14th International Congress of ISP Hamburg 1980
Commission 2 Working Group -

Presented Paper

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Topocart-Orthophot D 300 with Digital Control Unit and Cross Slope Corrector, the universal differential rectification system from Jena

Abstract

The range of application of the differential rectification equipment from Jena was considerably extended by the development of Orthophot D. In addition to the on-line production of orthophotos further application possibilities are:

- digital storage of z-profiles
- automatic differential rectification (off-line technique)
- correction of imaging errors caused by terrain cross slopes.

The mechanical and electronic innovations and their possibilities of use are described, with the main attention being focussed on the additional devices Digital Control Unit and Cross Slope Corrector.

1. Introduction

At the XIIIth ISP Congress held in Helsinki in 1976 the Jena Works demonstrated Orthophot C as a further improved version in the field of orthophoto equipment /2/. At the same time the supplementary devices "Digital Control Unit" and "Cross Slope Corrector" were for the first time displayed, which offer further automation possibilities and enable orthophotos to be produced with improved quality and increased working productivity /3/.

Although in /1/ the efficiency of the on-line technique for the production of orthophotos and orthophoto maps has been set forth, the Jena works has always endeavoured to complete its orthophoto equipment and make it flexible enough so as to offer the user the choise of a suitable technique satisfying the specific requirements of his particular task. So Orthophot D (Fig. 1) was the outcome of the development of two supplementary devices Digital Control Unit and Cross Slope Corrector and of a modification of Orthophot C.

2. Extension of the range of application

With the design of Orthophot D the range of application of the Jena Topocart-Orthophot differential rectification equipment was considerably extended. Apart from the proven and well-known on-line technique - the direct production of the orthophoto and the simultaneous drawing of a dropped-line contour chart - the following applications are also made possible:

- Digital storage of Z profiles with the Digital Control Unit during on-line differential rectification with Topocart-Orthophot D (e.g. for later use as control profile for automatic differential rectifications).
  Input and output of data are performed through the Digital Control Unit with peripheral punched tape device.
- Fully automatic differential rectification with Topocart-Orthophot D controlled by profile data with the Digital Control Unit (off-line technique).
- Correction of double images and staircases caused by terrain cross slopes at the strip edges of an orthophoto (produced in the scanning technique) with the Cross Slope Corrector in connection with an external computer and the Digital Control Unit of Orthophot D.
- By the extension of the range of calibrated focal lengths photographs can be differentially rectified up to c_k= 300 mm

With these time-saving features a considerably better economy in differential rectifications is achivieved. Use of up to 3 times larger slit widths is possible. At the same time a quality improvement of the orthophoto is achieved by the correction of the double images and staircases.

3. Innovations of Orthophot D 300

3.1. Mechanical-optical innovations in the basic instrument

The major modification of the differential rectification equipment involved the incorporation of a Schmidtprism in the vertical part of the parallel path of rays (Fig. 3 and 4). The

Schmidt prism is rotable about the optical axis. By rotating the prism a portion of the errors is corrected involving the image errors caused by the cross slope of the terrain. The prism is moved by a motor operated in a bridge circuit. The data transmitting receiver potentiometer is directly geared to the Schmidt prism and the gear of the motor.
The Cross Slope Corrector, which receives the information of the terrain cross slope through the Digital Control Unit processes this information by converting it into analogous control values for the rotation of the Schmidt prism and the correction of the magnification control.

This Cross Slope Corrector is housed in a portable box on a platform under the Orthophot (Fig. 2).

3.2. Electronic innovations

3.2.1. Digital Control Unit (Fig. 5)

Two modes of operation are made possible by the Digital Control Unit:

a) Production of a control paper tape during the scanning of a model by recording the Z coordinate.

b) Automatic tracking of the Z coordinate during the scanning of a model with and without cross slope information.

