

Presented Paper

Dr. Achim Z i c k l e r
JENOPTIK JENA GmbH, GDR 69 Jena, Carl-Zeiss-Platz 1

MKF-6 Multispectral Camera from JENA

Abstract

The MKF-6 is a six-channel multispectral camera specially designed for applications in satellites. So as to make multispectral photography accessible to a larger circle of users, we developed the MKF-6 M specified for use in aircraft. The main field of application lies in the sector of aerial photo interpretation. The MKF-6 M is briefly characterized by giving its technical data.

Introduction

The MKF-6M is a six-channel multiband camera which has particularly been designed for use in USSR-satellites. The development and construction of the six-channel MKF 6/MKF 6M Multispectral Camera has been solved by the JENA works in close cooperation with the Moscow Institute for Cosmic Research. For the first time the MKF-6 was used aboard Soyus 22 in September 1976. A modified version of this camera, the MKF-6M, had been operated in the "SALUT 6" scientific orbital station. In both experiments high-quality photographs of the earth's surface had been obtained. To make multiband photography accessible to a wide circle of appliers, a special type of multiband camera - the MKF-6M - has been developed for use in aircrafts. The main field of application lies in the sector of aerial photo interpretation. The major task is the reconnaissance and exploration of the earth, its configuration and its resources.

Here it will be appropriate to explore the Earth under spectral conditions differing from those obtainable by the eye or by normal photographic devices with a comparatively wide spectral sensitivity. The different soils, waters, vegetations, buildings, in brief, all terrestrial elements display characteristic absorptions in the narrow-band spectral regions which give information about their state and, partly, on their substance.

It is of vital interest, therefore, to take photographs of the Earth on black-and-white film in the various spectral ranges through narrow-band filters. Multispectral photographs of this kind ensure that our knowledge on the quality of the Earth, its mineral wealth, its pollution, its vegetation is expanded and continuously brought up-to-date. Multispectral technology permits to gain quickly and effectively a wealth of information which will be of great profit to geology, geography, geodesy, hydrology, environmental control, agriculture and forestry as well as to many other fields.

In addition, photographs taken with the MKF-6M can be used for the production of small-scale maps.

The MKF-6M Multispectral Camera includes the following units:

- . Camera body
- . 6 magazines
- . Suspension unit
- . Control console with sighting unit
- . Electronic package.

Main components of the camera body are:

- . six lenses
- . shutters with their drive mechanisms
- . diaphragm setting
- . data exposure facilities
- . image-motion compensation.

The performance of a multiband camera is essentially a function of its lens parameters. For the MKF-6M a high-performance lens has been developed - the 4/125 Pinatar -

being an optimum solution for multiband photography.

- . In order to achieve high geometrical resolution each lens is adapted to the respective spectral band. The represented modulation transfer functions (MTF) show that the diffraction-limited course is nearly reached.
- . The six lenses incorporated in the camera are adjusted to have equal calibrated focal lengths. That way, all photographs of a multiband set have the same linear magnifications.
- . A precision fiducial plate is adjusted with the optical axis of each lens to print nine fiducial marks onto each single exposure. The cross-lines guarantee a highly precise registration of the single pictures in the MSP-4 Multi-spectral Projector.

By combination of sharp-cut dielectric interference filters with colour glasses a special type of filters has been developed for the MKF-6M which distinguish themselves by high transmission and steep slope. As additional optical element in the photographic light path the filters meet highest demands as to flatness and plane parallelism. Apart from the great number of bandpass filters to be supplied, customers' requests can be considered after being checked for their materialization.

The MKF-6M is equipped with electrically driven rotating disc shutters time-tested over many years, made in our aerial survey camera production department. They have many advantages and meet all demands made on a modern photographic camera.

- . Large exposure time range. Exposure time to be set in $\sqrt{2}$ - steps between 7 ms and 56 ms.
- . Fully electronic control of the set exposure time to $\pm 3\%$.
- . High synchronism by mechanical coupling of all shutters.
- . An 8-step diaphragm setting permits to adapt each channel to the type of film used and to compensate different filter factors of the bandpass filters.

