, i. e. for map revision, map completion, and compilation of thematic maps. The ZTS is essentially a sketchmaster allowing image rotation, zoom magnification, and anamorphic stretch. These image transformations enable local matching of a photo section with the corresponding map section.

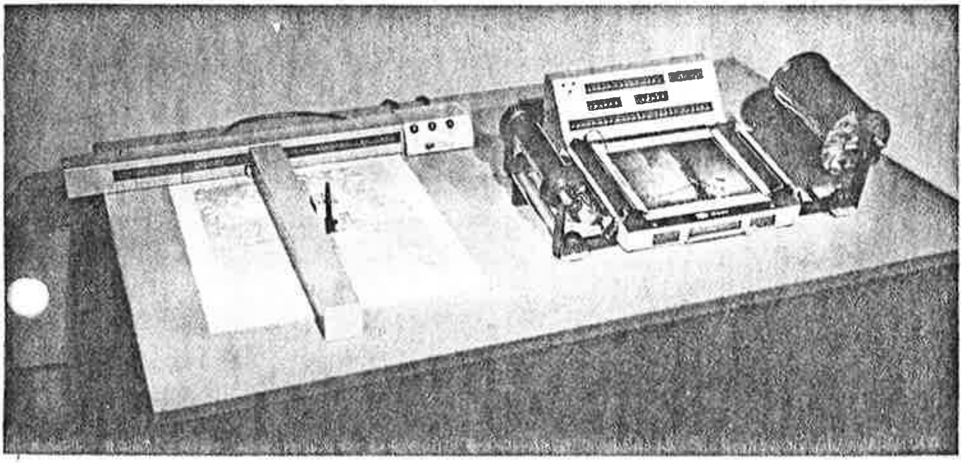

Fig. 11 Bendix LR-2 Line Rectifier

Some further important developments have been: Equipment for plotting from non-conventional images, the Bendix LR-2 Line Rectifier (digital version), P. P. V. Polarized Platten Viewer (DANKO) for the Kelsh type plotters, and various types of digitizing and recording equipment.

The trends in North America seem to be towards automation, such as: automatic pre-positioning, image scanning and correlation, on-line computer assistance, [illegible]

Hybrid systems and off-line approaches seem to be promising. Digital restitution techniques will increase in importance. Systems for handling non-conventional photography will be further developed.

The discussion at the first session was concentrated around the following topics: systems approach to the development of photogrammetric equipment (SCHÖLER), modular design principle (MEIER), optimization of equipment (BORMANN), new developments in the area of analytical plotters (HELAVA), and new developments of electronic correlators (ONDREJKA).

STANDARD TESTS FOR PHOTOGRAMMETRIC INSTRUMENTS

The second session of Commission II was devoted to the activities of the Working Group II/2, "Standard Tests". There were eight papers reporting on the work accomplished in the period 1968-1972.
DÖHLER in his invited paper summarized the history, objectives and activities of the Working Group, and elaborated on the standard tests. The basic topics of his paper are:

- improvements and completion of the tests proposed in 1968;
- execution of new tests for rectifiers, orthophoto instruments, and coordinatographs;
- experimental evaluation of the proposed tests;
- digital simulation of analogue plotters.

BORMANN and HASSLER reported on tests for analogue plotters. The data processing has been computerized. The programmes for single stage tests (Mono-Grid) and stereo tests (Stereo-Grid) are written in Basic Fortran. However, the basic set-up of the tests is as proposed by the Working Group in 1968. If the monocular grid measurements are carried out at two Z-levels, the data are subjected to a simultaneous least squares adjustment.
MARK and SCHÜRER reported on tests for mono- and stereo-comparators.
MARK proposed some modifications to the initial proposal, made in 1968.
In order to detect short periodic errors, the grid plate should be slightly turned with respect to the x, y- measuring system.
SCHÜRER developed a computer programme (in Basic Fortran) for data processing in the testing of mono- and stereo-comparators. The programme is flexible as far as the number of points and the completeness of samples are concerned. During the processing the gross errors are cleared from the observations. Processing is organized in three models: Model 1 considers only the three transformation para-

meters (two shifts and a rotation), Model 2, in addition, takes into account the scale error, while Model 3 represents a general affine transformation.