as to a) Production of a control paper tape

When scanning a model with Topocart/Orthophot and manually tracking the Z coordinate a control paper tape is produced with the Digital Control Unit in a constant X, Y grid. For this purpose the Orograph counter of the Orthophot is connected trough a synchro with the Y coordinate, and the appropriate Y interval is preselected. Thus, the Orograph serves as a clock generator for the control of the output unit.
The X interval is automatically given by the X step width.
The Z spindle adjustment of the Topocart is transferred through a synchro to the incremental rotary encoder IGR, which converts the rotary motion into a sequence of electrical pulses driving a bidirectional counter.
With each clock pulse of the Orograph the control system causes the output of the current result of the counter on punched paper tape or magnetic tape through the output unit.
With the change of direction of the Y motion an additional character is output after the first recording.

as to b) Automatic tracking of the Z coordinate

The Topocart-Orthophot instrument combination automatically scans the model in a meander-shaped way. Now the Orograph again serves as a clock generator for the control of the Digital Control Unit. With each clock cycle or, to be more precise, at the leading edge of the clock pulse the corresponding information is transferred from control paper tape or control magnetic tape through the input unit into the $Z_{nominal}$ memory.

At the trailing edge of the clock pulse the difference $Z_{nominal}-Z_{actual}$ is transferred into the appropriate memory.

The information of the actual Z coordinate (Z_{actual}) is obtained just as in the production of the punched paper tape. The difference $Z_{nominal} - Z_{actual}$ is measure of the necessary Z adjustment up to the next clock pulse.

Since the difference is produced in digital form, it is transformed by a digital-to-analogue converter into a DC voltage and supplied to the power amplifier for the DC servo motor, after in a following multiplication unit the influence of the Y speed (Y tachometer voltage) had been taken into account. Now the Z difference is reduced by the DC servo motor according to the applied DC voltage up to the next clock pulse. In this procedure the speed of the motor is according to the applied DC voltage kept independent of the load moment by using a DC voltage tachometer in a closed-loop circuit.

In this mode of operation the rotary motion of the servo motor is transferred to a synchro through a magnetic clutch.

If the character"direction change of Y motion" is recognized by the input unit, an X step is released by the control system in the Orthophot and the opposite direction of Y motion is preselected.

In the control system a circuit is incorporated, which regulates the scanning speed in dependence on the degree of difficulty of Z tracking, i.e. in terrain with strong relief the Y speed is reduced and vice versa.
In this way the optimum scanning speed is ensured.

If not only the information on the Z coordinate ($Z_{nominal}$) is on the data carrier, but also the information on the terrain cross slope ($\tan\alpha$) for each Z value, then the value $\tan\alpha$ is written into the memory with each clock cycle. A digital-to-analogue converter generates the corresponding DC voltage, which is taken to the Cross Slope Corrector.

3.2.2. Cross Slope Corrector (Fig. 6)

The Cross Slope Corrector produces the necessary correction values due to the terrain cross slope in X direction and the quantity φ_2 in dependence on the coordinate values X, Y, Z for driving the Schmidt prism and the magnification control in the Orthophot. The correction values are calculated according to the following formulas:

Rotation of Schmidt prism $$\varkappa = \frac{Y\,(\tan\alpha + \varphi_2)}{Z - X\tan\alpha}$$

Correction of magnification ΔM: $$= \frac{X \cdot \tan\alpha}{Z - X\tan\alpha} - \frac{\varkappa^2}{2}$$

The model coordinates X, Y and Z are transmitted through synchros to the potentiometers X, Y and Z. Quantity φ_2 is directly set by hand on the potentiometer. Thus the appropriate DC voltages X. tan α, Y (tan α + φ_2) and Z are applied to the wipers of X, Y and Z.
These quantities are interconnected by division and multiplication circuits and taken to the amplifiers of the servo motors M_1 and M_2, which are mechanically connected with measuring potentiometers and are located in the feedback branch of the amplifiers. Thus, the adjustment of the measuring potentiometers is always proportional to the change of the applied calculated correction voltage.
The Schmidt prism is mechanically connected with motor M_2 and so a rot-ation of the image corresponds to a particular position of the potentiometer.
Mechanically linked with motor M_1 is a correction resistor, which is directly connected to the computing bridge of the 400 Hz tracking system for the magnification control in the Orthophot.

