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AERIAL CAMERAS OF THE TES TYPE USED FOR TOPOGRAPHIC SURVEYING

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ABSTRACT: Aerial cameras of TES type are used for aerial photography of different physical-geographical regions. The cameras are supplied with rotor shutters and devices for automatic exposure control; lens are spheric (except for AFA-TES-5); distortion does not exceed 10 mkm, resolution is within 35-25 line/mm, accuracy of stereoviewing is about ± 3 mkm. The above instruments provide for decreasing scale of aerial photography by 1,2 ÷ 1,4 when comparing with AFA-TE type instruments. AFA-TES-5 camera has an objective of aspheric lens, distortion is not less that 16 line/mm. The instrument is used for aerial photography of large areas at small scales.

Aerial cameras AFA-TES with focal lengths 350,100,70 and 50 mm and angular fields 40,103,120 and 136,5° respectively, the picture shape being 18 x 18 cm, have been developed in the USSR. They have new lenses that enable to improve metric and image qualities of pictures, and an exposure automatic system with a rapid rotor shutter Picture mistakes can be fixed.

The quality of pictures is influenced by the following factors: photogrammetric distortion of the aerocamera, characteristics of shutters, nonflattening of the film and its deformation, correction quality of the optical system, image motion etc.

The distortion effect decrease is achieved by reduction of the symmetrical radial and colour distortion in calculations of wide-angle camera lenses and by improving their manufacture technology which enables the calculated data to be reproduced more accurately and tangent and asymmetrical distortion to be lowered. The calculated distortion of the lenses of the new aerial cameras is up to 5 μm. The real distortion of all cameras, except TES-5, is not more than 10 μm.

In developing the new lenses special attention was paid to eliminating chromatic and monochromatic aberrations. In this respect some progress has been made: in the new cameras the chromatic difference of magnification characteristic of "colour" distortion does not exceed 0.02 mm.

The geometrical distortions connected with the operation of the shutter were eliminated by using the central shutters placed very close to the aperture diaphragm or in the plane optically conjugated with it. The image quality is strongly influenced by the image geometrical motion dependent on the image movement rate and exposure. The rapid shutters in TES-type cameras enable to obtain real exposure up to 1/700 s. The short exposures provide images essentially without effects of the geometrical image motion.

The shutters of the new cameras are principally the same, they differ only in leaf sizes dependent on the diameter of the aperture covered, its maximum size being 35 mm.

The exposure control is performed by changing the number of the electric motor turns in proportion with the variation of the integral brightness of the terrain. The proportionality coefficient is determined by the two parameters: a relative aperture or a lens and by the ratio of the film actinism to the filter factor.

Automatical exposure control (AEC) in cameras of TES-type is performed with the help of a photoelectric exposuremeter consisting of a unit with a photo-cell and a regulator of turns of the electric-motor shutter.

Changing the proportionality coefficient is achieved by varying the sensitivity of photoelectric exposuremeter.

The results of the flying test showed that in the case of photography of medium contrast terrain (plain, foot-hills,etc) root mean square deviation of integral density of negatives is within ± 7-10%. During photography of the areas with considerable fluctuations of landscape brightness (mountain regions) the deviations are ± 12-16%.

The film flattening in cameras of TES-type is made by pressing it to the glass plate (focal lengths are 50,70 and 100 mm) that has calibration marks making it possible to fix residual errors due to nonflattening and deformation of the film. To increase the accuracy of film flattening a steady stretch of the film is provided before the exposure and at the time of photography by using an electromagnet friction unit with variable momentum and by pressing the film to the glass with an elastic slab.

Studies of the film flattening accuracy were carried out with an interference unit. They showed that under laboratory conditions the medium deviation of the film from the glass surface regardless of its type and a flattening method is ± 5-6 μm.

