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Application of Modern Photogrammetric Equipment in Architectural Photogrammetry

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Comission V

Abstract

Countries of the Third World face a rapid flow of revolutionary change in respect to their life pattern, values, tradition, and attitudes.

Therefore preservation or restoration of their cultural identity should have priority in development politics. The first step on the road should be done by way of preservation and conservation of cultural values such as historical buildings.

As it is the case in Europe already for a long time, photogrammetry could assume a decisive position, there.

The surveying of the facade of the Convento de Sao Francisco shall illustrate the possibilities and advantages of application of modern photogrammetric equipment in comparison to traditional plotting instruments and methods.

Introduction

"We learned about the difficulties to put a stop to excessive growth of the world population and about the short sightedness of neglecting necessary economic measures and their social bearings as well as the disregard of the fact that development for many people involves the realization of their cultural individuality and their basic needs (1)."

This is a quotation from the pre-face to the second report of the North-South Commission, written by its chairman Willy Brandt, exchancellor of Germany F.R.. It states very clearly, that cultural values are not a luxury of industry nations but are an indispensable part of their social organization. Therefore protection and preservation of the very traditions and cultural values should be rated very high in times of intensive technology transfer which involves the importation of alien cultural patterns, too.

There are many ways of developing and cultivating national individuality. One of them is the preservation of cultural values in the form of governmental protection and a modern maintenance of documentation of cultural values based on the Hague Convention of May 14 nth 1954 and the Convention of the General Assembly of UNESCO, Paris 1972.

Along these lines, Ouro Preto and Olinda in the NE of Brazil became classified as national monuments and have been put under UN protectorate.

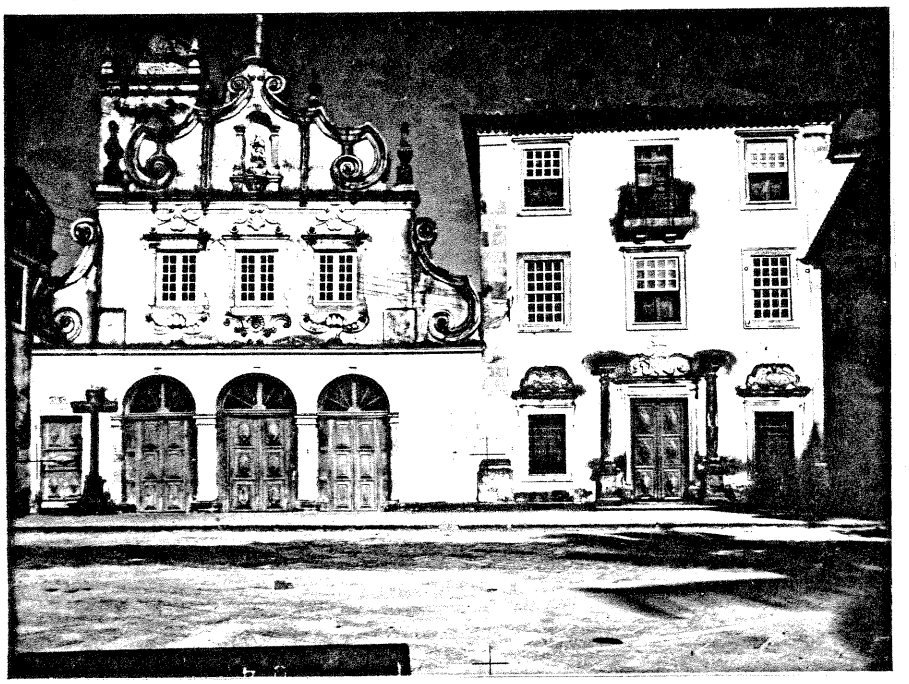

Fig. 1 Convento De Sao Francisco

Historic Observations

Olinda was founded in the early days of Brazilian history. In the year 1535 dutch settlers established an outpost of the East-Indian Company on the hills boarding the sea near the 8 th longitude. In their wake followed determined priests and artists who built more than 21 churches and convents, ornamented with elobarate lusitanean baroque. These monuments sited near the sea are now seriously endangered by dilapidation, consistency of soil, and tidal movements of the sea. Constantly increasing vibrations of nearby traffic caused dislocation and deformation of the monuments to an extend that cracks from 1-4 inches in the walls have been observed lately.

The Sao Francisco Convent built in 1585, destroyed in 1631

and reconstructed in the years 1715-1755 is one of the most splendid among the magnificent historical monuments of Olinda (fig.1).