Literature

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/3/ W. Marckwardt: Digital Control Unit and Cross Slope Corrector for the Topocart-Orthophot C differential rectification system from Jena
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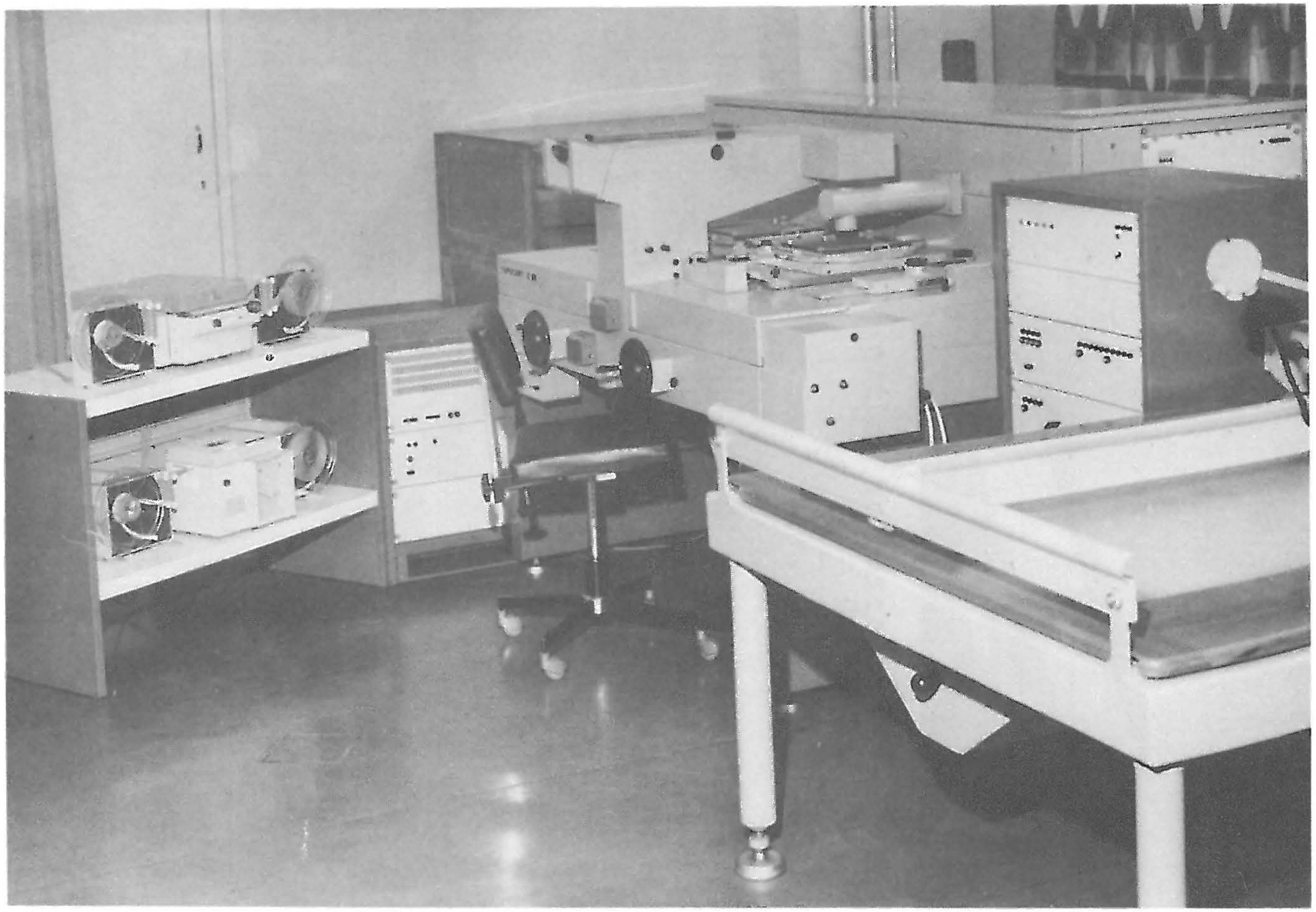

Fig. 1 Topocart with Orthophot D 300, electrical cabinet, Digital Control Unit, punched tape periphery, and drawing table

