THE LMK AERIAL CAMERA SYSTEM

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The continual increase in performance of photogrammetric data processing systems entails appropriately high demands on the equipment which has to supply the starting material, i. e. the aerial photograph. While, on the one hand, both the geometric parameters and the photographic quality of the imaging systems are increased to the limits of what is physically possible, similar progress has, on the other hand, been made in the conception of the aerial cameras regarding their handling capability, weight, dimensions etc. Here, decisive factors influencing the end product are especially the present possibilities of miniaturization, of having functions carried through by microprocessor controls so far implemented by mechanical components and of using lighter materials.

As a result of the dedicated development work the Jena optical enterprise now presents the LMK Aerial Camera System, which compared with the well-known previous type MRB incorporates essential modifications in design and has an increased value in use.

In order to relieve the operator and objectify and optimize the exposure process, an automatic exposure control was implemented. A novel feature of this equipment is the departure from the previously used integral measurement of the terrain brightness. Measurement is now made differentially, so that the risk of the underexposure of shadow parts is largely avoided. In addition, by preselecting the desired density range the measuring principle offers the possibility to indicate to the operator the necessary development gradation as a recommendation and thus to specify exactly the effective film sensitivity.

In the system's conception special attention was given to the reduction of influences reducing image quality. Apart from the improvement of the vibration-isolating properties of the mount the forward motion compensation realized for the first time in aerial cameras of this type leads to a considerable increase of image quality under flight conditions. The possibility of using high-resolution, less sensitive emulsions or making photo flights with longer exposure times even under unfavourable light conditions involves essential economical advantages both in the aerial photograph itself and for the entire following photogrammetric process.

Operation is further facilitated by the extended control and indicator panel on the control unit as well as by the remote transfer of levelling in addition to drift.

A major point in the conception of the camera was that the functional units requiring to be changed during the flight, namely lens cone and cassette, are not only considerably reduced in weight, but that the change itself can be carried out by the operator without additional manipulations.

1. Design of the system

The total conception of the LMR is based on the modular principle implemented already in the MRB. On the one hand, the modularity of the individual functional units renders it possible to combine lens cones of different field angles with the same camera mount and drive unit so as to complete a particular aerial camera type and, on the other hand, reduces the weight and dimensions of the modular parts to be handled. In the improved MRB conception an important point was to free the lens cone and cassette to be moved during the photo flight from all units required only once in the complete system so as to reduce weight and to accommodate them in one functional unit, which remains on the camera mount. For this purpose the drive unit was created.
The principle of separating the system into camera and control unit was adopted without modification.
The design of the whole equipment is schematically represented in Fig. 1.
The control unit consists of the permanently installed mount (1) in the fuselage and the control instrument (2).
The camera system (from bottom to top) consists of the mount (3) with the permanently fixed drive unit (4) on top of it, the inserted lens cone (5) as central unit and, finally, the cassette (6).

2. Functional units

The lens cones constituting the imaging system proper (camera) have in their design as far as possible been reduced to this function. They contain in addition to the lens and the image plane merely the marginal imaging facilities, the sensor of the exposure measuring device and the shutter. Thus a considerable reduction in weight could be achieved compared with its predecessor.
The PI 5.6/90 Superlamegon, 4.5/150 B Lamegon and PI 5.6/300 Lamegon lenses, whose high performance had already been proved in the previous instrument ([1] , [2] , [3]), have been integrated in the LMK without any modification in their optical design. The newly developed shutter has been standardized for all lens types; it is removable without the need of disassembling the lens cone. The focal-plane frame (image plane) has now a larger usable format of 228mm x 228mm and incorporates 8 fiducial marks which form a regular grid with a mesh width of 110mm. The marginal images essentially correspond to those in the MRB camera; the possibility is provided of imaging further, even externally produced, data.

The handling of the filters, which are now strongly reduced in weight, was considerably facilitated. They can conveniently be inserted from one side when the camera is swung out.

The narrow-angle (1.25°) sensor system for measuring the terrain brightness is accommodated beside the lens and covers the object details in the flight route. By forcing the same filter to be placed in position the measurement value is automatically corrected to the actual conditions.

