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MSP-4C Multispectral Projector - a colour synthesis instrument for the interpretation of multispectral photographs

Abstract

The MSP-4C Multispectral Projector is a four-channel colour synthesis instrument for the interpretation of multispectral and multitemporal black-and-white photographs taken from aircraft and space vehicles.

It transforms in an additive way the density differences between such black-and-white photographs into colour differences. The presentation of several photographs in one single composite colour image allows the effective interpretation of aerocosmic remote sensing photographs without using expensive digital image processing equipment.

Introduction

The MSP-4C Multispectral Projector is a four-channel colour synthesis instrument for the evaluation of multispectral or multitemporal aerocosmic black-and-white photographs for tasks or remote sensing of the earth; particular features are its high efficiency, universal applications, simple operation and expedient design.

The projector transforms the relative density differences between such black-and-white photographs additively into colour differences. The multitude of multispectral or multitemporal image details is simultaneously presented to the interpreter in a colour composite image, which facilitates interpretation in that the pictorial information is more easily perceptible.

The synthesis of several pictures into one single image by the MSP-4C Multispectral Projector permits already an effective evaluation of aerocosmic remote-sensing photographs without using expensive digital image processing equipments.

Multispectral technique

The multispectral technique holds out possibilities to acquire a better knowledge of terrestrial exploration objects, to visualize smaller differences between them than experienced with conventional photography on black/white film, colour film and so-called false colour film. It makes use of the object specific spectral-reflection properties for information gain.

In black and white photography, only those objects will become visible on the film (on account of their difference in density) whose integral reflecting power which covers the entire sensitivity range of the film is non-uniform.

However, despite their extremely different relative spectral reflection properties very many objects, especially within the classes vegetation, bare ground, water and snow, produce the same density and are not discernible.
Greater differentiation of the photographed ground is possible if its colourfulness is recorded on colour film or false colour film. In three spectral channels which correspond to the sensitivity ranges of the colour films the relative spectral reflection differences of the individual objects of the terrain are transformed into colour differences. Objects provided with such reflective properties may be recognized that way. The colours of the terrain taken on usual colour film are reproduced approximately as perceived by the eye, i.e. its sensitivity ranges (same as those of the eye) are in the blue, green and red spectral regions. The false colour film on the other hand has - in addition to two sensitivity ranges in the visible (mostly green and red) region - another emulsion sensitized for the near infrared spectrum. It reproduces natural objects in false colours. Living plants, for instance, strongly reflecting in the infrared show up in red, whereas red and green hues are transformed into green and blue. On account of its sensitiza-

tion, false colour film is of particular interest in the case of objects having great reflection differences in the infrared spectral region. But neither with colour photography nor with false-colour photography is it possible to discern all details of the terrain formation. It is a well-known fact that no conclusions can be drawn from the colour of an object to the relative spectral reflection behaviour. Numerous objects do not display any colour differences on colour film or when viewed with the naked eye. In the case of these objects, relative differences in the spectral reflection behaviour exist within the three sensitivity ranges of the eye or of the colour film which cannot be sensed by them.

A further differentiation of the surface of the Earth is only possible by increasing the number of channels and, consequently, of colour separations, a feature implemented in the MKF-6 Multispectral Camera which is provided with six spectral regions. The advantage of multispectral photography is that it makes use of a great number of spectral ranges and their optional position in the spectrum (adapted to the problems in hand) at simultaneously narrower channel bands.

It is the task of the MKF-6 to transform the relative spectral brightness differences of the objects into as great density differences as possible on the six black/white films. A direct evaluation of these photographs as to their density is ineffective without highly sophisticated automatic scanners and electronic data processing equipment.

The MSP-4C Multispectral Projector developed for this purpose is a relatively simple evaluation unit. It is the objective of this colour-mixing projector to retransform the relative density differences into as great colour differences as possible. To this end, up to four black and white photographs are added together to form a colour composite. The instrument consists of four individual projectors into which different colour filters may be inserted. Assuming, for example, that photographs of the MKF-6 were placed into two projection channels of the MSP-4C which are projected one upon the other with a green colour filter in the one channel and with a red filter in the other. The result is that those objects on the black/white photographs of the MKF-6 which have produced the same densities on both pictures are imaged in the colour mixed from green and red, i.e. yellow. Those objects which have a lower density e.g. in the green projection channel than in the red channel display a stronger green colour, i.e. they have a green yellowish shade. Here, the colours are produced according to the laws of additive colour mixture.

The wealth of multispectral picture information of the black-and-white photographs is thus clearly presented to the operator in one colour composite. This concentration of several photographs in one picture enhances the effectiveness of evaluation as only the interesting relative density differences are transformed into colour differences. With exclusive use of negatives or positives absolute differences do not produce colour gradations, but merely lead to brightness changes between the objects.

