The true heading of the aircraft is obtained by periodic astral observations. A continuously recording directional gyroscope maintains a record of the aircraft heading between astral observations. The position of the aircraft is determined by one or a combination of astral observations, loran fixes, radar, visual observation, and photography, depending upon the area to be surveyed.

During flight the total magnetic field intensity, the aircraft heading, and the angular displacements about the gimbal axes of the detector head and the gyro vertical are continuously recorded by graphic milliammeters. The process of determining the various magnetic quantities from these data is carried out after the flight is completed.

The vertical reference gyroscope used to measure the inclination of the aircraft is subject to certain errors so an alternate system for establishing a vertical reference was developed employing an oil-damped pendulum. The pendulum will produce true readings only when the aircraft is in a state of nonaccelerated flight. The directional and vertical gyroscopes are used, therefore, to ascertain when the accelerations due to changing attitude are at a minimum. Points are selected during these periods for computing the magnetic quantities.

In order for the magnetometer to be employed to the greatest advantage, a stable aircraft and smooth flight conditions are required.

Charts showing the components of the earth's magnetic field are issued periodically by the Navy Hydrographic Office and the U. S. Coast and Geodetic Survey. The angle of declination or magnetic variation is of primary importance because of its requirement for navigational purposes. The other components, angle of dip, total intensity, and vertical and horizontal fields were formerly of more or less academic interest but are now finding increasing use in specialized fields of research, development, and geophysical exploration.

Up to the present time, the great bulk of magnetic surveys for chart-making purposes have been conducted employing instruments consisting of rotating coils or the deflection and oscillation of small magnets. Although these instruments are capable of highly precise measurements on the ground, they have not been particularly adaptable for use in aircraft for the determination of the earth's complete magnetic field vector. They also require that surveys be conducted on a point-by-point basis, which is time-consuming.

Surveys of oceanic areas have been made with similar types of instruments and have required the use of nonmagnetic ships. Such measurements were terminated in 1929 when the only existing nonmagnetic vessel, the "Carnegie," burned off the island of Samoa. Similar to ground measurements, the data taken at sea is a point-by-point process with one set of observations made each 200 to 300 miles. Measurements made at sea, however, were less accurate than those made on land.

The airborne measurements are expected to be of the order of accuracy of those made at sea. The airborne surveys, however, will have the advantage of greater speed, continuous recording, and the avoidance of small magnetic anomalies near the surface of the earth.

Due to the constantly changing nature of the earth's magnetic field, the problem of tying a large number of observations made at widely separated times to a common time base should be considerably simplified with the use of airborne instruments due to the fact that vast areas may be mapped in a short period of time.

At the present time the magnetometer is limited to operation in areas of dip angles of about 50° and greater. With additional development the range of operation can be extended to all areas of the earth. Only one instrument has been constructed, and it is undergoing flight tests at the present time.

Avoiding Trial-and-Error in Inframicroscopic Photography[1]

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The phenomenal surge of interest in the general field of photography that preceded World War II was not followed as closely as might have been expected by a corresponding development in photomicrography. New lenses and other factors produced an infinite variety of "close-ups" achieved with techniques which were used to scientific advantage but were pursued largely as a hobby, to obtain unusual patterns in subject matter. The field of photomicrography scarcely developed in these years beyond the needs of those who required the technique for teaching purposes or to illustrate scientific publications.

Strictly speaking, this was true of America more than of Europe, owing, perhaps, to the available equipment there, particularly that of German origin. For some years before the war even the person who pursued photomicrography as a hobby was accustomed to replacing the lens of his Leica with a suitably threaded adapter, which contained a shutter and an indirect-vision aperture and which fitted, in turn, the eyepiece of the microscope. In this instance all three elements—the camera, the adapter, and the microscope—were manufactured by the same firm, Ernst Leitz of Wetzlar, although adapting devices were generally available for most cameras. Much of the work in America was, and still is, accomplished by connecting the camera to the microscope by means of a flexible sleeve, often an automobile radiator hose. While excellent photographs can be obtained with this simple device, the technique has certain serious disadvantages, particularly in regard to stability and variable focusing, difficulties which now can be remedied with several types of standard equipment.

Between the range of the close-up and that of true

[1] Use of this particular camera does not imply its endorsement by the U. S. Public Health Service.

photomicrography there lies another field of invaluable and fascinating photography which invites further exploration: the photomagnification of objects grossly visible to the naked eye. It is a range that may be defined as that lying between the scope of normal human vision at 10 in. and that of actual low power photomicrography.

