The scale of photography used in Professor Jackson's project was 5.08. This may be considered as one of the limitations of using the photogrammetric method, because some specimens may range in size from ten to thirty feet. Photogrammetric inaccuracies can result in photographs taken of such subjects. Consequently, the inability to photograph accurately at certain distances, from the subject, is a definite limitation of this method.

Conclusion

For relatively smaller specimens, the photogrammetric method can provide great accuracy and complete information in measuring deformations of the specimens. Under good lighting conditions the photographs can be taken without stopping the load application, and, as a result, rapid records can be continuously obtained. But for larger specimens, the scale of the photography (O/f) usually may be greater than the limiting value (6.35 to produce values comparable to a 0.001 in. dial gage). For large specimens it is more difficult to obtain better accuracy.

Care must be taken that a precise lens is used in the camera for photogrammetric measuring. The focal-length, angular field, and depth of focus of the lens must form a compatible system for each test set up. Different structural tests may require different lenses and obtaining these lenses may become expensive.

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*A New Portable Reflectance Spectrophotometer for the Selection of Film and Filters for Aerial Photography**

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ABSTRACT: *The paper will consist of (1) illustrations and description of the Reflectance Spectrophotometer built by Perkin-Elmer Corporation for the U. S. Army Engineer Research and Development Laboratories (2) the operating characteristics of the instrument and (3) examples of the first field data obtained and how it applies to the problem of film-filter selection.*

BROADVIEW, as well as many other groups and individuals, has long felt the need for a logical and systematic approach to the use of films and/or filters for the best delineation of aerial photographic subjects. Because the images on a photo represent so many hues that no one film-filter combination will separate all the objects, the few objects which are of primary interest usually determine the film-filter combination used. A choice of a film-filter combination all too often has had to depend on guesswork as to the spectral

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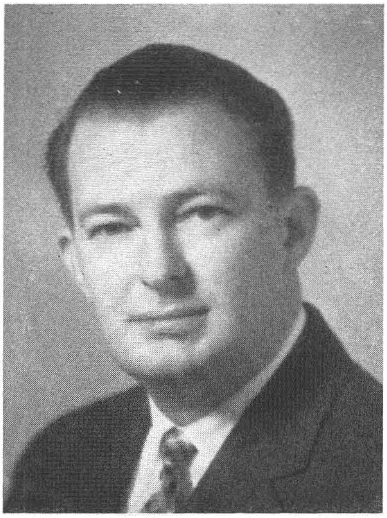

J. C. Little

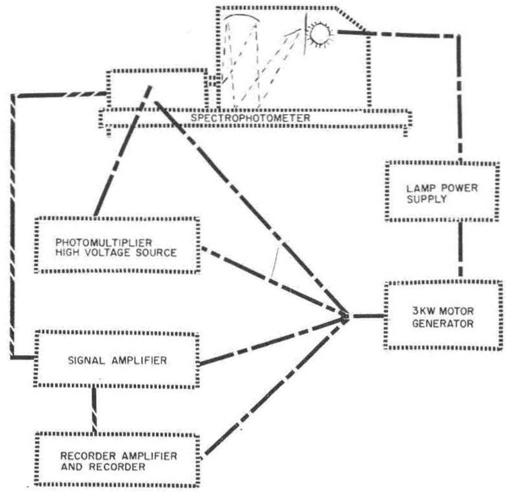

Fig. 1. Schematic of spectrophotometer system.

reflectance properties of the subjects to be photographed. Present practice makes use of perhaps eight film-filter combinations, several of which are sensitive in the same general spectral region.

Laboratory groups have collected much spectral reflectance data, some being on subjects which may be found on aerial photographs. In some cases this information has been a guide for the selection of film-filter combinations. The laboratory method is not applicable to all subjects found on an aerial photograph, for the sample must be taken from its natural surroundings. Transporting such samples as concrete, asphalt, or dry grass has no effect upon the validity of the results. Such subjects as line grass and lightly crusted soils, however, do not have the same reflectance characteristics once they are disturbed. It was primarily for the purpose of measuring the reflectance characteristics of these surface materials that the portable reflectance spectrophotometer described in this paper was developed. With this portable reflectance spectrophotometer, disturbing subject samples is unnecessary.