The new series consists of the following cameras: AFA-TES-5, AFA-TES-7, AFA-TES-10 and AFA-TES-35. All the cameras, except AFA-TES-5, are provided with removable filters yellow, orange and transparent. The smoothing of illumination is performed by depositing a shading coat on the filter surface.

Camera AFA-TES-5 is intended for photography of large areas in small scales, mainly for geological mapping in the scales 1: 100 000- 1: 200 000. It is provided with Russar-62 lens with aspheric optics. The lens has a constant yellow filter. The main optical characteristics of the camera are given in Fig.1, where Ia is the principal optical scheme, I b is the resolution on panchromatic film of 22-type with the total aperture obtained with absolute contrast mires in meridian /M/ directions and tangertial /T/ direction, I c is the average radial distortion.

The aspheric lens enabled to improve illumination in the image plane at the camera angle up to 136.5°. But the difficulty of making aspheric surface did not allow to decrease photogrammetric distortion to the values suitable for precise photogrammetric measurements. For the test samples the maximum photogrammetric distortion is 0.05 mm, for the commercial ones it is 0.1 mm.

Very wide angle cameras AFA-TES-5 due to their large angle and high image quality are used successfully and enable to obtain a new type of geological information in studying stretched and weak structures.

Camera AFA-TES-7 is intended for photography of plain areas for the purpose of topographic mapping in the scale 1: 10 000 and larger. It is provided with Russar-80 lens whose focal length is 70 mm, angle of view is 120°, the relative aperture is 1: 6.8. The main optical characteristics of AFA-TES-7 are presented in Fig.2.

Camera AFA-TES-10 is intended for photography of hill areas in different scales. It is provided with Russar-71 lens whose focal length is 100 mm, angle of view is 103° and relative aperture is 1: 6.8. The main optical characteristics of AFA-TES-10 are presented in Fig.3.

Camera AFA-TE-35 is intended for photography of montain regions, towns and localities. It is provided with Russar-68 lens, whose focal length is 350 mm, angle of view is 40° and relative aperture is 1:7. The camera enables the central rotor shutter to be used, the magnification in lens pupils being 0.7. Due to this, with relative aperture being 1:7, the diameter of the aperture diaphragm, and therefore the shutter aperture are equal to 35 mm. The main optical characteristics of AFA-TE-35 are given in Fig.4.

In camera AFA-TE-35 vacuum flattening of the film to the plane at the time of exposure is used. The choise of this method is due to the fact that images obtained with AFA-TE-35 are mainly intended for making photoplans with high enlargement when negatives defects caused by mechanical damages of the glass and photographic layer that are inevitable in pressing the film to the glass, deteriorate the quality of negatives noticeably. And one need not use register-glass reseau.

Application of the said new cameras makes it possible to decrease air survey scale in 1,3 times to conventional cameras due to improving air photo quality only.

The main technical characteristics of cameras of TES-type are given in the table.

TABLE

The main characteristics of the TES-type cameras

Parameter	units	TES-5	TES-5M	TES-7	TES-10	TE-35
Focal length	mm	50	50	70	100	350
Camera angle	degree		136.5	120	103	40
Relative aperture	-		1:9	1:6.8	1:6.8	1:7
Illumination	-		$\cos^{1.48}\beta$	$\cos^{2.7}\beta$	$\cos^{3}\beta$	$\cos^{4.78}\beta$
Stereoscopic fusion accuracy	μm		±3.3	±3.5	±3.0	±2.8
Resolution not less than	1/mm		16	25	30	35
Photogrammetric dispersion not more than	μm		100	10	10	10
Exposure range	s	1/70 -1/700	1/80 -1/240	1/70 -1/700	1/70 -1/700	1/70 -1/700
Cycle time	s	2.4- -1.4	2.4	2.4- 1.4	2.4- 1.4	2.4- 1.4
Register-glass-reseau		yes		yes	yes	no
AEC		yes	no	yes	yes	yes