ZETH conducted a testing procedure for optical rectifiers. The partial tests cover both the image quality and the metric properties. The image quality is evaluated by means of test targets for resolving power, whereas for the metric tests a precision grid is projected, recorded photographically and measured.

ZANGOLIES proposed tests for the orthophoto and associated relief representation equipment. The tests for orthophoto printers are basically similar to those for rectifiers using resolution targets and a grid plate. In addition some dynamic phenomena have to be considered. The grid plate should be turned about 20^{o} with respect to the X, Y-system, recorded by stripwise traversing, and finally measured and analyzed for errors. A test model has been recommended for the relief representation. The results (e.g. contour lines), derived from the droplines, can be compared with those obtained by direct plotting. For routine inspection a test-model can be used, and the results of successive tests mutually compared.

MARCKWARDT reported in his paper on tests for coordinatographs (automatic and non-automatic). The integral metric tests can be similar to those for monocomparators. This would require large test grids to be measured in two positions, turned through 100^{o}. A more practical approach appears to be partial tests covering the reversal and the tracking errors, differential scale errors, non-perpendicularity, and straightness of ways. Attention was also paid to dynamic errors.

A method of simulating errors in mechanical stereoplotters by means of digital computers, was introduced by DORRER. The method implements the displacement analysis of spatial mechanical linkages. Spatial displacements and rotations can be represented by matrix equations. The flow of metric information (kinetic signals) is along chains of mechanical linkages. The position of each linkage, relative to the adjacent one, is defined by four parameters. Associated with each linkage is a coordinate system; the relative position of the two adjacent coordinate systems is determined by the transformation matrix. When the chain of linkages is closed, the product of all transformation matrices is unity.

The disadvantages of this approach are: the number of parameters is large and some instrumental errors cannot be handled.
Similarly the optical trains can be described in algebraic terms. Lenses, prisms, and mirrors are attached to mechanical links, which are determined by their (local) coordinate systems. An input ray to an optical element should be trans-

formed from the preceding to the new system (by multiplying the corresponding transformation matrices). The output ray of this element represents the input ray of the following optical element in the train. Some preliminary simulation experiments were performed sucessfully.

AUTOMATED AND ANALYTICAL INSTRUMENTS

The third session concerned the activities of the Working Group II/3, "Automated and Digital Type Instruments", and some other related papers. G. LORENZ in his invited paper reviewed the objectives of the Working Group, its activities, contributions of individual members, and outlined the directions for future work. The main areas were: design principles (JAKŠIĆ, KONECNY, MAKAROVIČ), image correlation (HELAVA), digital type equipment (HELAVA, JAKSIC, FRIEDMAN, MAKAROVIČ), digitizing and recording devices (BABOCK, DUCHER), and automated orthophoto equipment (LOVING, MAKAROVIČ).

Other related papers were: on image scanners (THOMPSON & OULETTE, HELAVA & CHAPELLE, MASRY), digital processing of image data (HELAVA & HURNBUCKLE & SHAHAN), coherent optical correlators (KOWALSKI, KRULIBOSKI & FORREST), Galileo Digital Stereocartograph (INGHILLIERI), computer assisted stereocomparator (SEYMOUR & WHITESIDE), digital line rectifier (FORREST), and on stereoplotter with on-line desk calculator (DORRER & KURZ).

Special attention was provoked by the paper on epipolar scan correlation, presented by HELAVA and CHAPELLE (a similar approach was also applied by MASRY). After completing the relative orientation (in a digital type instrument), the scan-lines, which may cover the whole width of the model, are oriented along conjugate epipolar lines. The corresponding video signals are fed into the computer (digital), corrected for the effect of the orientation parameters (rectified), and cross correlated. As a result, heights of multiple points in each epipolar plane are generated. These heights are recorded and can be used off-line for further automatic processing.

The values of the incremented video signal, initially stored in the computer, are re-located (i. e. corrected for tilt and relief displacements) in order to convert the perspective digital image into an orthogonal one. This address modification technique is needed both for scan shaping and for orthophoto printing. Some preliminary tests have shown promising results.