The MSP-4C Multispectral Projector ensures many reproduction possibilities of the colour composite contained in conventional photography. In addition to black-and-white reproduction, where no colour filters are used, several colour reproductions will be possible. The black-and-white reproduction yields a composite image which depending on the selected colour separations is similar to an exposure made on panchromatic or infrared black-and-white film.

If the colour separations of the MKF-6 from the blue, green and red spectral regions are mixed in the MSP-4C using the corresponding filters blue, green and red, the coloured picture of the terrain appears to be approximately true-to-nature. A true reproduction in natural colours is neither necessary nor possible.

With the respective correlation - as in the case of false-colour film - a conventional false-colour picture is obtained. Of by far greater importance for the evaluation in the colour mixing projector, however, are those false-colour presentations, where the fixed correlation between photographed colour and projected colour is missing. By a suitable choice of brightness and colour filter in the projection channels the mixed colour can be located in those ranges in which the human eye disposes of its maximum colour discrimination capability.

In addition to the evaluation of multispectral photographs, the MSP-4C projector can also be used for the interpretation of temporally variable processes of the Earth's surface. Such changes may be both of a local and spectral nature.

To this end, photographs of the terrain to be observed are taken at the beginning and at the end of the investigation period. The projector will then clearly display variations on the surface of the Earth in the form of colour changes. Further to its application in the exploration and observation of the Earth, the multispectral projector can be employed to advantage in all those provinces where the visual evaluation of multispectral, multitemporal, etc., black-and-white photographs is absolutely necessary.

Description of the instrument

The method of obtaining black-and-white separations and their subsequent synthesis to form a colour picture - a principle on which the multispectral technique with the MKF-6 and MSP-4C is based - places high demands on the instrument manufacturing industry. The problem to be solved in the development of the MSP-4C was:

Up to four multispectral black-and-white photographs taken with the MKF-6 with a high geometrical resolving power and minor registration errors must be additively united to form a colour composite where small relative density differences in the photographic material are transformed into as large colour gradations of the colour composite as possible. It was our objective to develop an instrument of excellent geometric and photometric resolving power to be able to evaluate the

multispectral characteristics of the MKF-6 photographs with least losses of information.

The MSP-4C Multispectral Projector has four independent optical projection channels, so that the arbitrary combination of the individual images becomes possible.

The MSP-4C Multispectral Projector incorporates the following important geometric and photometric characteristics as well as operating and service features:

- Rapid and exact registration of the images of the MKF-6 camera according to precisely positioned cross marks.
- Excellent geometric resolving power and few registration errors thanks to the specially designed projection lens.
- Precise controls for all necessary image manipulations with large adjusting ranges.
- Variations of image scale without affecting the image sharpness by pancratic projection lenses.
- Conversion of slight density differences of the composite image by optimally selected glass interference colour filters and little stray light.
- High and constant brightness of the composite image by stabilized low-voltage high-duty halogen lamps and optimally designed illumination optics.
- High uniformity of illumination in the projection plane by specially designed illumination optics with adjustable projection lamps and concave mirrors as well as by unvignetted projection lenses.
- High uniformity of luminance of the projection screen due to the excellent scattering capability and optionally usable Fresnel field lens.
- Large range of brightness variation with low colour temperature change by additional neutral filters.
- Arbitrary combination of black-and-white photographs, colour filters and brightnesses with low losses of image sharpness, image registration and uniformity of illumination.
- Large-format, glare-free projection screen with high resolution.
- Large-format photo cassette for taking enlarged photographs with high resolving power and good photogrammetric quality by replacement of the projection screen.
- Recording camera on a swivelling arm for taking photographically reduced pictures.
- Point-by-point brightness measurement for exposure setting with manually attachable measuring head.
- Convenient operation and interpretation by a seated operator, simple change of photographs and safeguard against incorrect manipulations.

. Easy maintenance by convenient access to all important components and by special dust protection measures.

Interpretation possibilities

The MSP-4C Multispectral Projector allows the visual interpretation of

. cosmic photographs taken with multispectral scanners e.g. from the remote-sensing satellites Soyus, Salut, Landsat and Skylab,

. aerial photographs taken with multispectral cameras or multispectral scanners,

. multispectral, multitemporal and other black-and-white photographs on film in the form of positive and/or negative material,

. photographically preprocessed or computer-optimized black-and-white photographs

by using a multitude of synthesized composite images in the form of

. false-colour presentations including pseudo-colouring of individual black-and-white photographs,

. natural colour presentation, and

. black-and-white presentations.

The MSP-4C Multispectral Projector allows the photographic recording of

. single image or composite images at 5 times magnification,
. single images or composite images at 0.6 times minification.