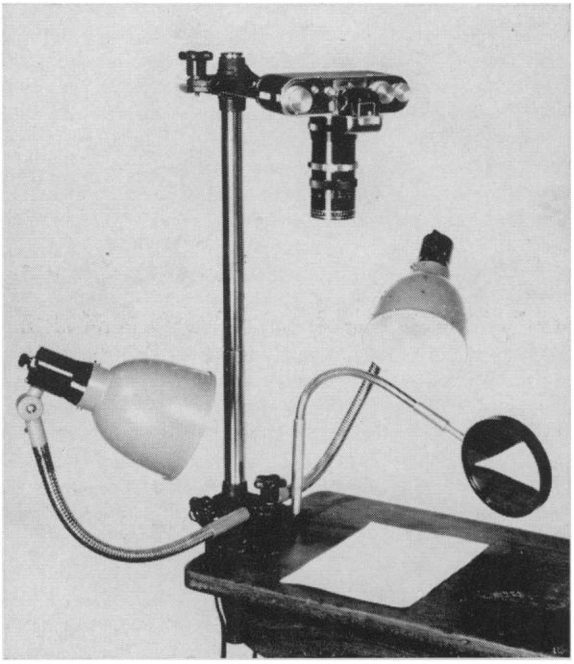

FIG. 1. Alpa reflex camera mounted for close-up photography.

In some European technical literature the range has been defined as ''macrophotography'' (also, and more correctly, ''photomacrography'') although we may quarrel with the use of these terms, which specify all photography below the microscopic range. Perhaps the term ''inframicroscopic photography'' might describe this undefined area. As a functional field it chiefly covers the study of surface structure, animate or inanimate, and was first introduced in popular photography in terms of such subjects as razor blade edges, cactus spine points, and insect wings. The technique rapidly became a valuable scientific tool in all spheres, from botany to ballistics.

Certain unique problems face the scientist or hobbyist who pursues photography in this range, particularly if the material to be studied varies in texture, translucency, color, or depth. These difficulties are unique because they greatly exceed those found in either normal photography or photomicrography, where lighting and focusing are more constant factors. With these problems specifically in mind, cameras and accessories have been devised to meet the requirements of this highly variable intermediate range.

The Swiss-made Alpa-Reflex is one of these cameras, with precision accessories cleverly contrived to fill the needs of every range of photography from infinity to microscopic. It is literally an all-purpose, 35-mm miniature camera (24×36 mm) ideally suited to general outdoor photography and to photomicrography, as well as to the perplexing inframicroscopic field. Equipped with mirror reflex focusing, eye-level view finder, complete range finder, and a standard 5-cm coated lens, the flash-synchronized focal plane shutter allows time exposures as well as a scale extending from 1 sec to 1/1000 sec. A small but valuable feature is that the exposure setting can be read at any time, since the setting knob does not rotate when the shutter is released. Coated and color-corrected lenses with focal lengths $3\frac{1}{2}$–18 cm are available and can be easily adjusted, being fixed in bayonet mounts. Unusually long helical screws of 20-mm range permit exceedingly close-up focusing with ease. To adapt the camera to photomicrography nothing more is needed than a clamping ring which fits—or can be ordered to fit—the extension tube of any microscope, while a complete survey of the microscopic image is provided by the ground glass screen in the reflex view finder.

It is the intermediate field of the so-called macrographs to which the Alpa-Reflex is particularly suited (Fig. 1). It must be remembered that in photographing objects that are in one plane, as a smooth surface, a lens of standard focal length should be used in preference to a wide-angle lens. In three-dimensional subjects a better perspective is produced by increasing the focal length of the standard lens. The reproduction ratio should be selected with the size of the ultimate enlargement in mind. All surfaces have a limit in the degree of possible magnification, beyond which further detail is lost, a definite limit of resolvability beyond which no more finite detail can be distinguished. In the case of three-dimensional objects, where the depth of the field is the essential factor, only the questions of perspective and lighting determine the focal length, since the depth of focus is the same for the reproduction ratio regardless of the focal length.

Such problems, which may be exasperatingly difficult to solve with improvised equipment, particularly when color film is used, are reduced to a minimum with supplementary lenses. To begin at the scale of normal photography, the standard focal length 5-cm lens, having a 3-mm range of adjustment, allows a focus ranging from infinity to 1 meter. To focus under 1 meter, extension tubes usually are provided with a +1 D supplementary lens to cover the gaps in range left as the result of using the tubes. However, the function of the main lens is considerably impaired by supplementary lenses; hence the desirability of using interchangeable lenses of greater focal length ($7\frac{1}{2}$–18 cm), in which case the usual supplementary lenses of shorter focal length are unnecessary. The intermediate tubes provide a continuous range of supplementary extension.

The versatility of this equipment, designed with the problems of inframicroscopic photography in mind, obviates the discouraging and wasteful trial-and-error methods of focusing and lighting and justifies the initial expenditure.