FORREST presented his new stereoplotting concept, which comprises a sequential process of stereomeasurement, computation, and automatic plotting. The system consists of existing components: a single stereocomparator, computer, and an automatic coordinatograph.

Another development by FORREST has been the LR-2 Digital Line Rectifier. This system includes a photo stage, equipped with the Bendix Datagrid digitizer, an on-line digital computer and an automatic coordinatograph. The operator traces h a cursor the features on the photograph to be plotted. The movements are fed into the computer, rectified (and transformed) numerically, and fed to the plotting coordinatograph. The LR-2 is applicable to any type of image record (frame, panoramic, infrared scanning, radar) of nearly flat terrain.

A new computer assisted comparator was introduced by SEYMOUR and WHITESIDE. The basic components of the system are the O. M. I. three stage comparator and the PDP-15 computer with interfaces and peripherals. The on-line computer enables the relative orientation to be performed before measurements are initiated. It also controls the Dove prisms and the zoom optics for undisturbed stereoscopic viewing and edits the output data. The computer also applies the corrections for distortions, transforms coordinates,and computes the standard errors. Special editing routines automatically detect gross errors and prevent their recording.

DORRER and KURZ reported on a stereoplotter interfaced with programmable desk calculator. The experimental system consists of the Wild A 10 Autograph and the Wang 700 A calculator with an electronic interface. This on-line sequen- l system is suitable for digitizing, storage, display, and processing of model coordinates. The calculator assists in the relative and absolute orientations, performs averaging of repeated observations, and determines the standard deviation, corrects for earth curvature and other errors, determines the locations of the projection centres, forms and adjusts strips, computes on-line scaled or transformed coordinates, distances, areas, or volumes, etc.

INSTRUMENTS AND TECHNIQUES FOR CARTOGRAPHIC PROCESSING OF SPACE PHOTOGRAPHS

The attention of the Photogrammetric community was focussed on the successful launch of the Earth Resources Technology Satellite (ERTS-A) which took place during the Congress. The subsequent sessions on space photography, held in Commissions I, II, III, and IV were also the scene of high actuality. With the exception of single papers from Canada, Germany, and Austria respectively, the invited and three presented papers to Commission II all came from the USA. In his paper on "Instruments and techniques for cartographic processing of space photographs", F. DOYLE from the U. S. Geological Survey gave a review of these instruments and techniques. This review concentrated mainly on telemetered images, as used with weather satellites, ERTS, and Mariner, for studies of the Earth and Mars, respectively. The use of panoramic and conventional photography for lunar mapping was described only in the discussion of the Apollo 15 mission.

Space photographs can either be transmitted to the ground station point by point ("a bit at a time"- telemetered) or the original films can be recovered. The latter possibility was realized in the Gemini and the Apollo-missions. If the image is telemetered, it has to be recomposed from the telemetered data. Three methods of doing this were given by DOYLE. They are the kinescope recording (using CRT), printing with a laser beam image reproducer (LBIR), and printing with an electron beam recorder (EBR). The CRT system is simple, but prone to geometric distortions and low resolution whereas the LBIR has a very good resolution at the expense of its flexibility. The EBR combines a good resolution with good flexibility, so that the known geometric image errors can be removed. The photogrammetric work in processing the images from weather satellites deals mainly with the computation of the map positions of regularly spaced image points and the subsequent linear interpolation for all other points between the previously transformed ones. Further problems of photogrammetric or cartographic interest are the plotting of three-dimensional cloud-field maps, isotherms, etc.

The ERTS-imagery was the main topic of the invited as well as that of a majority of the presented papers. The invited paper summarizes the purpose and the operation of the system used to process the ERTS data, and describes a procedure of semi-automatic spectral pattern recognition ("Autographic theme extraction system").

Two presented papers by a group of authors from the Bendix Corporation go into more detail of the processing system of the ERTS-images, whereas KRATKY, of the NRC, Ottawa, in his paper on the "Photogrammetric solution for precision processing of ERTS-images" specifically describes the procedure of numerical rectification as applied to the ERTS-images of Canada. In this method, a preliminary pass of the telemetered data is carried out through an image reproducer (EBR or LBIR). The images thus obtained are compared with existing maps, rectification data are computed and used in a second pass through the image reproducer to form the rectified ERTS-image. The principle of this procedure is the same as that applied in the USA.

