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MULTISPECTRAL TECHNIQUES FOR GENERAL GEOLOGICAL SURVEYS

EVALUATION OF A FOUR-BAND PHOTOGRAPHIC SYSTEM*

by

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**U. S. Geological Survey, Menlo Park, California

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INTRODUCTION

For several years the author and Michael F. Sheridan have been making a general geological survey at 1:62,500 scale of the well-exposed rocks of the White Mountains and the adjacent volcanic desert plateau near Bishop, California (figure 1). The tuffs, granites, sedimentary rocks and metavolcanic rocks in this arid region are varicolored and conventional black and white aerial photographs have been a useful mapping aid, especially in mapping the extensive Bishop tuff. The work is fairly typical of general geological surveys at large scales (1:24,000 and 1:62,500) and stands in contrast to special purpose studies or reconnaissance of large inaccessible areas.

A large number of true color and false color aerial photographs and multispectral viewer screen images of the study area were made available to us and we have been asked to consider what imagery would have been the most useful for distinguishing rock types. Our only control over the experiment was to select the flight lines and altitudes.

DISCUSSION

The multispectral aerial camera and accompanying projector used in the experiment were developed by Edward Yost and Sondra Wenderoth, Science and Engineering Research Group, Long Island University (Yost and Wenderoth, 1967, 1968). Flights were in August 1967 at about 24,000 feet above the ground with one airplane carrying three cameras -- the multispectral camera (figure 2) loaded with black and white infrared sensitive aerial photographic film (infrared sensitive Kodak no. 5424) and two 70 mm color cameras, one loaded with Kodak Ektachrome Aero 3/8442 color positive film and the other with Ektachrome Infrared Aero 8443 film. All cameras were fired simultaneously and all viewed the same area on the ground.

Each lens of the multispectral camera had its own separate filter: blue, 325-520 nanometers (millimicrons); green, 480-610 nanometers; red, 590-700 nanometers; infrared, 700-980 nanometers (figure 3). The four photographs of the same area are recorded side by side on one piece of 9-inch-wide black and white film. Large tarpaulins of red, yellow, blue and grey canvas (100' x 100') were laid out on the ground and the intensity of incident and reflected light at various wavelengths was monitored with radiometers during the flight. Film exposure, processing and subsequent colormetric measurements were thus under control.

The roll of multispectral negatives was first copied on a roll of positive film before being placed in a special four lens projector (figure 4). The four positive photographs were superimposed in registry on a viewer screen that had to be studied in a darkened room. The colored scenes created could be infinitely varied by manipulating filter and light controls (figure 5) for each of the four lenses. This camera-projector system effectively keeps all photographs locked in fixed positions on rolls of uncut film and solves reasonably well the registration problem inherent in making a composite image.

The numerous scenes, in true and false colors, that were constructed were searched for information not apparent on other photographs -- conventional 9" x 9" black and white matte finish photographs at various scales that are being used in the study area and the film positive copies of the two 70 mm color films. Guidelines as to what the most useful image would be on the viewer screen were lacking so that the attempt to find projector settings that would noticeably enhance known contacts and rock types was a tedious trial and error process. The four multispectral photographs were studied individually by placing the roll of film positives on a light table and also by projecting them one at a time on the viewer screen. Stereo pairs so commonly of great value to geologists were not available for the color photographs or projections and it was not possible to critically view the various images side by side in one field of view with good and equal light or to test them in the field.

Colorimetric measurements taken on the viewer screen itself were used to describe the color of the various rocks represented on a few select screen images (Yost and Wenderoth, 1968, p. 60-63).

CONCLUSION

Photographs on true color film were readily judged the most useful for unraveling the general geology of the Bishop-White Mountains area. Geographic locations were most easily recognized on these images and although known contacts between rock formations were visible on most images, they were generally most conspicuous on the true color film. When manipulating the viewer screen images there was a definite tendency to select as "best" the projection that simulated the true scene as remembered, i.e., that simulated the true color film image. Many specific comparisons of color photographs with black and white photographs by geologists (e.g. American Society of Photogrammetry, p. 63, 80, 85, 293, 294) confirm the preference for color film.