By means of this exemplary model, ways of documentation and preservation by application of modern photogrammetric equipment shall be depicted.

Documentation of Cultural Values

Documentation of cultural values is to be divided into in

-Primary,
-Secondary, and
-Tertiary Documentation.

The original cultural asset as well as any recallable storage of information (i.e. original publications, data collection of pictures) is included in the Primary Documentation. Secondary Documentation yields storage of original information such as books, papers, microfilm, and brief information gathered by autopsy. The latest form of documentation is the Tertiary Documentation. This additional form of documentation contains excerpts from the two other documentations, thus providing a specified selection of documents and information concerning a certain object. The documentation of shape is part of the Tertiary Documentation. In the first place it holds records of terrestrial photographs which can be put to use by scaled interpretation or combination of measurement.

The documentation of form is the base for multi-disciplinary research and preservation of cultural assets. In many ways it can be called the most important part of documentation of cultural values. It grants the immediate assessment of any change and defacement of the original stock. Its maintenance requests a strict reference to the original.

Therefore documentation of surface should be produced on grounds of none-generalized presentation of actual form of the cultural asset, only. "According to International Law, the recording of the actual form of a cultural asset makes it possible for the user of information, to explore and preserve cultural values as an unchanged original," says Foramitti. Only after recording of an objective actual form, derivation from the required form can be tolerated (2).

Photogrammetric Equipment for Architectural Survey

The dualism of prensenting actual and required form could be revived, especially after the introduction of analytical plotters combined with intelligent digital drawing tables into the field of architectural survey.

Different design of the hitherto sucessfully employed analogue plotters on the one hand and the increasing employment of analytical plotters on the other hand, may have caused this development.

"In analogue plotters the picture carriers with the inserted metric photographs are displaced in X and Y, rotated and tilted (relativ and absolute orientation) until the same orientation

of the metric photographs is achieved, albeit at a reduced scale, as that applicable at the moment of exposure. Mechanical space rods establish the projection rays between the ground point in the model and its image in the photograph. The model point, i.e. the point of intersection of the space rods, is moved in X, Y, and Z, via mechanical measuring spindles, by means of handwheels and a foot disk. The drawing table follows continuously the movement of the model point by direct mechanical link between plotter and drawing table.

Compared to that in analytical plotters a virtual (i.e. not visible) model point is similarly moved in X, Y, Z by means of handwheels and the foot disk. Rotary encoders on handwheels and foot disk transmit the movement of the model point to the computer. A so called Real-Time-Program then computes the back projection of the model point into the left and right metric photograph by means of previously computed orientation elements. A servo-control-system compares the image coordinates x, y computed in this way with the effective values measured at the same time by linear encoders in the image. Any difference between the measured and computed values is immediately corrected by a horizontal movement of the picture carriers to ensure that the optical stereo model is always maintained. This computing and control cycle is so rapid (75 times/sec) that the operator notices no differences between analogue and analytical measuring-mark control. The attached digital drawing table has its own intelligence provided by a microprocessor and can be used for on-line and off-line plotting. Extensive system-software accelerates the operators efficiency by linear and non-linear connection of points, rectangularity, parallel lines, user-definable symbols, and line types as well as automatic writing (3)."

With the introduction of photogrammetric methods in respect to architectural survey it became apparent that restitution of actual and required form presented a well known problem. In 1907, E.Dolezal, an engineer of great merit regarding architectural photogrammetry, already complained that the actual surface is rendered unrecognizable by the individual approach of the designer to the subject (4). Mr.Dolezal"s complaint is quite understandable. In the early days of surveying historic monuments and the first application of photogrammetry in this field only some points of the object were determined by intersection methods or by stereo-comparator measurements. In between of these measured object points the required form was interpolated and designed. The essential density of selected points required for mapping the actual form could not be achieved. Only when the analogue plotter was introduced, the non-generalized recording of actual form, the objectivity of depiction, and homogeinity of accuracy in the field of form documentation of a cultural asset became possible.

The demand for knowledge of art-history and constructional engineering when operating an analogue plotter is considerably high.

It has been discovered lately, that up to now, a mainfold of content of cultural assets has not yet been considered. These additional characteristics manifest themselves as traces of construction of an respective object. The operator might run the risk to mistake these micro-traces of the original material

for the design of the artist or the craftsman, thus confounding the actual and the required form.

The following issue embarks on a presentation of the survey of the Sao Francisco facade, executed by the Wild BC1 and its digital drawing table TA2. Along with the technical depiction, there will be discussion of the problems occuring with the recording of actual form and the demands put before the operator.