We believe that the use of data collected by this instrument will enable more intelligent selection of film-filter combinations. Because the instrument has a wider spectral range than our present film sensitivities, data collected may also aid the development of new photographic products.

Figure 1 is a schematic of the portable reflectance spectrophotometer system. The major components are largely production items. The motor generator set, for instance, consists of a standard two-cycle, air-cooled gasoline engine coupled with an electric generator. The rated output of this set is three kilowatts; the demand of the system is less than two kilowatts. The high pressure Xenon arc lamp makes the greatest single demand upon the system; its output is rated at 800 watts.

Power goes directly from the generator set to the lamp power supply and the lamp ignition circuit. That circuit is automatically cut out after the lamp ignites. The generator also supplies power to the recorder amplifier and recorder, the signal amplifier, the photomultiplier high voltage source, and the wave length drive motors.

Figure 2 is a graphic representation of the spectral output of a typical high-pressure Xenon arc lamp. Considerable difficulty was experienced in selecting a light source, since the specifications called for a wave-length range beyond those of standard portable light sources. The high-pressure Xenon arc lamp, with its broad spectral output, enabled the instrument to be designed to gather data from 250 millimicrons to 1,500 millimicrons. The line spectra, which can be seen on the graph, present no difficulty under field

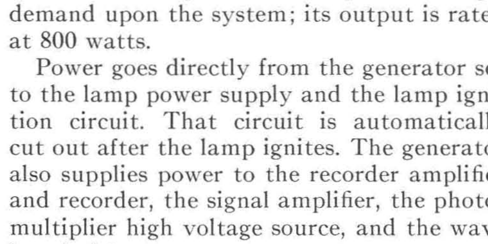

Fig. 2. Graph of spectral output of Xenon lamp.

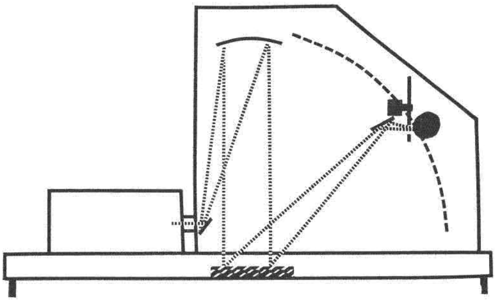

FIG. 3. Drawing of main instrument.

conditions because the resolution is not great enough to show them.

Figure 3 shows the primary components of the main instrument. The dotted lines represent the path of light from its source to the monochrometer entrance port. The lamp, the 13 cps chopper and motor, and a diagonal mirror can be moved as a unit along the dashed arc. The angle at which light strikes the sample plane (at the bottom of the instrument) can thus be set from 30 to 78 degrees to simulate the various angles of the sun. The chopper, which interrupts the light from the lamp, also controls a circuit in the signal amplifier which essentially subtracts the ambient-light-signal from the ambient-light-plus-Xenon signal; only the difference is recorded. Since a large amount of ambient light reduces the sensitivity of the instrument, a black canvas apron may be attached to surround the sample area.

The light reflected from the sample is picked up by a spherical collector mirror six inches in diameter and with a focal-length of 60 inches. The light is then reflected into the monochrometer by another diagonal mirror. The entrance slit of the monochrometer is near the focal-point of the collector mirror. With the monochrometer in this position, the sample area is approximately a six-inch circle. When analyzing samples such as brush or tall grasses, adjustable legs may be attached to take readings on sample areas up to five feet above the ground.

Figure 4 is a plan view of the single-pass littrow-type monochrometer. The light enters at port (A), passes through the entrance slit and is projected onto the plane mirror (B), which reflects it through the prism to the littrow mirror. The beam is then reflected back through the prism to mirror (B), to diagonal mirror (C), and through the exit slit onto the photomultiplier tube. If the infrared region is being studied, a diagonal mirror may be inserted to divert the beam to a collector mirror and lead sulfide cell.