Several images capturing or displaying the non-visible infrared wavelengths showed certain contacts with particular clarity but no overall advantage in general utility was evident. The enhancement of vegetation and the haze penetration characteristic of infrared images is of no noticeable advantage in this barren desert where the air is relatively clear. Vegetation patterns do not seem to be closely related to principal geologic features.

The opinion of the author is that study of a great many images while making general geological surveys would be impractical and unproductive. The multipurpose true color photograph may be a near optimum for making such general surveys of accessible areas at common (e.g. 1:62,500) scales where geologists will be on the ground studying many details and interpretations. Multispectral images on the other hand may be most useful for special and gross tasks such as delimiting a particular lithology over large or inaccessible areas. It then becomes necessary to know what subjects (e.g., lithologies) are irrelevant, so they can be suppressed while features of interest are enhanced. The difficulty of making this choice may be considerable, but presuming fore knowledge, the lens, filters and projector settings of a multispectral system can be tailored to characteristic spectra reflected from a few chosen lithologies so that those lithologies are enhanced.

In the experiment described here the four broad-band camera filters were chosen without any special task in mind and no guidelines for projector settings were available. In subsequent work the spectra reflected from bare rocks and a few soils near Bishop and elsewhere in California will be used to select specific filters and projector settings.

REFERENCES

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Optical Society of America, 1953, Science of color, Crowell (ed.), Committee on Colorimetry.

Yost, E. F., and Wenderoth, S., 1967, Multispectral color aerial photography: Photogrammetric Engineering, v.33, p. 1020-1033.

Yost, E. F., and Wenderoth, S., 1968, Precision multispectral photographic evaluation for earth resources applications, chapter 10, Long Island Univ., 77 p.

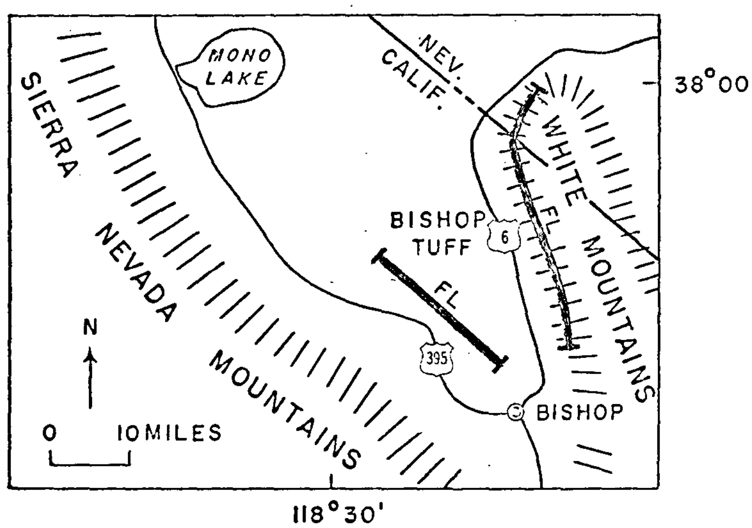

Figure 1: Index map showing location of study area and flight lines(FL) near Bishop,California