After the discussion on ERTS, DOYLE continues in his invited paper to describe the photogrammetric reduction of the Apollo 15 photography which was produced by a panoramic camera of 610 mm focal length (ITEK) and a special mapping camera of 75 mm focal length (Fairchild). These were the "first truly photogrammetric systems" in orbit around the moon. The choice of these cameras for this rpose was challenged by H. SCHMID of the U.S. National Ocean Survey in the subsequent panel discussion. A rectifier for the panoramic Apollo photographs (ITEK) and the basic concepts of the lunar triangulation system with the metric photos are also outlined. Finally, the processing of Mariner 9 images of Mars is summarized in which the amazing achievements, in the manipulation of digital images as applied in this programme, are illustrated.

In a presented paper, H. LICHTENEGGER, University of Graz, Austria, derives the "General case of cosmographic perspectives", which are perspective projections of spheroids from large distances (altitudes).

In his contribution the "Combined plotting from satellite and aerial photographs for topographic mapping", O. KÖLBL derives the planimetric control from the satellite imagery (scale 1 : 1 mill.). The plotting itself is done from aerial photographs (scale 1 : 100,000) and consists of the production of controlled mosaics. The coordination of the aerial and satellite images is speeded up by super imposing both images by means of projection using colour separation in a rectifier. The argument for this procedure is that in many countries aerial photography is available, but the conversion to maps is not possible due to the lack of control, skilled personnel, and funds. In such cases, the availability of satellite imagery may be an alternative to provide (planimetric) control and a fast mapping procedure. In the discussion, GUY reported that similar experiments were also being carried out in France.

The discussion of the panel suffered somewhat from the general enthusiasm of the panel members for space photographs. There were hardly any critical or negative remarks on the developments going on towards mapping the earth from space. It would also have been very interesting to discuss as critical a paper such as G. PETRIE's "Some considerations regarding mapping from earth satellites", (Photogrammetric Record, Oct. 1970). Nevertheless, the concluding remarks of F. DOYLE are valid when he says that the solution of the photogrammetric problems in the space programmes represent major contributions to the state-of-the-art and that many developments in digital image processing come only from the space programmes. Whether he will also be right in his expectation that mapping from space will cause "increases in the mapping capability comparable to those which aircraft photography made over plane table surveying", only the future photogrammetrist will be able to judge.

MULTI-MEDIA PHOTOGRAMMETRY AND REMOTE SENSING

The two subjects multi-media photogrammetry and remote sensing were treated in one session for organizational reasons. In the discussion of the commission's work however, it is appropriate to keep the two fields separate.

Multi-media Photogrammetry

The definition of multi-media photogrammetry as given by Dr. J. HÖHLE, Karlsruhe (W. Germany) in his invited paper applies if the imaging rays before entering the lens of the camera, do not only pass through one, but through several media. Consequently refraction at the interfaces between these media perturb the central perspective.
So far, mainly two media-photogrammetry, specifically underwater photogrammetry with one plane interface, was studied. The work of J. HÖHLE extends this into more than two media and also includes spherically shaped interfaces. The applied procedures, however, are only experimental. Practical operational programmes do not yet exist.

Plotting from multi-media photography with analogue stereoplotters has been investigated for quite some time. An example of this are the experiments with the multiplex type instruments, in which the tracing table is placed in a water tank (U.S. Navy Hydrographic Office) or where plane parallel glass plates are used to simulate the water (Technical University Graz).

The use of an analytical plotter has been successfully tested at the University of New Brunswick. As yet however, no procedures have been devised for the relative and the absolute orientation. HÖHLE suggests that a separate digital orientation be carried out and subsequently used in the analytical plotter as input.