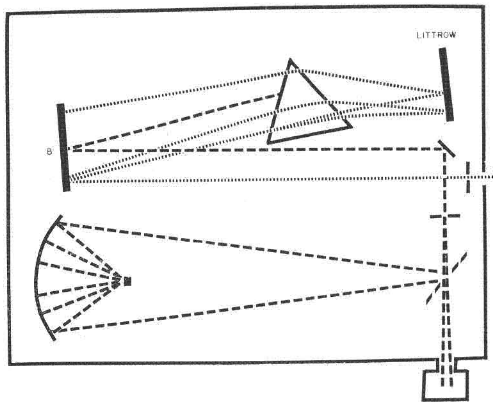

FIG. 4. Plan view of internal components of monochrometer.

At the slowest scanning speed, the instrument achieves a resolution of approximately two millimicrons in the ultra violet and five millimicrons in the infrared. At this speed the time for scanning the full spectral range of the instrument is 55 minutes. The fastest scan can be accomplished in about 15 minutes, but it results in a lower resolution.

The recording produced by the instrument must be rectified because of the variables introduced by the energy distribution of the Xenon arc and the spectral sensitivity of the photomultiplier tube or the lead sulfide cell.

Figure 5 is a reproduction of a recording of

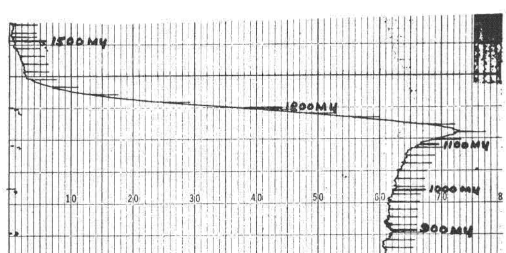

FIG. 5. Reflectance recording.

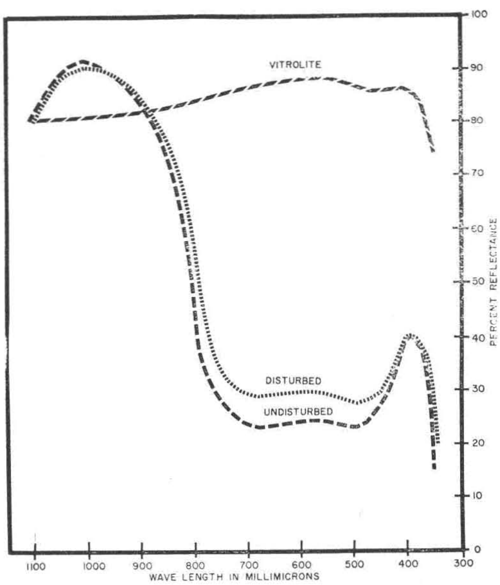

FIG. 6. Reflectance data on sand.

the reflectance of vitrolite, using the photomultiplier tube. The wave-length marker, a mechanism attached to the drive shaft of the littrow mirror, introduces a pulse over the signal at every 1/10 rotation of the shaft. This pulse produces the hashmarks seen on the recording. Also attached to the shaft is a vernier scale which has been calibrated for the interpretation of wave-lengths.

Figure 6 is a graph of some reflectance data fathered in the field. The ordinate is per cent reflectance; the abscissae is wave-length in millimicrons. At each field site a vitrolite curve is run for use as a reference.

The subject of this analysis was desert sand plains. The material consisted of approximately 90% sand, a small percentage of pebbles, and the remainder fine silt. Around the roots of bushes there was a higher concentration of silt which formed a a thin crust. A major portion of the area, however, had a surface of loose sand with an immediate subsurface of sand and silt. It would be nearly impossible to transport such a surface into the laboratory without disturbing it. If this material is turned over by a spade or a truck tire, the silt is brought to the top and the reflectance changes, as may be seen in the curves. Between 450 and 750 millimicrons there are wave-lengths with 15% to 20% difference between disturbed and undisturbed areas. Other soils will show entirely different characteristics when disturbed.

This portable reflectance spectrophotometer was developed and built by Perkin-Elmer Corporation on a contract from the U. S. Army Engineer Research and Development Laboratories at Fort Belvoir, Virginia. It was completed in October 1958 and is now being used by Broadview on a research contract with ERDL. A program has been initiated to collect reflectance data in many of the important climatic environments found in North America.