Photography

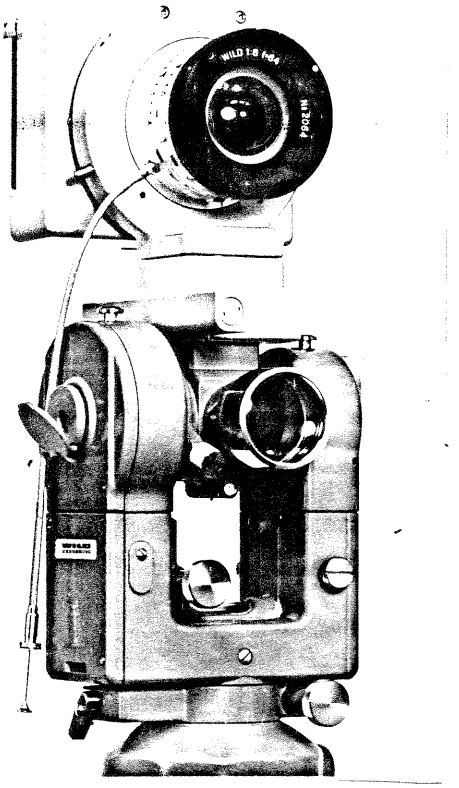

Fig. 2 Terrestrial Camara Wild P 32

The metric photographs were taken by terrestrial camera Wild P32, using Fuyi-Neopan SS film (Fig.2). While taking the photographs with the two camara axes perpendicular to the base line and tilted in a vertical angle of zirka 2.4 gon, advantage has been taken of the offset of the principal point, closely linked to the object. The base-line was b=2,100 m and the distance to the object zirka 23 m. The base-to-distance ratio of 1:10 was kept comparatively small. Such a minor grade of depth extension of the object would have permitted a greater base line without fear of concealment within the stereo-model. Stereoscopic exaggeration of the facade in the stereo-model would have led to a greater accuracy in definition of the actual form even when a photo scale of 1:350 had been used. A plotting scale of 1:50 was chosen, which implies a proportion of 1:7 between photography and plotting scale.

In a local coordinate system, tied to the base line, 8 control points, which had been distributed all over the facade, were determined by intersection.

Photogrammetric Restitution

For restitution the analytical plotter Aviolyt BC1 and the digital drawing table Aviotab TA2 of Wild/Heerbrugg AG have been employed. Fig.3 illustrates particular components of this computer-aided plotter. Apart from the Aviolyt AC1 the Aviolyt BC1 has been designed specially for daily photogrammetric routine work. Its mechanical features and great flexibility in software qualifies the instrument for solution of nearly any photogrammetric problem. When plotting terrestrial photographs in architectural photogrammetry especially the zoom-enlarging (6-20 times) has been very helpful to achieve a better reconnaissance of actual form.