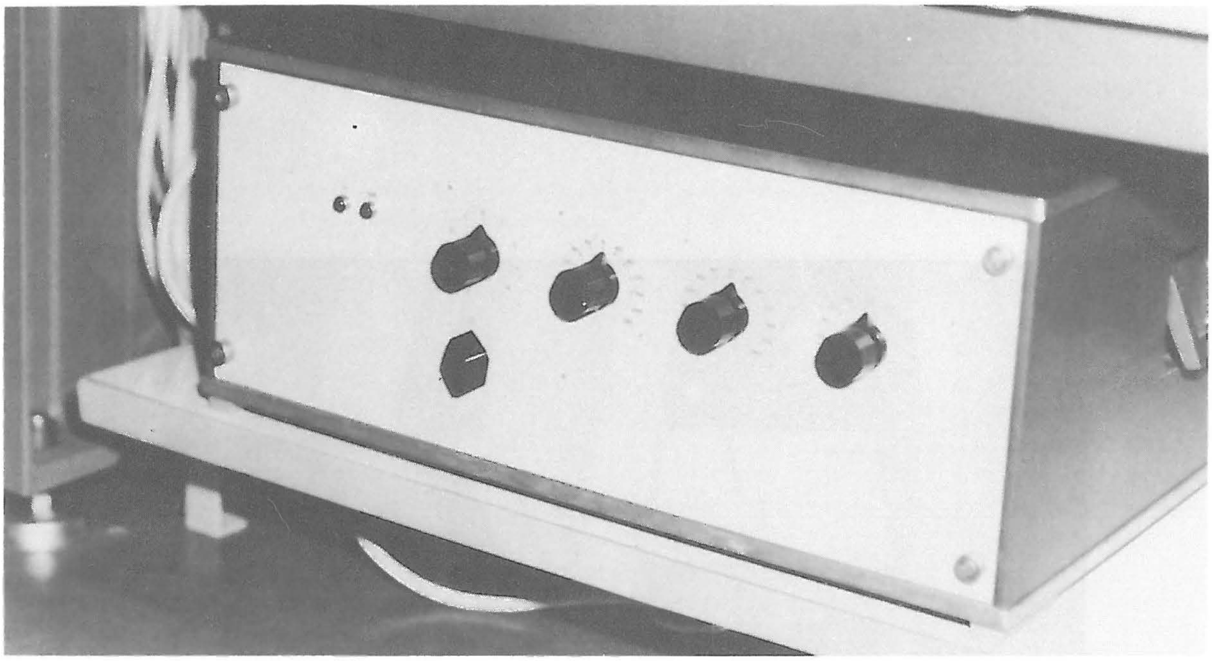

Fig. 2 Cross Slope Corrector on its platform under Orthophot D 300