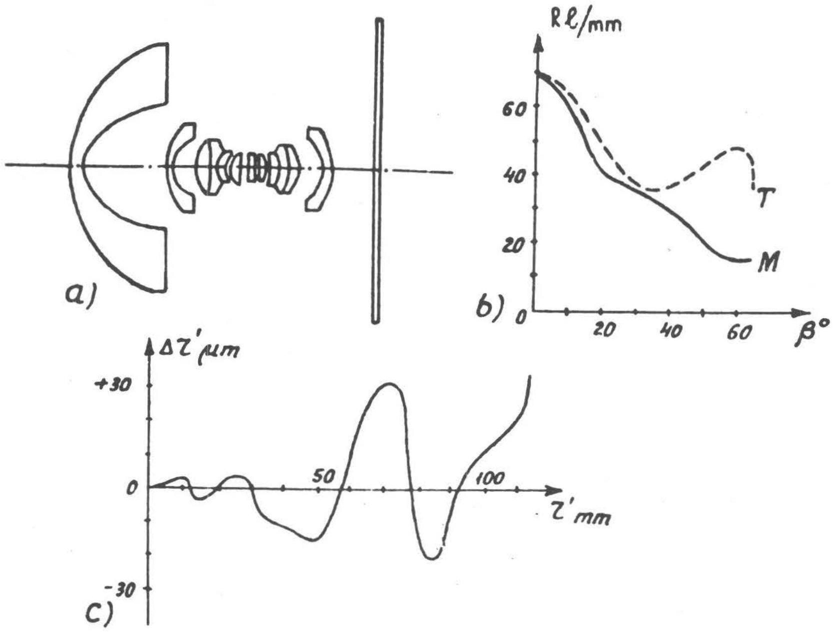

Fig.1.Russar-62-9/50 lens

a) principal optical scheme
b) resolution
c) average radial distortion

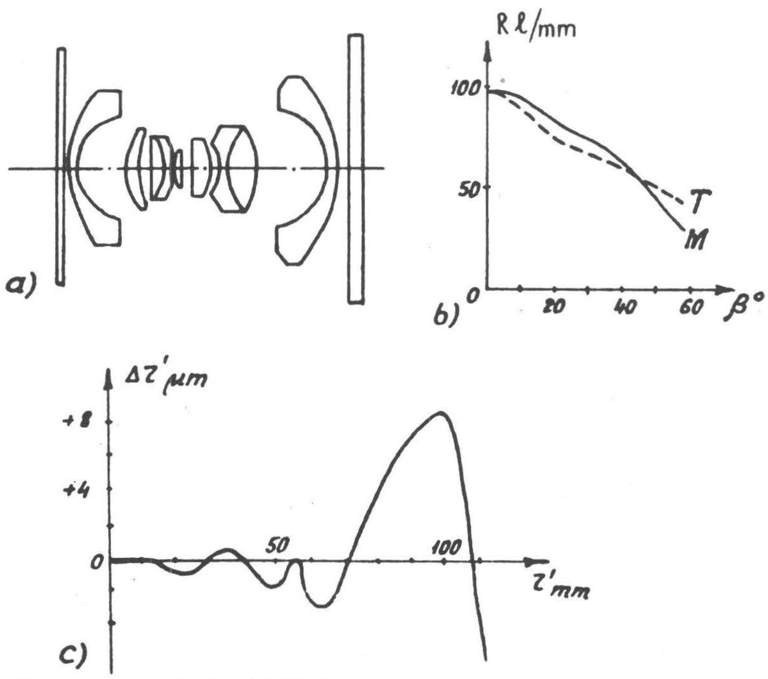

Fig.2.Russar-80-6.8/70 lens

a) principal optical scheme
b) resolution
c) average radial distortion

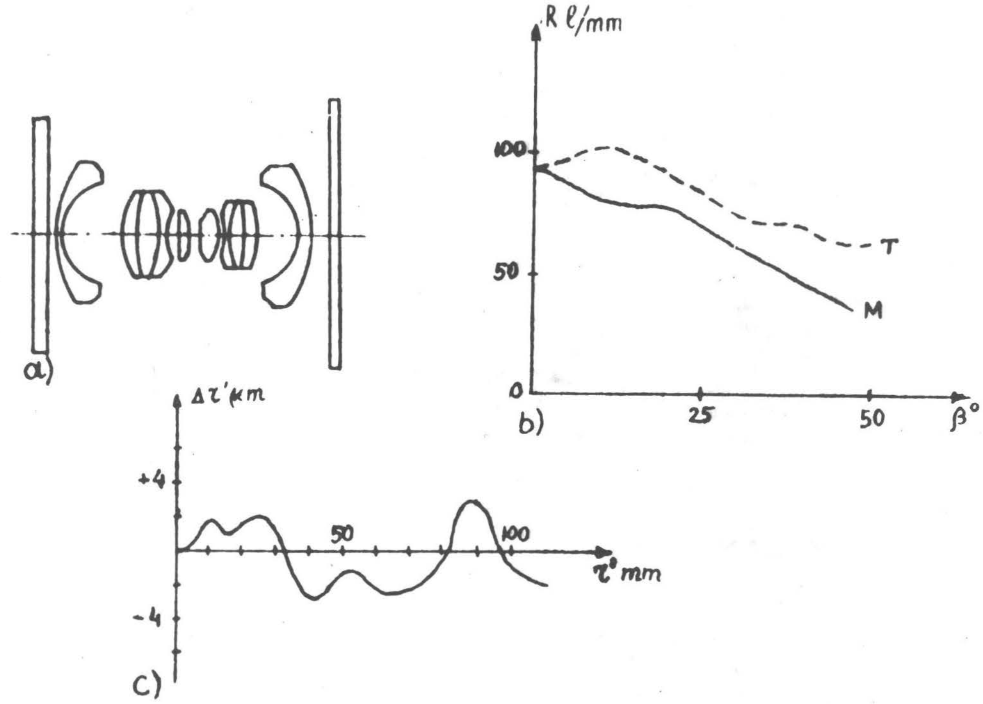