To facilitate interpretation of the photographs additional data are exposed onto the film.

- . Highly precise cross-lines for precise registration of the photographs in the MSP-4 Multispectral Projector.
- . Channel numbers - located in the lower left corner of each picture. They are slightly displaced from channel to channel, so that they appear side by side in the colour mixing projector.
- . 10-step gradation scale for photometric photointerpretation. Density gradings: ($\Delta s/\text{step}$) 0.3
- . Exposure number (only in channel 1). Exposure counter to be reset electrically. 4-digit display.
- . Clock with central seconds hand (only in channel 1)
- . Note plate (only in channel 1)

Exposure time (only in channel 2). It is exposed in 3 digits in binary code. For distinctions, the three bits are provided with different symbols.

The excellent lens performance necessitated a facility that would compensate the aircraft's advance relative to the earth surface and thus prevent image blur. This compensation is materialized in the MKF-6M by a swinging follow-up motion of the whole camera during exposure. The maximum permissible error of this compensation is 0.8 mrad/s.

The MKF-6M is designed for unperforated 70 mm roll film. The magazine may be loaded with 120 m film of a thickness of 0.18 mm, which corresponds to about 1250 photographs. The capacity is, however, increased, if films with a thinner base are used.

The film supply indicator gives the length of unexposed film left in percents and is, therefore, independent of the material used.

Film advance is controlled electronically. Film end or film break is indicated on the control console. All six magazines are of identical design and are, thus, interchangeable.

The suspension unit forms the link between camera body and fuselage. It is equipped with antivibration facilities in order to protect the camera from undesirable vibrations, especially from those caused by the engines. Thanks to the camera suspension in the centre of gravity there is no conversion of longitudinal vibrations into quality-reducing rotational vibrations. The camera body rests on a support ring which is rotatable in azimuth for drift setting. Correct drift setting is made automatically via the sighting unit.

For horizontal adjustment the suspension unit can be inclined along flight as well as across flight according to the indication of the circular bubble.

Control console and sighting unit incorporate all elements for controlling the MKF-6M during the photo flight as well as for monitoring the correct operating cycle. This means that the operator is relieved in his work considerably. The necessary information is transmitted via electrical connection cables so that control console, sighting unit and camera can be installed in the aircraft at the place particularly suitable for their application. The sighting unit contains a telescope of high light-gathering power whose field of view covers a frame of the MKF-6M. Besides the image of the terrain flown over, the patterns for drift setting and setting the speed of image-motion compensation - a straight course lines and a spiral adjustable in its speed of rotation - can be seen in the eyepiece.

Except the knob for spiral speed adjustment and a pushbutton for single exposures, all the other control elements are arranged on the control console which has to be installed so that it is conveniently accessible to the operator.

The operating cycle of the MKF-6M is so that after switching over to "sequential exposures" the first exposure is released immediately. By this, it is possible to start taking serial pictures above a certain point. The aim point is sighted by means of a cross in the centre of the visual field.

Of course, it is also possible to take single exposures during the regime "sequential exposures". The period of the regime "sequential exposures" is automatically computed from the set values of the overlap degree and the speed of image-motion compensation.

The vital functions of the MKF-6M are monitored fully electronically. Film advance of all six magazines as well as shutter function and image-motion compensation are checked, and proper operation is indicated by pilot lamps. A failure is signalled by permanent lighting of the "failure" lamp. Continuous monitoring of the camera by the operator is, therefore, rendered superfluous.

For special application purposes it is possible to connect an MRB-9/2323 Aerial Survey Camera. The control elements required for operating the aerial survey camera are integrated in the control console, which is divided into three sections

- . section with controls for both cameras
- . control system for MKF-6M
- . control system for MRB-9/2323.

The two cameras are coupled so that they are released simultaneously, but only every second or every fifth release pulse acts on the aerial survey camera because of its larger field angle. Release pulses for single exposures always operate on both cameras. But it is also possible to operate both cameras individually. Drift compensation is set via the sighting unit for both cameras simultaneously.