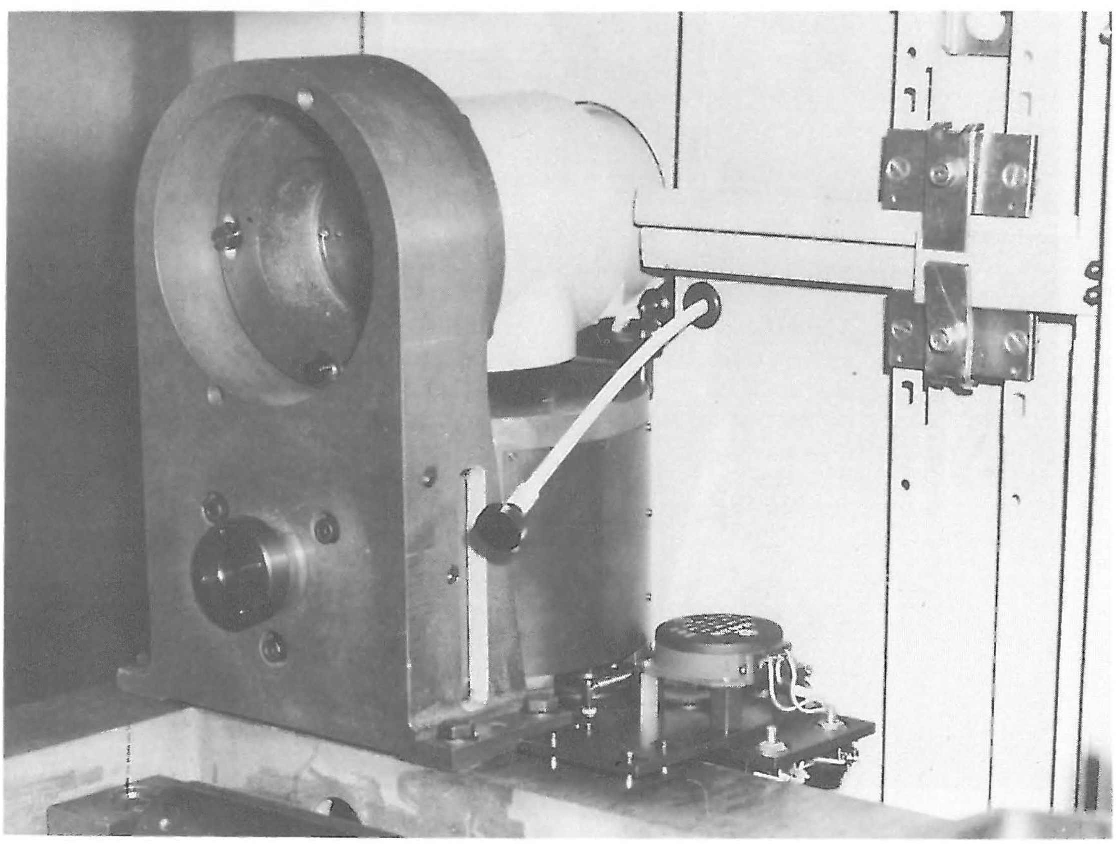

Fig. 3 Schmidt prism with driving system

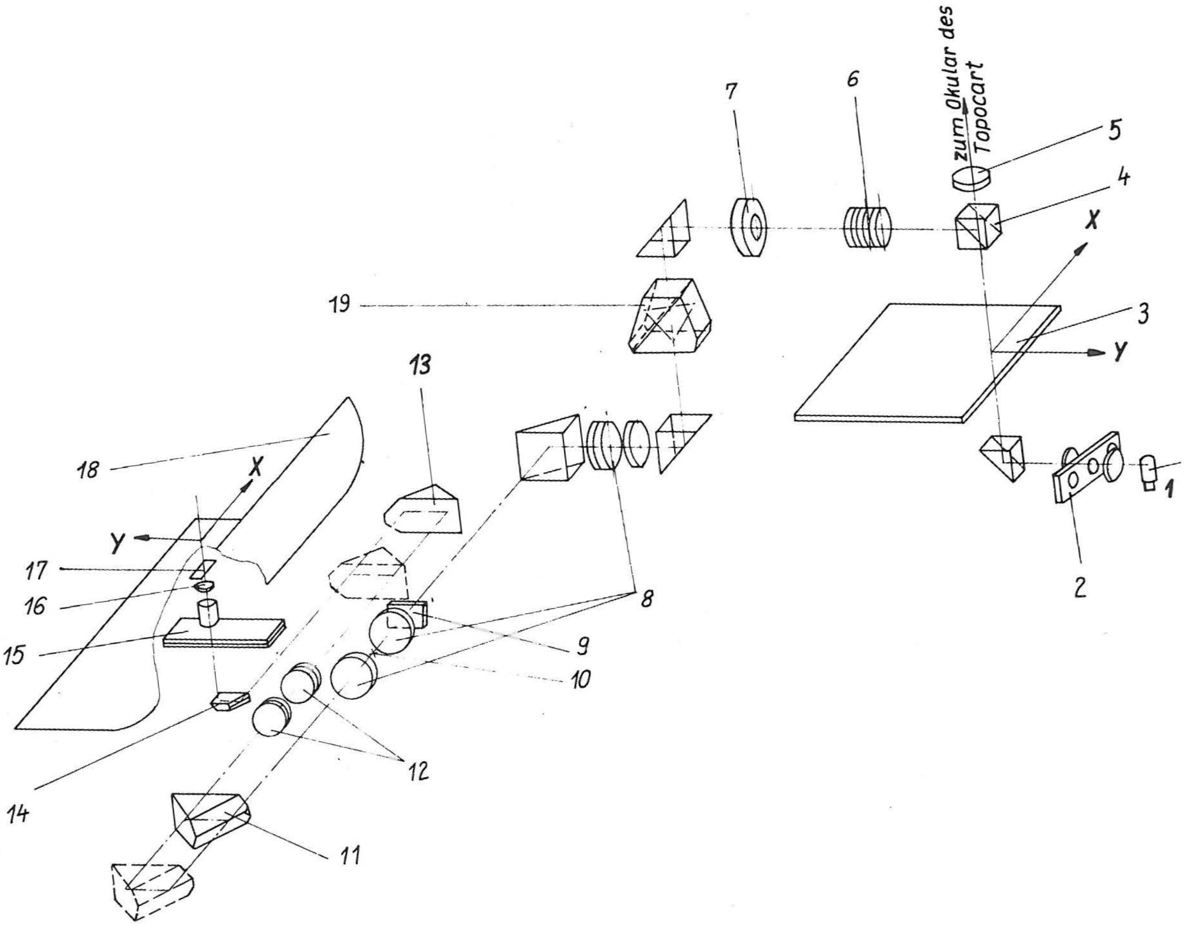