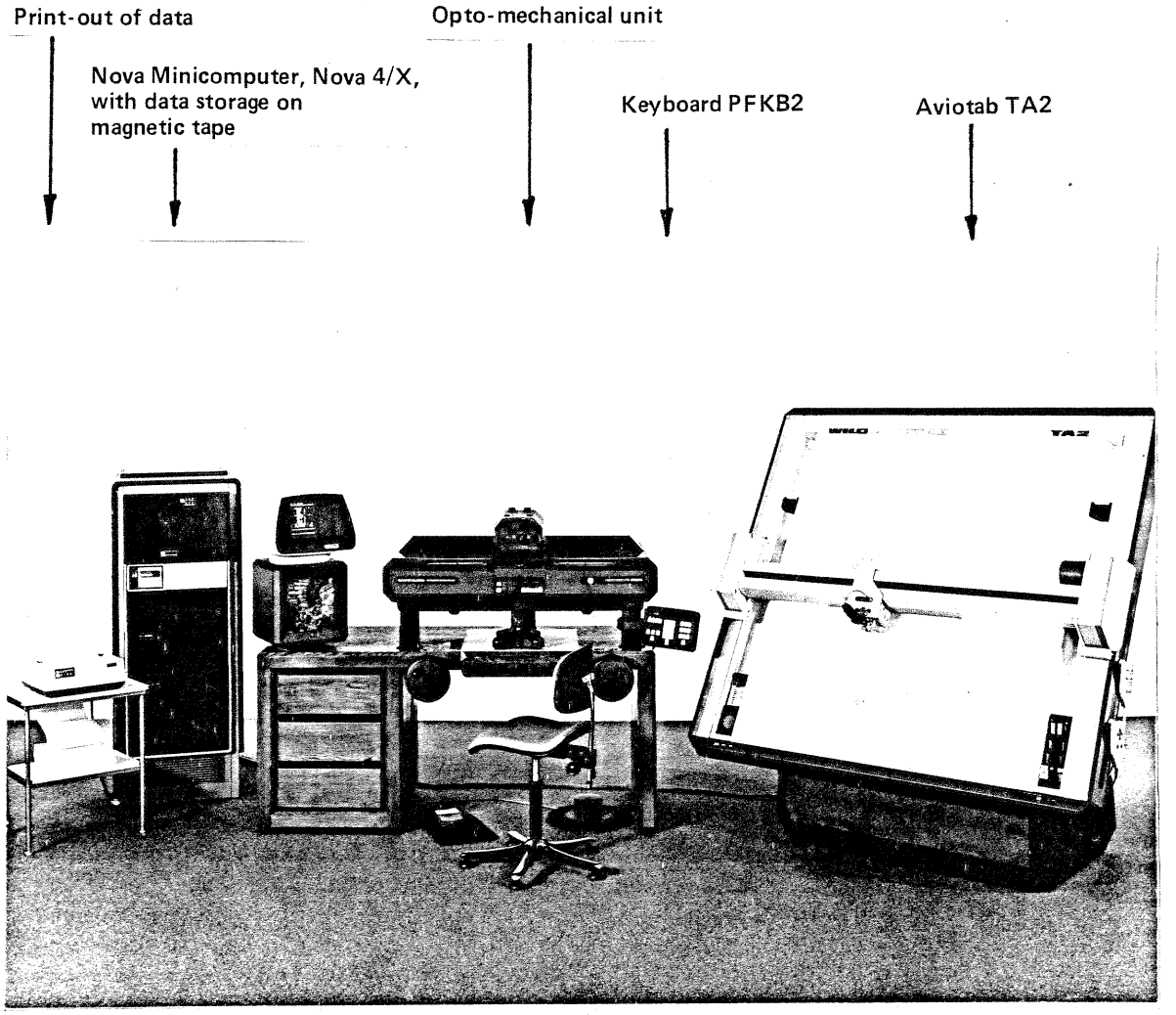

Fig. 3 Wild Aviolyt BC1

From the operational point of view there are 3 basic phases of an on-line analytical operation (5):

-Input of data and definition of the image geometry
-Reconstruction of the photogrammetric model and
-Detailed photogrammetric compilation of the model

The time spent on input of data and the measuring purposes for inner and outer orientation with 8 control points did not exceed an average of 15 minutes.

The course of work to be performed at the plotter may be observed from figures 4,5,6.

The system software has been developed in structured programs and modular design. There are modules for preparation, restitution, calibration, for restitution itself, and for test purposes. All modules have a tree structure. Possible branches are offered to the operator by means of a menue. The data, such as: camara calibration data, orientation data for the photographs, control point data, picture and model coordinates are stored in separate files following INP-Mode. They can be recalled during operation by file name as well as

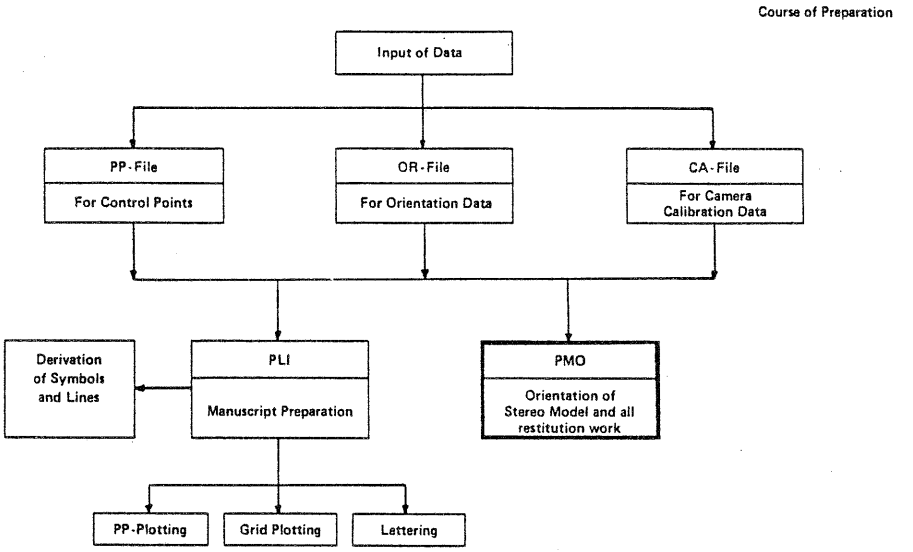
Course of Preparation
Input of Data
PP-File
For Control Points
OR-File
For Orientation Data
CA-File
For Camera Calibration Data
Derivation of Symbols and Lines
PLI
Manuscript Preparation
PMO
Orientation of Stereo Model and all restitution work
PP-Plotting
Grid Plotting
Lettering

