

# RECTIMAT CM, AN ADDITIVE COLOUR PROJECTOR AND PRECISION RECTIFIER

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## INTRODUCTION

Remote sensing has been a field of growing importance in recent years. Having marketed its MKF-6 and MSK-4 cameras for multiband photography, the Jena works logically sought to provide equipment for the convenient processing of such photographs. The MSP-4 Additive Colour Viewer, on the one hand, can mix multispectral photo sets into colour composites but is incapable of transforming them into defined scales. The well-known RECTIMAT C Precision Rectifier, on the other hand, employs Transformar lenses for the 420-690 nm wavelength range. Practical experiments (1) have shown that it is sufficient to effect spectral selection in the photographic taking process and to use broad-band colour filters in projection, e.g. for photographic additive colour mixing. In order to offer the user a novel combination of additive colour projector and rectifying photoprinter, we designed the RECTIMAT CM.

## FEATURES

Like RECTIMAT C, RECTIMAT CM is a precision rectifier having five degrees of freedom and having its main parts arranged along a vertical optical axis. The two models differ little externally, but the CM is based on a revised concept regarding both software and the precision of principal point shifting and illumination. Its applicability includes the rectification and simultaneous additive colour presentation of black-and-white multispectral photo sets taken from air and space platforms for remote sensing purposes.

For the small-size multispectral MKF-6 and MSK-4 photographs, the concept includes a particular procedure employing a special photocarrier and pertaining software. Large-format multispectral imagery can be handled with the aid of a punch, a

clamping strip, a control point map and a special operating cycle. The extended software includes a method for establishing, by means of the rectifier itself, the input data required for photographic transformation. An automatic vanishing point control facility can be switched on separately, which reduces rectification by control points to three degrees of freedom.

The new features of the CM do not restrict its general applicability as known from the RECTIMAT C, and there is no change in outer dimensions, weight, operating conditions and climatic requirements.

#### OPERATING PROGRAMS

The RECTIMAT CM is furnished with eight operating programs, a memory program and two calibration programs. These programs facilitate the operator-machine dialogue and ensure automatic operating cycles and precise positioning of the various movable components. The following operating modes are possible:

- Rectification by control points (MAN1)
- Rectification with automatic Vanishing point control (MAN2)
- Rectification by input of rectification elements (AUT1)
- Determination of rectification data from known map control point coordinates and measured coordinates of the respective control points in the photograph (AUT2)  
(AUT2 with additional AUT1 is the so-called "automatic rectification")
- Black and white exposure (EXP1)
- Exposure in colours (EXP2)
- Multispectral exposure, up to 3 photographs (EXP2/MSP)
- Calibration program/normal photocarrier (ZERO)
- Calibration program/multispectral photocarrier (ZERO/MSP)
- Storage of actual settings of the device (MEM)

The depressing of the respective button (for ZERO/MSP and EXP2/MSP two buttons) selects the operating program. After the input of the necessary data and the other possible selections (i.e. protectivefilter) the computer controlled process starts with depressing the button "START". A comfortable and

rational mode of operation is provided by blocking those buttons and parts of the panel not necessary in the selected program.

#### MAN 1

Depressing button MAN 1 on the stationary control panel selects the classical rectification procedure with five independent degrees of freedom. The various operating controls are grouped on a small hand-held control box, which during the rectification process proper may be placed on the projection easel beside the control point sheet. The control buttons effect both coarse and highly sensitive adjustments of the various degrees of freedom by means of the RECTIMAT's central computer and a 16-step time-and-speed control system. The computer calculates the formulas of the projection model, controls the independent variables and displays the selected settings simultaneously.

#### MAN 2

In this mode the buttons for manual shifting of the principal point on the hand-held control box are blocked, and principal point control is effected automatically. With the instrument switched on and program MAN 2 selected, the software invariably sets  $f_a = f_e$  (rectification focal length equal to camera focal length). It is necessary for the operator to key in the focal length of the camera used, so that the system can compute the correct image shift. This focal length will then remain stored until a new focal-length-input or the machine is switched off.

#### AUT 1

The operating variables for all five degrees of freedom are entered at the control panel. They are then set automatically through the motor drives if AUT 1 will be started. Together with the photograph to be rectified, the operator requires the input values to be furnished by analytical preprocessing. Every photograph has to be centred on the photocarrier by means of the centring accessory supplied with the instrument.

## AUT 2

For this operation it is also necessary to centre the photograph on the photocarrier.

Upon selection and start of this program the instrument is automatically levelled and set to a 5 x magnification. After this the control point coordinates at the respective map scale are entered (six digits before and three digits after the decimal point, in mm, state "InP"). Where six digits do not suffice, the differences between map coordinates must be formed.