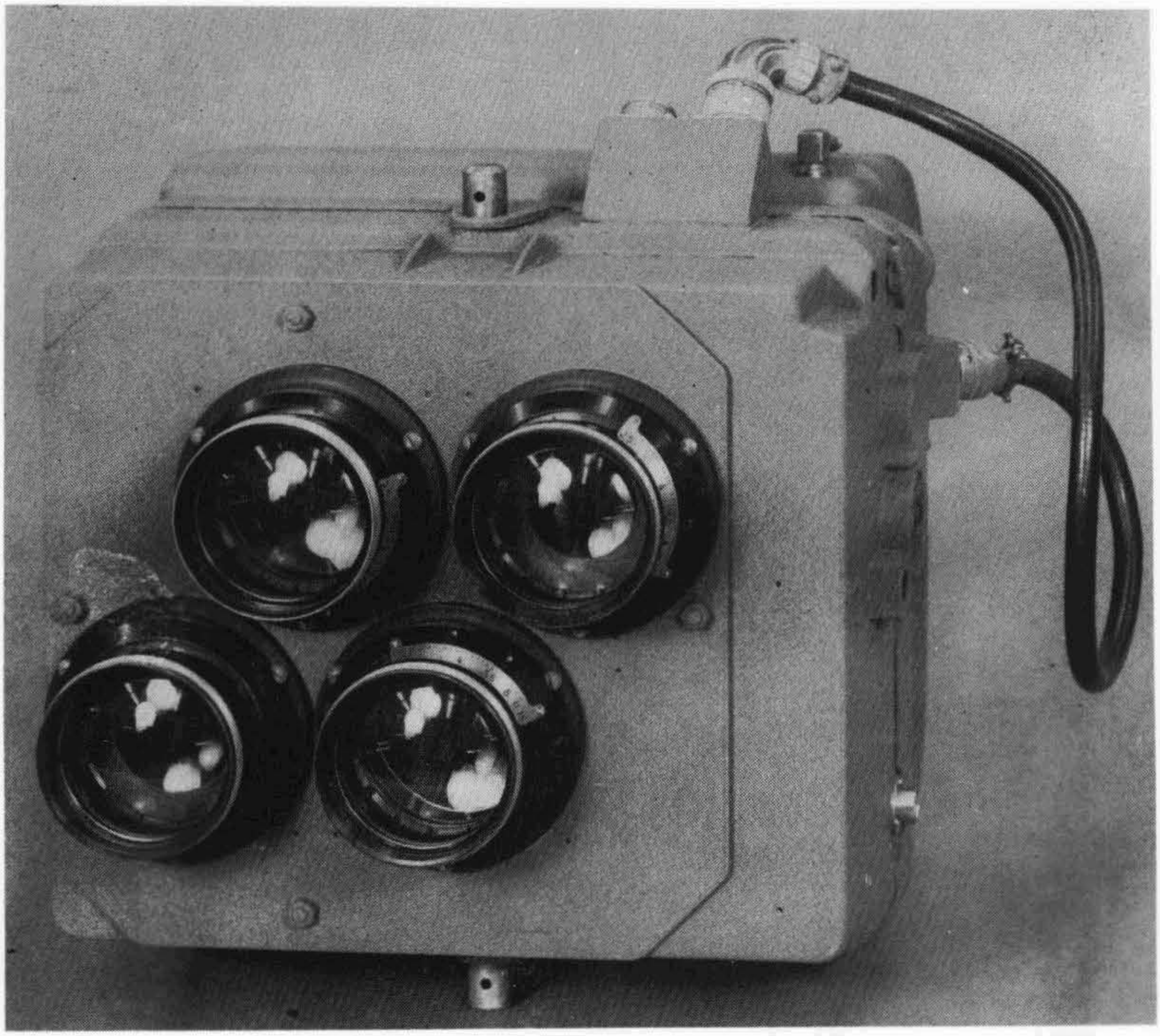

Figure 2. Four-lens multispectral camera.