Fig. 4

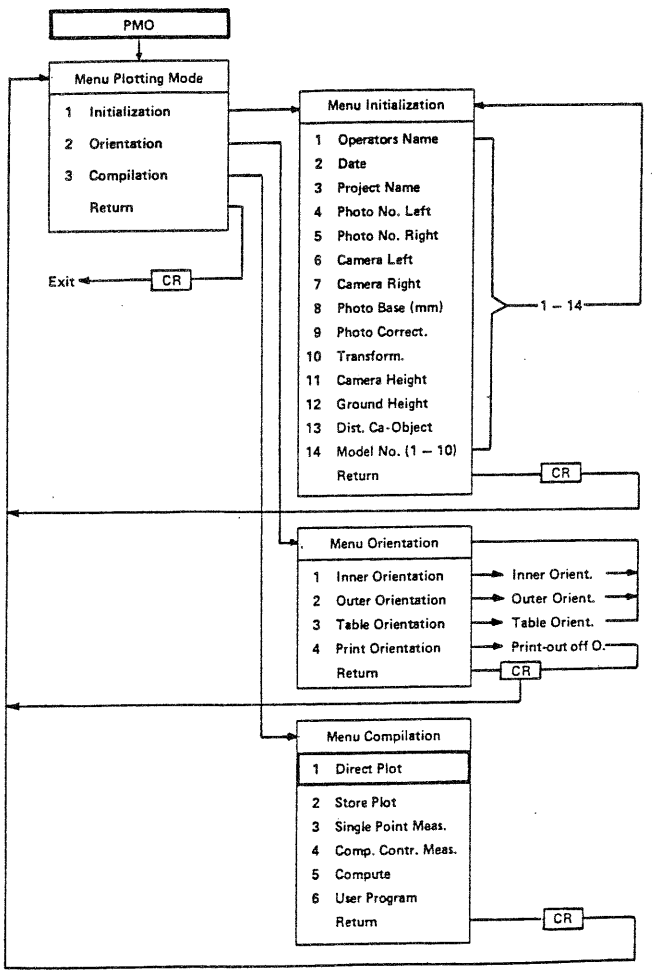
PMO
Menu Plotting Mode
1 Initialization
2 Orientation
3 Compilation
Return
Exit
CR
Menu Initialization
1 Operators Name
2 Date
3 Project Name
4 Photo No. Left
5 Photo No. Right
6 Camera Left
7 Camera Right
8 Photo Base (mm)
9 Photo Correct.
10 Transform.
11 Camera Height
12 Ground Height
13 Dist. Ca-Object
14 Model No. (1 – 10)
Return
1 – 14
CR
Menu Orientation
1 Inner Orientation
2 Outer Orientation
3 Table Orientation
4 Print Orientation
Return
Inner Orient.
Outer Orient.
Table Orient.
Print-out off O.
CR
Menu Compilation
1 Direct Plot
2 Store Plot
3 Single Point Meas.
4 Comp. Contr. Meas.
5 Compute
6 User Program
Return
CR