Fields of application

The MSP-4C Multispectral Projector may be used for the interpretation of remote-sensing data for purposes of the production of food plants and raw materials as well as research and control of the environment especially in the following fields of economy and science:

. Agriculture: type and quality of soil, state of agricultural cultivation, quantity and distribution of animals

. Forrestry: assessment of the standing crop of wood, centres of fire

. Melioration: planning of irrigation and melioration systems

. Geology: exploration of mineral deposite and water resources

. Geography: economic and traffic geography, urban and settlement geography: land utilization

. Cartography: topographic and thematic mapping, updating of maps

- Hydrology: Resources and distribution of fresh water, ground water, distribution of ice and snow, water level of dammed-up lakes
- Utilization of oceans: quantity and distribution of fish and water plants
- Oceanology: pollution of oceans, ocean currents, condition of coasts
- Catastrophe warning: state of volcanoes, flood protection extent of floods, earthquake warning, spread of large-scale fires, danger of glaciers and avalanches, spread of sludge masses and mud flows.

Fig. 1 MSP-4C Multispectral Projector from Jena

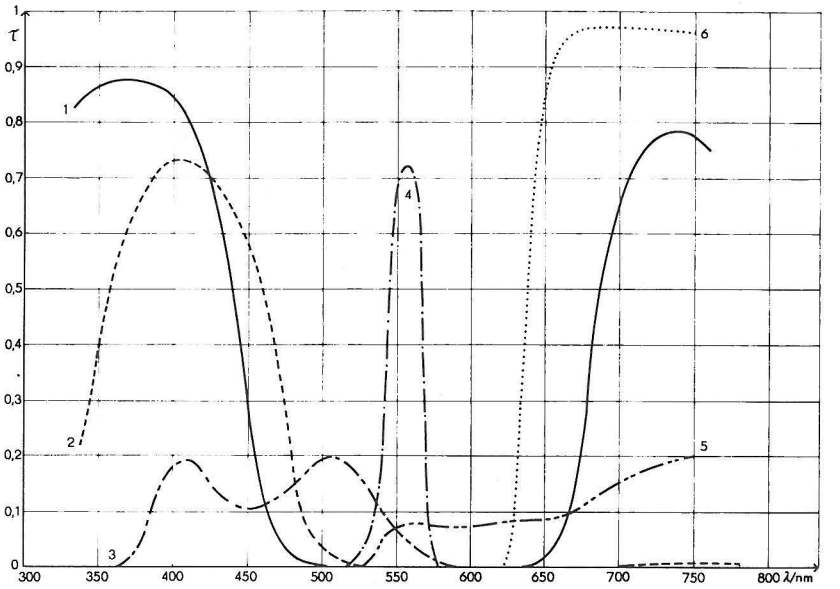

Fig. 2 Relative spectral transmission of the colour filters 1=purple filter;2=blue filter;3=blue-green filter; 4=green filter; 5=yellow filter;6=red filter

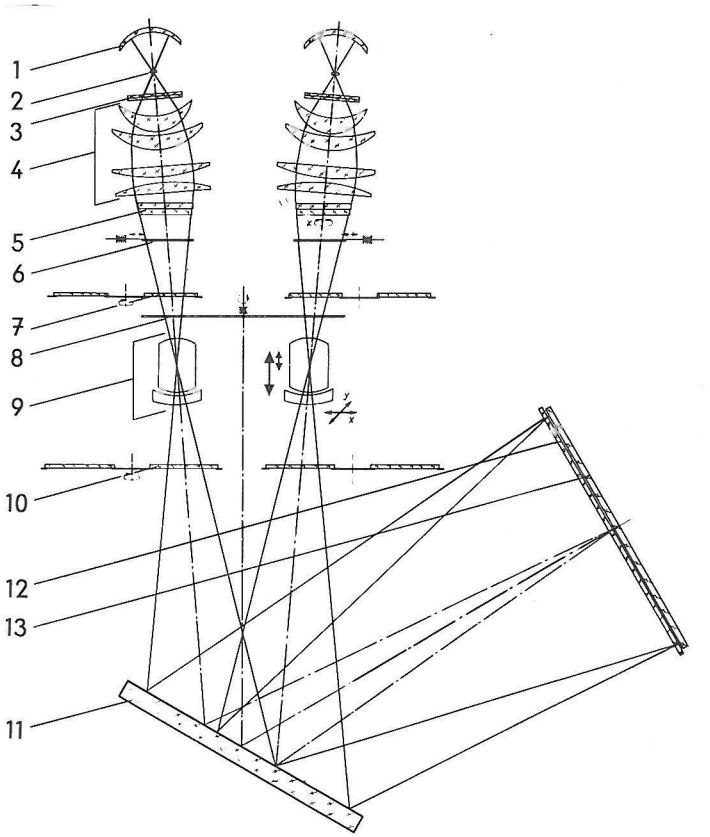

Fig. 3 Optical arrangement of the MSP-4C