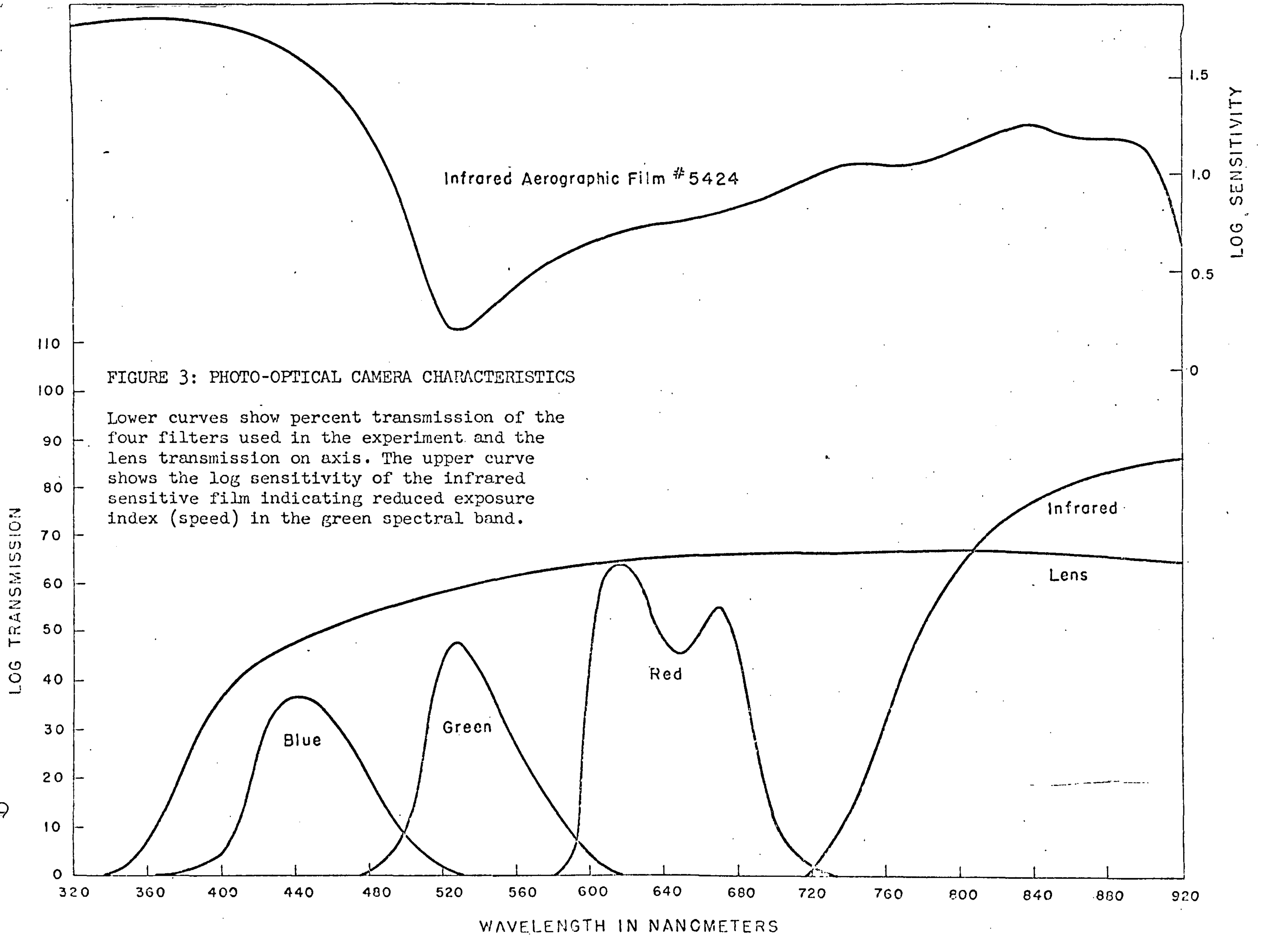

FIGURE 3: PHOTO-OPTICAL CAMERA CHARACTERISTICS

Lower curves show percent transmission of the four filters used in the experiment and the lens transmission on axis. The upper curve shows the log sensitivity of the infrared sensitive film indicating reduced exposure index (speed) in the green spectral band.