Fig. 5

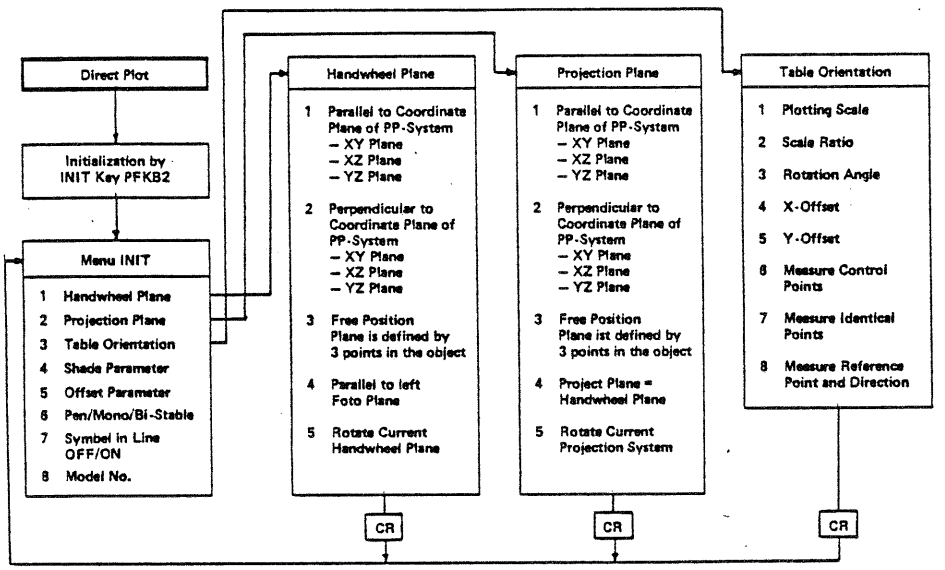

Fig. 6

printed out, if required.

The PLI-Program permits creating and editing a maximum of 999 symbols for the customers special library.

Concerning the Direct Plot-Program (fig.6) of the compilation program, i.e. computer-aided restitution of points or lines from stereo-pairs, it should be pointed out that the movement planes of the two handwheels and the foot disk, a right handed orthogonal coordination system, can be rotated in space in any direction. Hence for example the plane defined by the two handwheels to lie in a building elevation which is rotated to any sense whatever relative to the camara axis and the control point system (6). As a result, restitution work is economized by cutting down the number of photographs and plotting of architecturally complicated interior, for example, is simplified. Projection plane-and direction can be fixed in similar variety.

The Direct Plot-Program depicts the actual main program and is executed in combination with the alphanumeric keyboard and the functions keyboard PFKB2 for graphic functions.

In regard to documentation of the actual form this software system together with the digital drawing tabel holds a key position. In this connection the following functions keys of the PFKB2, out of a total of 32, are of importance:

-SYNCHR : Functions key for synchronous plotting mode
-RECT : Preselection key for plotting straight lines at right angles to each other
-PARALLEL: Preselection key for automatic plotting of a parallel line
-LINE : Preselection key for straight-line connection of two points
-CURVE : Preselection key for a curved connection of a series of points
-COMPLETE: Functions key for the automatic return of the plotting head to the initial point of continuous series of lines

There is no doubt about advantages which the functions keyboard holds together with the digital drawing table for the

customary photogrammetric mapping. With some exception, which will be delt with later on, the advantages, recorded below, might be transferred to application of architectural survey, too:

-Restitution of pictures with absence of standard conditions for photography
-Fully flexible enlargement ratio from photograph to plot
-Gain in accuracy, conditional on instruments and software
-Avoidence of loss of accuracy by direct scribing
-Considerable saving of time by computer aided orientation and restitution
-Economical labor at all stages
-Shortening of the phase of the initial period by menue aided interactive method