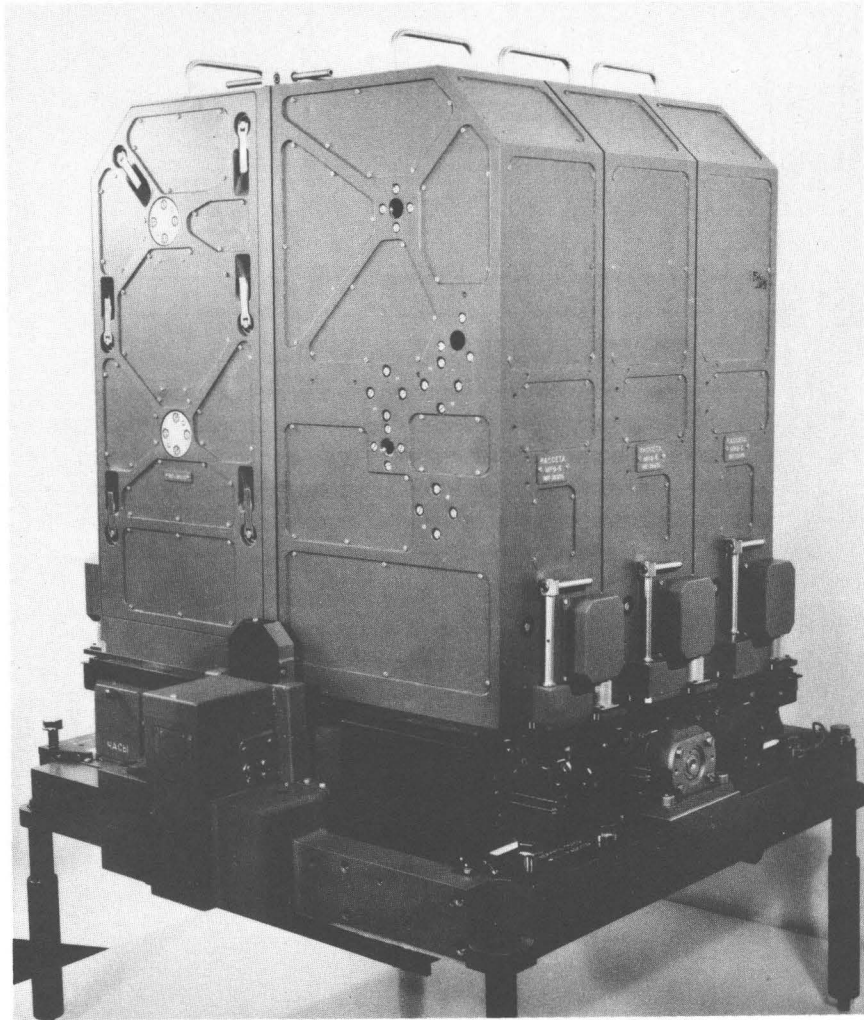


Fig. 1 Multispectral Camera MKF-6M

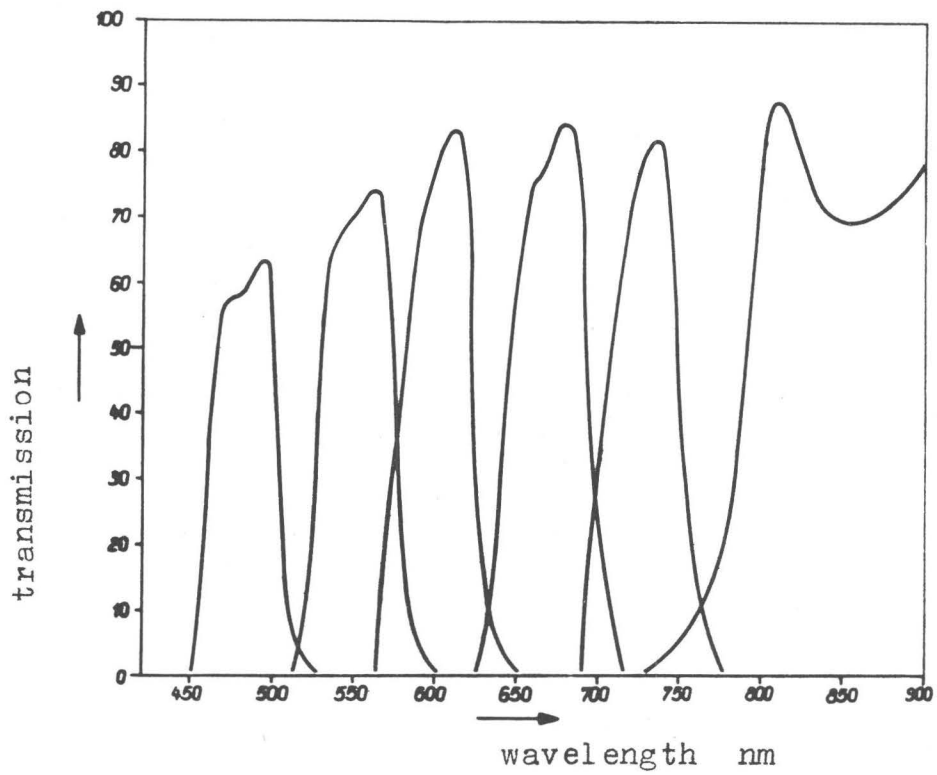