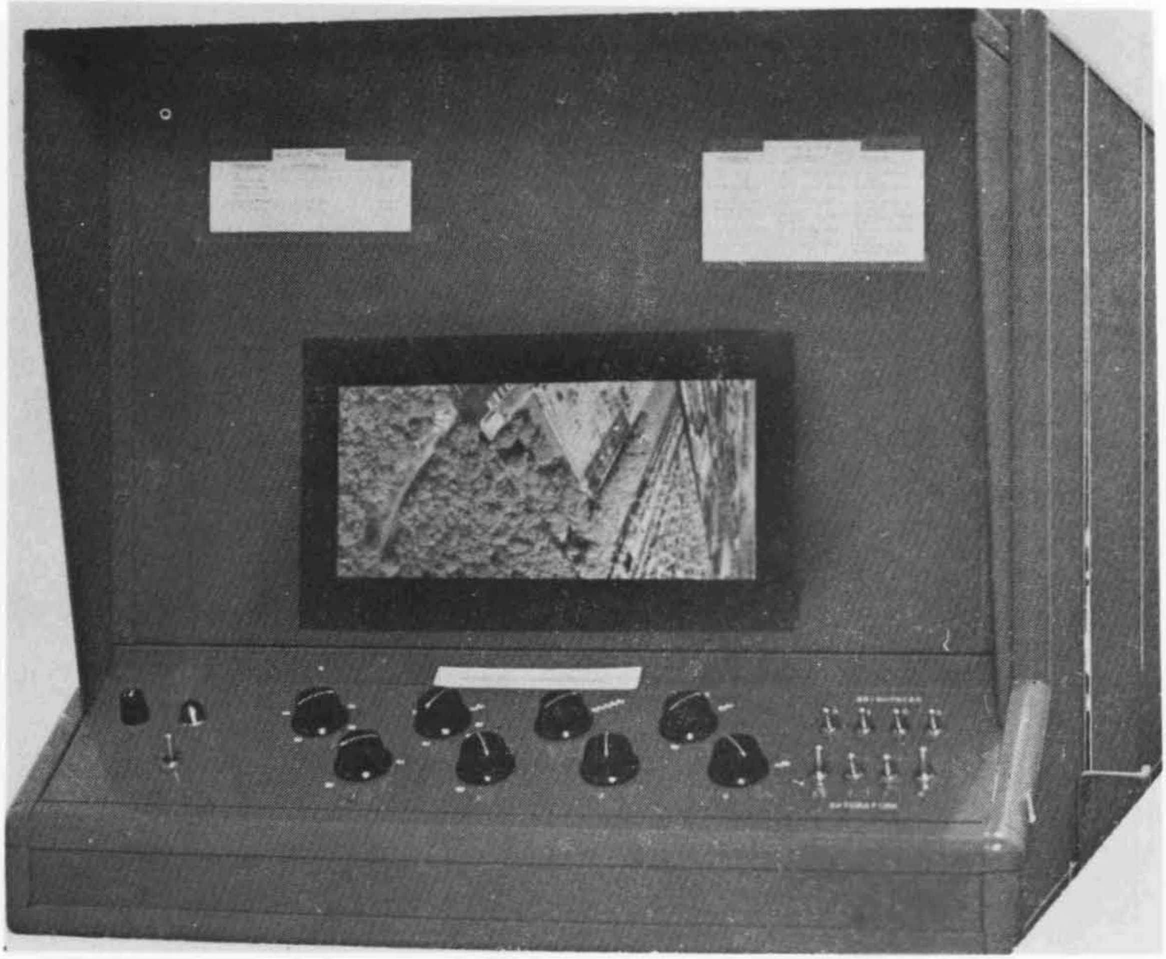

Figure 4. Multispectral additive color viewer.

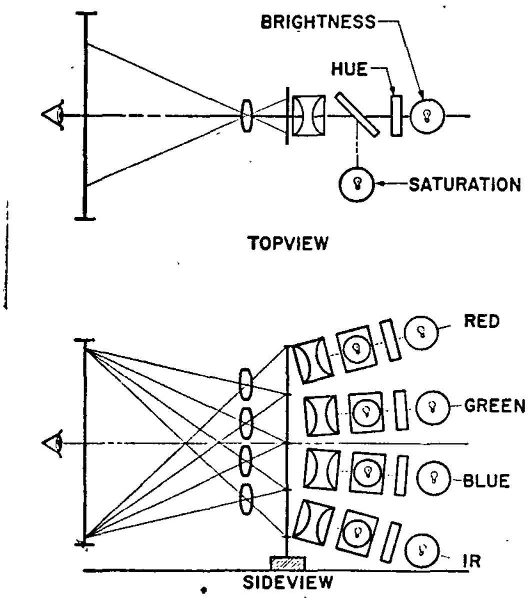

Figure 5. Schematic diagram of the additive color viewer.

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