Fig. 4 Optical diagram

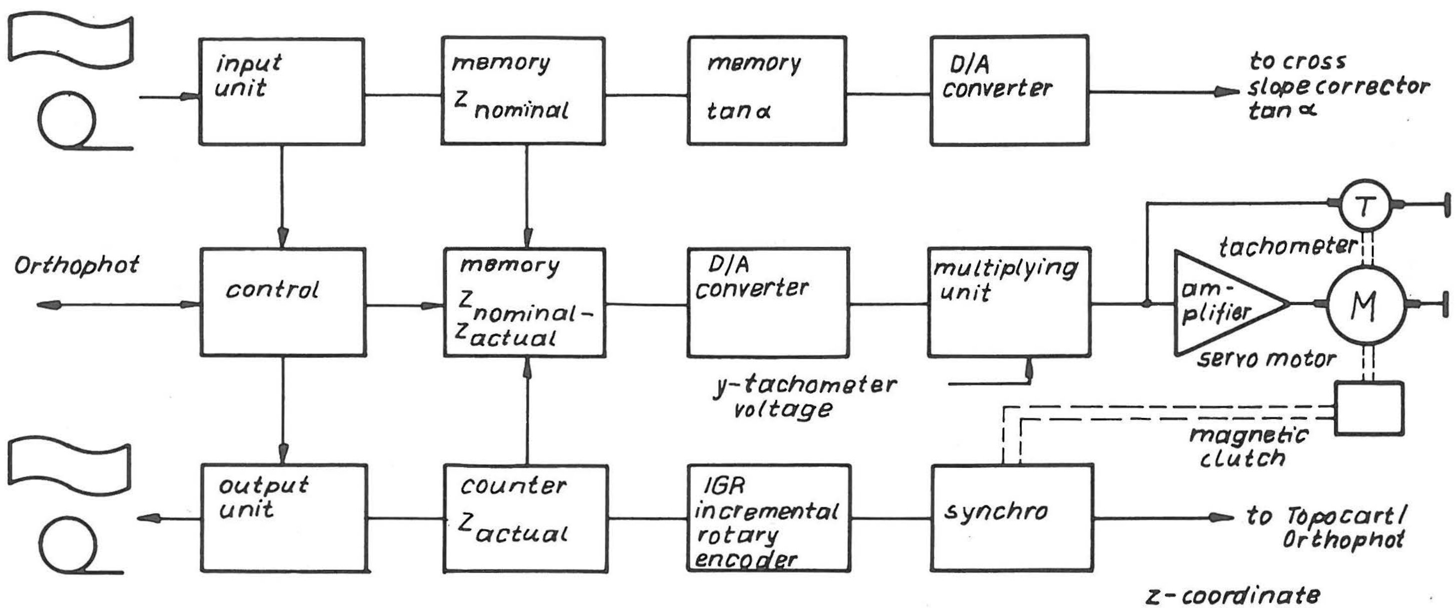

Fig. 5 Block diagram of