Another approach to plotting from multi-media photography is and was that the measurement of the stereomodel should be done directly in a stereo-plotter, without any special provisions, and that the greatly deformed stereo model should be corrected by computation. This correction has been done so far only approximately, but the rigid transformation is possible and could be done by coupling the plotter with a disc computer, or by using hybrid plotters. Here again, operational orientation procedures do not yet exist.

Although a lot of underwater work has also been done in France (Institut Français du Petrol), Japan (Kyoto University), and the U.S. (U.S. Naval Oceanographic Office), it was only mentioned very briefly in the short discussion, which was centered around the problem of mapping the bottom of the sea. It is only possible to carry this out to a very limited extent by means of aerial photography, where a maximum depth of about 20 m is possible. For depths greater than this, underwater photography, echo sounding, or imaging Sonar is used. J. POLLIO, from the U.S. Naval Oceanographic Office described the difficulties encountered with underwater photography, e.g. control lighting, obstacles at the bottom of the sea, and the small field of view. In reply to the question whether Sonar or photography was preferred he answered that wherever possible, photography is preferred.

Remote-Sensing

The subjects on remote-sensing "Methods and instruments for radargrammetry" belonging to Commission II and "Geometrical aspects of remote-sensing" from Commission IV were treated in three invited papers and two presented papers in a combined session of these two Commissions.
There were three other papers which could not be presented owing to a lack of time.
The subject of "Remote-Sensing" was treated in separate sessions at the inter-congressional symposia of Commissions II and IV held in 1970 in Munich and Delft respectively.

From these symposia presentations it appeared, that the centres of photogrammetric research in this field were located at ETL, Ft. Belvoir; Goodyear Aerospace Corp., Litchfield Park; both in the USA,; University of New Brunswick, Canada; University of Hannover, W. Germany, and ITC (with NIWARS), the Netherlands. This impression was confirmed at the Congress in Ottawa in as much as all of the papers on this subject came from these five institutes.

Research on the photogrammetric problems of remote-sensing does not have a long tradition and suffers from the arbitrary security restrictions on many of the results already obtained. As a result, procedures similar to those familiar in conventional photogrammetry, but with unconventional remote-sensing imagery, do not yet exist. Whereas the papers presented at the 1970 symposia of Commissions II and IV were rather theoretical and introductory, the ones presented at the Congress in Ottawa were by contrast more practical. It is expected that this trend will continue.

The series of presentations at the session was opened by G. KONECNY, University of Hannover, W. Germany, with "Geometrical aspects of remote-sensing". In this paper, the author lists the remote-sensing systems which are of interest to photogrammetrists and summarizes the metric problems involved in their use. He then gives a survey of the projection equations for the imageries produced with the remote sensors. This is followed by a discussion of the very crucial problem of controlling the exterior orientation of the sensor and consequently the geometric fidelity of the imagery. There are basically only two alternatives: the measurement of the sensor's movements or triangulation with overlapping imagery. The latter item is also specifically discussed in a presented paper by E. DERENYI, University of New Brunswick, Canada: "Restitution of dynamic imageries". The first alternative, however, deserves preference. KONECNY finally describes a series of numerical tests with Thermal Infrared and SLAR-imagery whereby single strips of imagery as well as model coordinates derived from overlapping images were compared with maps. The discrepancies are large by photogrammetric standards, but the values are obtained without the use of control points, apart from the minimum number required for absolute orientation, and moreover the imagery is not produced with a photogrammetric use in mind.

In the second contribution, F. LEBERL, ITC, Enschede, The Netherlands, dealt more specifically with the "Evaluation of single strips of SLAR-imagery". The theory of its functional and stochastical models was studied, and the possibilities of rectifying a single strip of imagery discussed. Finally a numerical test with imagery produced over the Netherlands was described. The image is compared with a map, but in this case a number of control points is assumed to be given. The residual errors obtained are within the graphical accuracy at the scale of the imagery.