The four control points having been entered, the display reads "Scale". Then the operator actuates the  $e_x$  and  $e_y$  buttons to effect the coincidence between the control points in the photograph and the respective quadrant markings on the easel. The measurement being concluded, automatic computation and then automatic positioning by means of AUT 1 will follow.

## EXP 1

Rectification proper being completed this program can automatically control exposure time, f-stop and shutter release for black & white exposure. Exposure time is variable between 0,3 s and 999.9 s. A light protective filter is placed back in position at the end of the exposure. An exposure time once selected will remain set until the machine is shut down or a new exposure time is entered.

## EXP 2

Analogous to EXP 1, this program controls exposure time, filters and f-stops.

It operates with three exposure channels, each being permanently assigned a colour filter while the respective exposure time is variable between 0,3 s and 999,9 s per channel.

The sequence of the channels (filters) is blue - green - red. Exposure timing, shutter operation and filter change are automatic.

This program is primarily intended for printing on colour positive or colour negative materials. As reported in ref.

(1) it is also used for producing additive colour composites from large-size multispectral photography.

#### EXP2/MSP

The EXP2/MSP program controls the filters, principal point shift, correct shutter release and illumination provided that the ZERO/MSP program ran and so the correct constants for the computation of the model are transferred.

Exposure time and filternumber for each MSP channel have to be entered by an operator/computer dialogue. Then the individual photos of the multispectral set are centred on the special photocarrier and the latter inserted in the machine. If data of a previous rectification are to be considered, they must be transferred by means of the MEM program and set by means of AUT 1.

After the room light has been switched off and the photopaper laid on the easel, the program can be started. The further operations will be performed automatically. By suitable combinations of filters and exposure times, real- and false-colour composites can be produced.

#### MEM (Memory program)

This program is used jointly with AUT 1. Upon depressing the MEM button, the current statuses of all five degrees of freedom are read into a memory. If a different state has been set in between by means of MAN 1 or MAN 2, return to the original status is possible by depressing AUT 1 and START. The settings stored with MEM remain in the memory until the machine is switched off or until settings are changed if AUT 1 is selected.

#### ZERO (normal photocarrier) and ZERO/MSP (multispectral)

All settings in the RECTIMAT CM are performed by means of motors and incremental encoders, which generate an additional zero pulse at every revolution. The ZERO program causes all setting elements to adopt a defined initial position, with the zero pulse of the respective coordinate serving as a datum. With the program completed, all tilts are zero, the principal point is on the optical axis, and magnifica-

tion with the 150 mm lens is 3X. Thus the entire system is calibrated and ready for all further programs. The ZERO program is compulsory after every switching on of the machine; the calibration is maintained until shut-down or starting ZERO/MSP for multispectral performance.

#### PRODUCTION OF ADDITIVE COLOUR COMPOSITES WITH THE MSP PROGRAM

For the production of additive colour composite images from MKF-6 and MSK-4 photographs, the machine outfit includes a second photocarrier, the marker plate of which is provided with selected reseau marks of the respective cameras, with which the photos of a multispectral set are to be aligned. For that purpose the outfit includes a special aligning microscope and a transillumination box. Insertion of the loaded photocarrier into the machine completes the preparations. If the lamp is run at maximum brightness, it produces a colour temperature of 3.200 K. Accordingly, the initial filtering and the pertaining exposure time ratio for most applications is

blue : green : red

1 : 2 : 3

This basic setting may be varied depending on the desired colour effect.

Registration accuracy is around 0,1 mm, which in colour composites of this size and magnification still renders a brilliant overall impression.

#### PRODUCTION OF ADDITIVE COLOUR COMPOSITES FROM LARGE-FORMAT IMAGERY

This procedure is principally suitable for making colour composites from photographically recorded scanner images and large-format multiband photography. According to (1), the technique may also be used for small-format multiband photographs, although with greater time consumption compared to the MSP program.

The program used for this technique is EXP 2 for general colour exposure. It also allows single photo exposure through a colour filter if the exposure time of the unused channels is set at  $t = 0$ . The principle, described in detail in ref. (1), consists in placing the individual photos in the image

plane successively and exposing them one after the other through different colour filters. Colour mixing is effected in the projection plane. Geometrical correlation is by a control map, which is positioned by means of a clamp strip alternately with the colour photopaper, which is exposed repeatedly. The control map is, preferably, a laminated papermetal foil with control points or reseau marks mapped at the desired imaging scale.

The accuracy of registration between the individual exposures essentially depends on how accurately the original photos are aligned. If a 10X magnifier is used, the reseau mark can be set within 0,1 mm of the fitting cross. This method has the advantage that its registration accuracy is largely independent of magnification, due to each channel being correlated with a control map.

#### REFERENCES

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