Fig.3.Russar-71-6.8/100 lens

a) principal optical scheme
b) resolution
c) average radial distortion

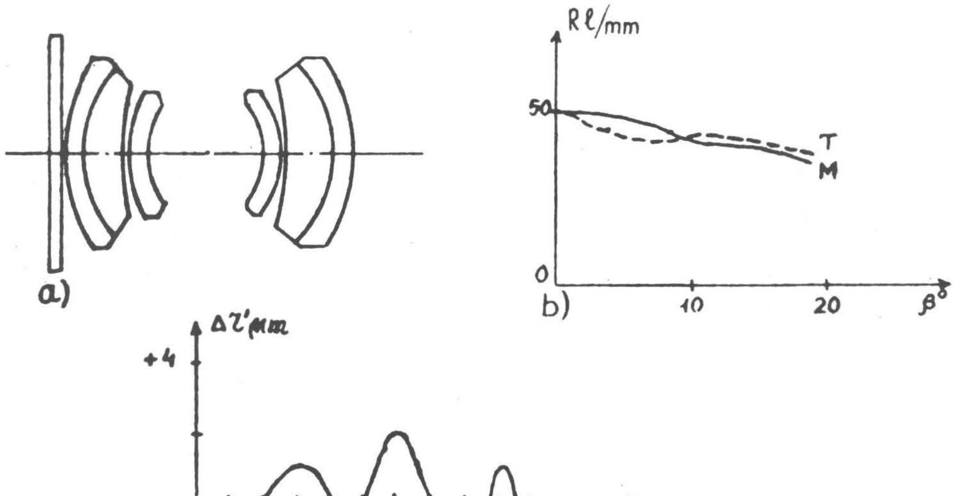

Fig.4.Russar-68-7/350 lens

a)principal optical scheme
b)resolution
c)average radial distortion

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