In the paper "Methods and instruments for the restitution of radar pictures", by K. YORITOMO, ETL, Ft. Belvoir, USA, the history of restituting radar images is reviewed, up to the latest military orthographic radar restitutor, built by Goodyear Aerospace Corporation for the U.S. Department of Defense. This instrument scans the given electronic image, prints the rectified image, and removes all known deformations, including relief displacement. The latter is possible by combining the orthographic attachment with a specially developed analytical plotter. This plotter is also the subject of the presented paper by L. GRAHAM of Goodyear

Aerospace Corporation, USA: "An improved orthographic radar restitutor" in which the main improvement consists of the use of a laser for scanning the original and printing the rectified image, instead of the CRT's of the original restitutor.
"Rectification of infrared imagery" by S. MASRY and J. GIBBONS, University of New Brunswick, Canada, dealing with the use of the orthophotoprinter of the Analytical Plotter AP-C is a paper presented to Commission I, but which in its ntent belongs rather to Commission II. So far, the programme for the APC has been to remove the systematic panoramic distortion of thermal imagery, but more complex rectifications can be carried out as well with the same principle. Representing a group of authors at NIWARS, Delft, The Netherlands, K. KUBIK describes the approach followed in a paper entitled "KARIN-A programme system for the mapping of remote-sensing information". There, numerical rectification of various types of imagery is possible. The programme is operational, but does not involve the use of parallaxes. This, however, is also not necessary in view of the Dutch topography.

In a separate presented paper "On model formation with remote-sensing imagery" by F. LEBERL, the computation of model coordinates from overlapping remote-sensing imagery is treated.

In the discussion, the chairman, Prof. K. RINNER, proposed a modified definition of photogrammetry, not as the science of measuring from photographs, but more generally from the two-dimensional storage of certain geometric and physical properties of an object. In full, this definition states:

> "Photogrammetry is the science of determining geometrical and certain physical parameters of an object from photographic, two-dimensional storages of certain geometric and physical data of this object. The photogrammetric procedures can be classified according to sensors or the data they measure, according to the arrangement of storage locations for this data in the imagery,and finally according to the time function determining the order of storage".

Only two items could be discussed in the final panel discussion, namely the problem of controlling the exterior orientation of the sensor during imaging, and the plotting of height information from side looking radar. Referring to the paper by E. DERENYI it was concluded, that the sensor's orientation can only be effectively controlled by measurement and/or stabilization, but not by procedures analogous to photogrammetric relative orientation. A quick survey of the state of art in measuring orientation parameters showed that for small scale radar-mapping (1 : 200,000), the present technology is sufficient.

With regard to the plotting of height, an insider, K. YORITOMO of ETL, USA, called the radar interferometer (which is still on the classified list) a powerful tool to be used with single radar images. It is, however, expected that stereo-plotting, either analogue or digital, will also be a useful procedure for the measurement of heights. It is planned that research in the period until the next series of intercongressional symposia will concentrate on the problem of stereo-plotting from remote-sensing imagery. This was also part of the content of a resolution proposed and accepted by the Commissions. In general, the desire was expressed to complement the theoretical study by experimental research. So far this has been hampered by the lack of appropriate imagery.

RESOLUTIONS

1. Commission II recommends that the Working Group II-2 "Standard Tests" be continued. The emphasis should be placed on testing the proposed procedures under various operational circumstances, and on optimizing these procedures.

2. Commission II recommends that the Working Group II-3 be continued and renamed "Automated and Digital Instruments". The Working Group should include in its efforts and emphasize the advantages and effectiveness of digitizing directly from stereoplotters. It is also recommended that an inter-commission working group II/IV be formed to continue the study of the methodology of the automatic processing of photogrammetric data with the special emphasis on its relationship with data bank systems.

3. Commission II recommends to evaluate the capabilities and limitations of analogue versus digital components of various programmetric equipment.

4\. a. The efficiency of various types of orthophoto equipment should be evaluated by means of comparative tests.

b. The economy of automated equipment should be evaluated against the conventional one.

These evaluations should be coordinated with Commission IV, through an inter-commission working group.

5. Commission II recommends to the manufacturers of photogrammetric equipment to make their components mutually compatible. This requires some standardization, in particular of the interface units and formats. A working group should be established. For example, Commission II recommends that ISP contact the International Society of Electronic Engineering regarding the need for standardizing magnetic tape input and output features.

6. Commission II should encourage research in the area of image data handling, i.e. pointing, parallax clearance, scanning, and telemetry of image data.