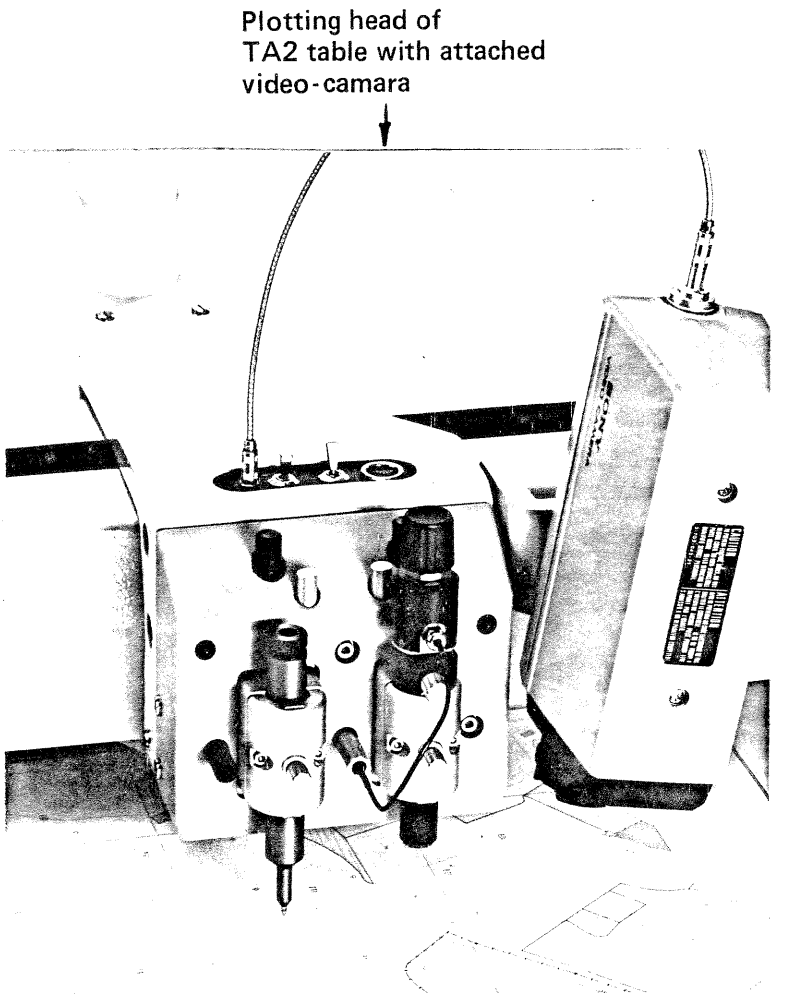

Fig. 7

The final product is a complete fair draught. Compared to conventional methods the cartographer's work can be economized to a great extent. The considerable increase in quality of the plotting product can be attributed to the intelligent drawing table and the fact, that a video camara can be attached to the plotting head (Fig.7). Thus the general uncertainty about the result can be avoided by direct view onto the drawing table.

It must be pointed out however, that the standards required of an operator at the analytical plotter, especially for architectural survey, are considerably high. For reasons of the methods of employment of the functions keyboard and its mode of interpolation and simplification which may accelerate the plotting process to an extraordinary extent, strict self discipline on behalf of the operator is required. He might be endangered to turn away unintentionally from plotting the actual to plotting required form.

Results obtained during the process of surveying facades

showed that the functions: "RECT, COMPLETE and PARALLEL" are rarely used. In case of presence of sufficient density of selected points, functions such as "LINE" and "CURVE" for interpolation of lines and curves, register the actual form adequatly. In critical situations the operator should turn to synchronous surveying. The functions of "LINE" and "CURVE" are always safe for application in case the operator misses the actual form for reasons of differential uncertainties in guidance of the structural lines by the floating mark, which require subsequent manual work of the cartographer for the plot.

Decisions should be guided by careful attention to

-Accuracy of definition of the object and
-Accuracy of photogrammetric measuring, too (7).

Accuracy of definition depends on the structural shape of the monument. Especially the old objects might be very heterogeneous.

The photogrammetric accuracy of measurement depends on

-Arrangement of control point measurement and photography as well as
-Restitution and depiction of the results.

Hence it might follow, that by means of high measuring accuracy (+- 4 m) of the plotter, the resolution of the positioning system (+-20 m) of the drawing table, as well as the possibility for direct scribing, parts of the monument are depicted far more accurate as originally defined. That may be a reason for missing the actual shape, too.

If the accuracy of definition of an object permits it, greater enlargement is possible by greater accuracy of the analytical plotter.

Figs.8,9,10 depict the result of restitution, including cross-sections on X,Y and Y,Z coordinate system, at a Wild BC1 analytical plotter. Mapping has been achieved by direct scribing without any cartographical revision. For depiction of the spiral scroll forming of the volutes, the function "CURVE" of the functions keyboard has been successfully employed, along with a close succession of selected points. Each operator knows about the difficulties occuring during the restitution of volutes at an analogue plotter combined with an analogue drawing table, which make cartographical revision a necessity. For depiction of straight-lined molding relief ornaments and cornices, surfacing the facade, the function "LINE" together with a varying density of selected points has been used. The synchron mode has been preferred in case of uncertainty in definition of the structural shape as well as visible damages to the facade.

Dealing with these particular items of architectural survey of the actual and required form, the question arises, wether the operator has to perform a substitute for a plaster cast or a summary replica (8). Hereof the conclusion could be deduced that the operator has to accept a special responsibility for the reproduction of works of art.

The employment of the analytical plotter facilitates performance of this special task considerably.