The camera mount was reduced in its dimensions and its vibration isolation improved by reducing the natural frequency and by a symmetrical design of the spiral spring bearing. The tilt motion for levelling is performed by a universal joint whose fulcrum point approximately coincides with the projection centre of the camera lenses. Therefore, the required diameters of the holes in the fuselage are reduced to a minimum.
Regarding the arrangement of the film transport and the film pressure plate mechanism the cassette nearly corresponds to the proven MRB design; in its detail conception it was, however, modified by the incorporation of a device for the compensation of the linear forward motion of the image.
The shift of the projected terrain image relative to the stationary emulsion in conventional systems, which is caused in the exposure period in the image plane by the forward motion of the aircraft, has so far partially produced a considerable degradation of the image quality and rendered the use of high-resolution emulsions impossible because of their low sensitivity. In the LMK system the disturbing image motion is compensated in that the pressure plate together with the vacuum-clamped film is shifted at the same speed and in the same direction. The calculation of the compensation speed is performed by the microprocessor using the v_g/h_g ratio which is determined by the control unit. The maximally compensatable image speed is 64 mm/s. The exposure of the fiducial marks is made with an extremely short exposure time at the mid-point of photo exposure. On the one hand, this ensures the sharp imagery of the fiducial marks and, on the other, the conditions of the interior orientation for the total image content are strictly satisfied.

The drive unit consisting of two ring-connected segments contains in addition to the electronics for the camera function control the components for the film pressure plate function (vacuum pump and lifting magnets) as well as the film transport motors.
This unit remains on the mount so that the modular parts to be moved, namely lens cone and cassette, could be freed from the mentioned components and thus reduced in their weight.

A checkboard with signal lamps on the drive unit serves for indicating the status of the cycle run and, in case of need, for locating faults in the instrument.
The principle of the control unit as a separate equipment with fully centralized operating and control functions corresponds to the proven MRB system. The number of the indicated elements was however increased so as to give the operator the possibility to optionally monitor the automatically running functions or to check those functions to be influenced by him.

The levelling of the mount of the control unit is automatically transferred to the universal joint of the camera mount, same as the azimuthal rotation of the control unit for drift correction. The latter is made in the well-known manner by visually matching the motion direction of the terrain image on the screen of the projection system with the engraved course lines. By means of a reversing prism system incorporated in the path of rays of the projection system a synchronous motion of the ground image with the natural motional direction resulting from the aircraft motion is achieved, so that the operator's reorientation is no longer necessary.
Visible on the ground image is also the well-known endless tape with moving marks, whose synchronism generated by visual match supplies the v_g/h_g ratio required for the functional control. This ratio enters the calculation of both the camera cycling rate and the image motion compensation.
The indicating panel of the control unit shows in digital form the f-stop setting as well as the exposure times, both the one required due to the exposure measurement and the one set in the control unit. The setting operation proceeds automatically, after the film sensitivity has been input and the desired f-number selected. For this purpose the computer ascertains a representative minimum value from one block each of brightness values, which are supplied by the sensor located in the lens cone. The sequence of the minimum values is subjected to a smoothing process, which is designed so, that the system essentially responds only to larger or long-term minimum value changes. On the basis of the given effective emulsion sensitivity the computer determines the necessary exposure time for the f-stop setting and adjusts the shutter appropriately. If the setting range is exceeded, the f-stop setting is automatically corrected. Should the total range of stop/exposure time not suffice, the next possible value of the exposure time is used and the discrepancy relative to the nominal setting signalized by a blinking light. The automatic exposure system is capable of being switched off, so that the parameters can also be set by hand.
When the image motion compensation is switched off, the amount of image motion to be expected on the basis of image speed and exposure time set is digitally indicated to the operator. Indicated is also the degree of forward overlap which is generally identical with the preselected value. However, the indicated actual value deviates from the preselected value, when the calculated cycling rate cannot be realized by the system. The camera cycle then proceeds in the possible minimum time. The resulting smaller overlap is indicated and signalized by blinking. This is effected, when the main switch is switched to the "series exposure" mode. Another operating mode is the

"minimum cycle" in which a preselected overlap is intentionally dispensed with and which is applied when in photography the largest possible overlap is to be achieved.
A third operating mode "single image" is intended to be used for taking pinpointed single photographs.
The sequence of shutter releases in the exposure series is indicated by an image sequence display in the form of an opto-analogue "count-down". This consists of a group of 10 green LEDs, which signalize the ready state of the system and successively extinguish in the period between the shutter releases. An additional yellow LED lights up in the period before the next following shutter release, in which an additional single image release is no longer permissible. A red LED lights up during the running camera cycle and, in addition, signalizes any possible troubles in the system.
All manipulating controls are clearly arranged and ensure convenient operation. Thanks to the new light-well arrangement the screen image is largely undisturbed by the spurious light of the environment.

3. Conclusion

Compared with its predecessor MRB the LMK aerial camera system represents a new generation of cameras, which due to their novel characteristics exhibit a considerable increase of the value in use. The results achievable with this system ensure an optimum of quality and information for the following plotting process.