Digital Control Unit

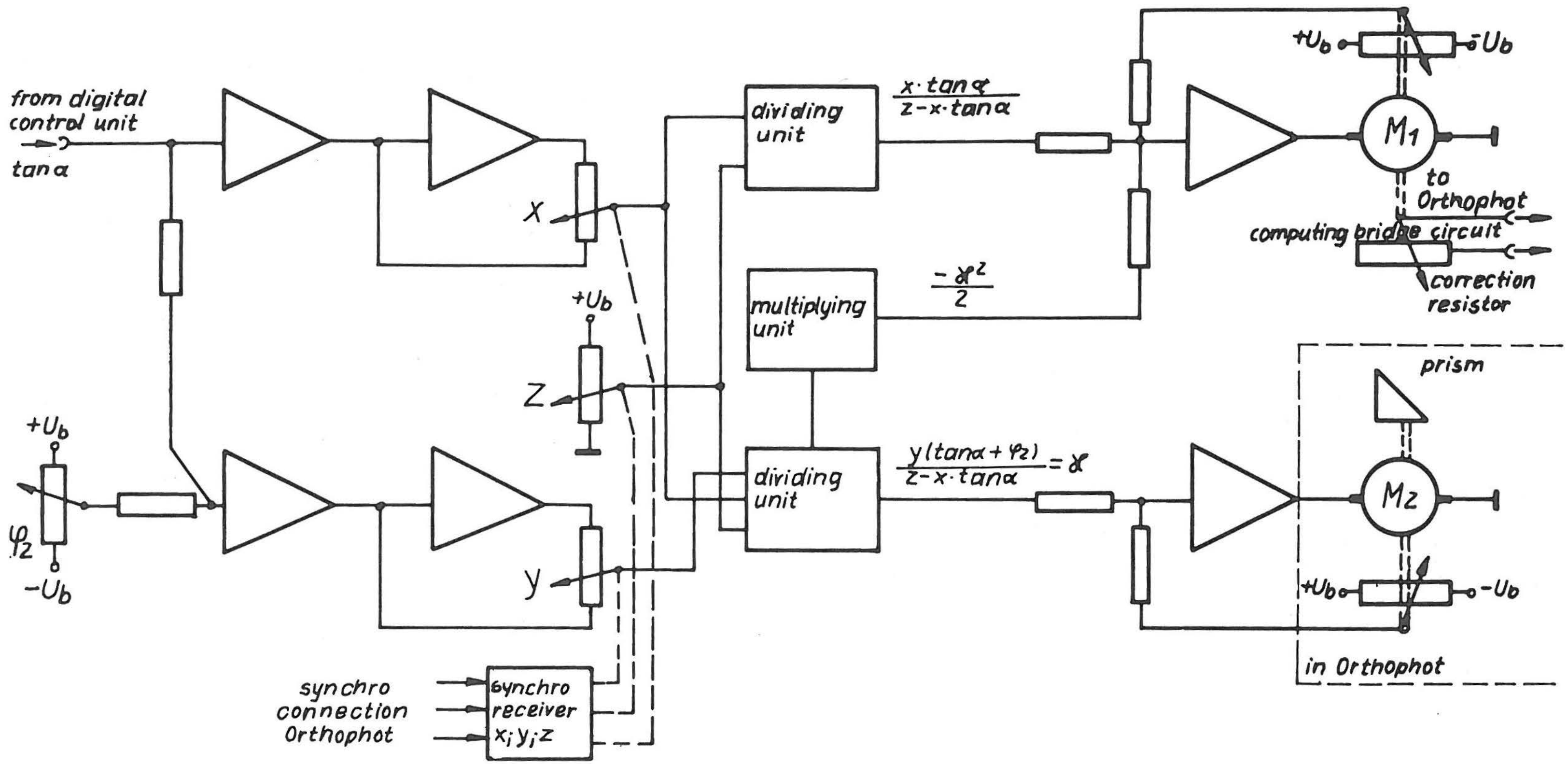

Fig. 6 Block diagram of Cross Slope Corrector