Fig. 8
Convento De Sao Francisco

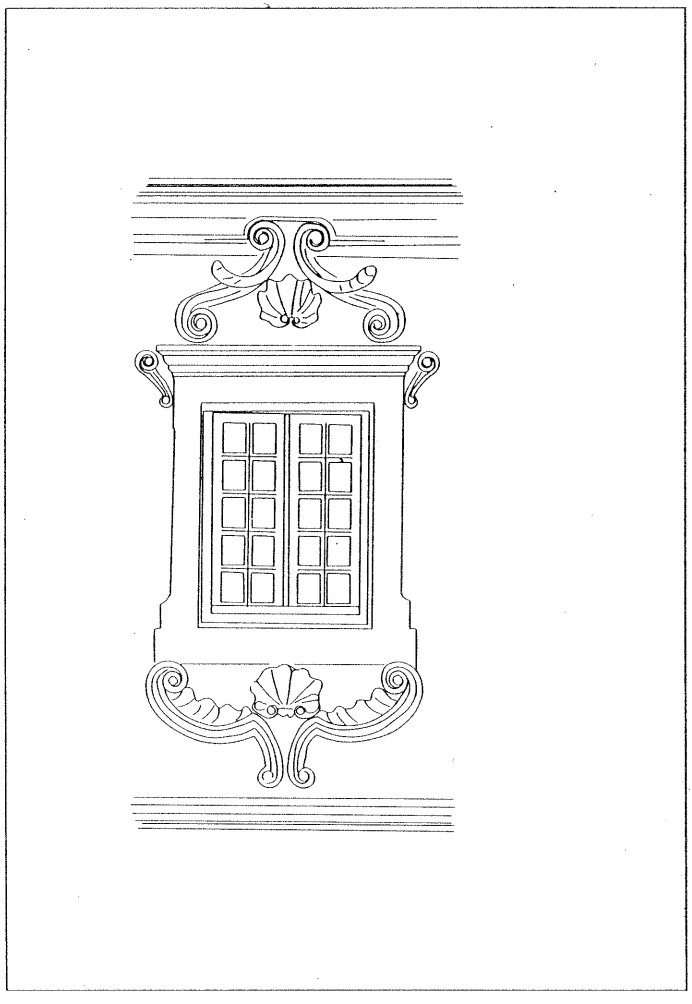

Fig. 9 Convento De Sao Francisco
Escala original 1 : 25

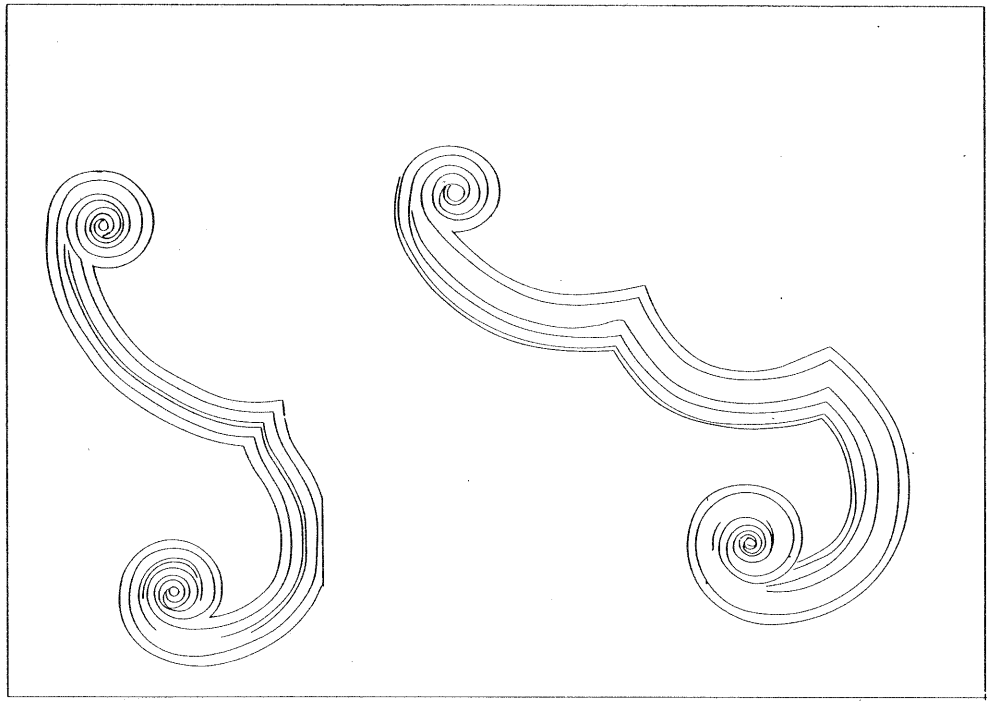

Fig. 10 Convento De Sao Francisco
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