Literature

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Summary

A new aerial camera system is presented, which due to the optimized and/or entirely new functional principles exhibits a considerable increase of the value in use as compared with the predecessor type MRB. Important features are in particular the newly introduced linear motion compensation and an automatic exposure system on the basis of differential object brightness measurement with gradation indication.

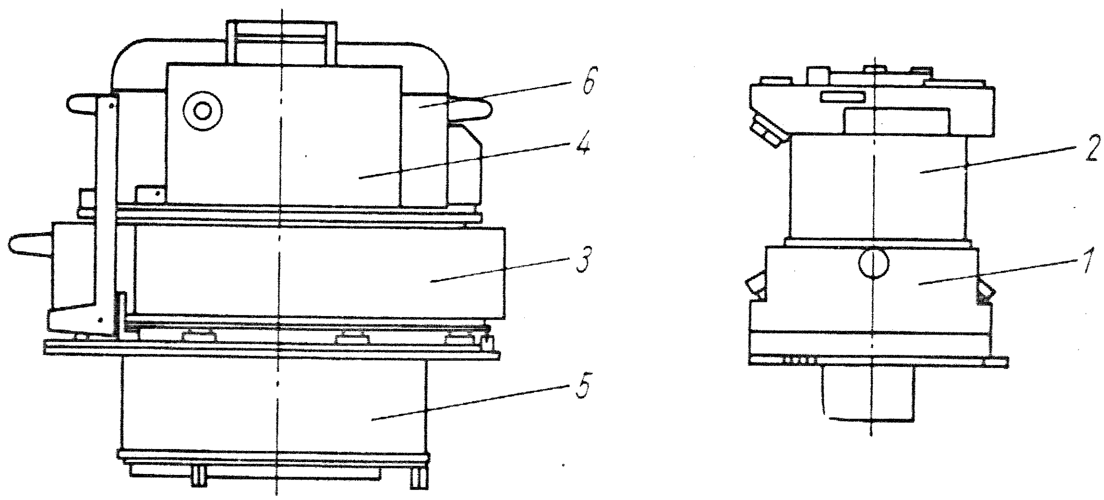

Fig. 1. Aerial Survey Camera System, schematic

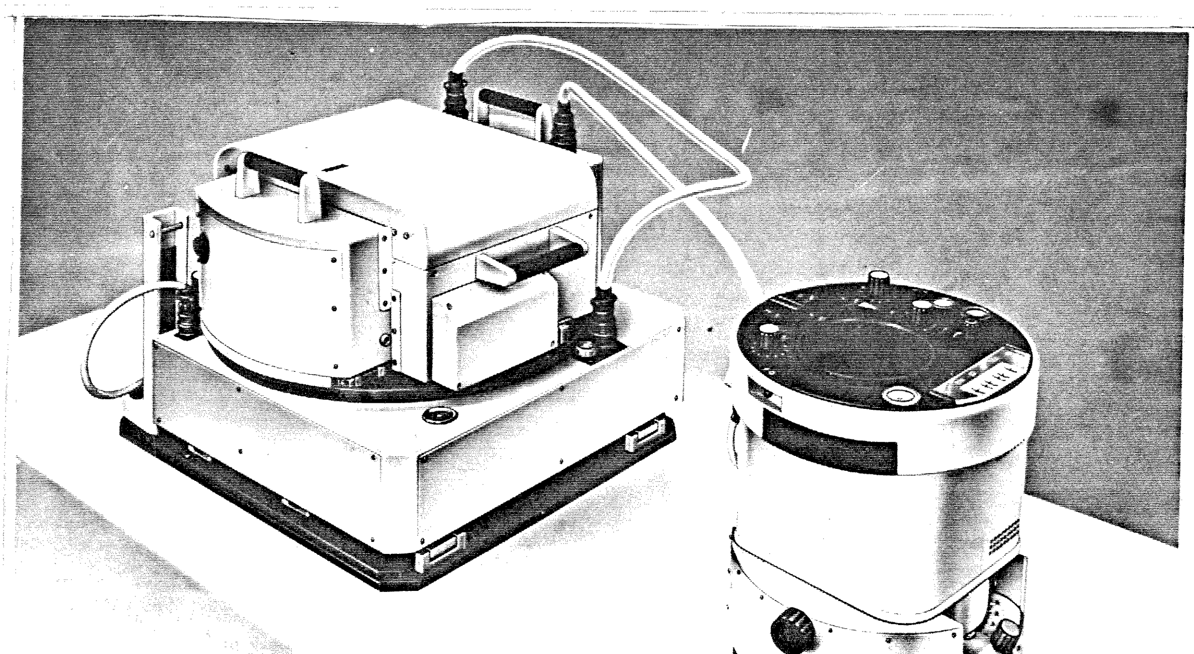

Fig. 2. Aerial Survey Camera System, total view