Fig. 2 Filter curves

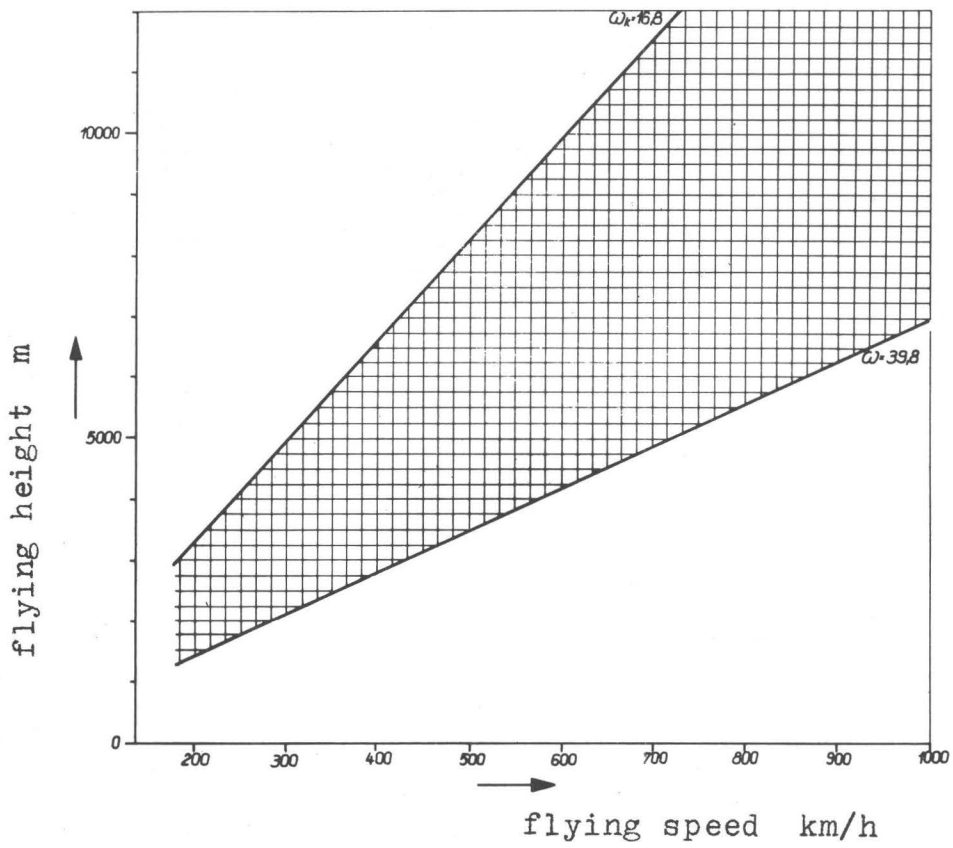


Fig. 3 Working range of the forward motion compensation