cation of a pictorial art. Codification is also hampered by the lack of scientific terms necessary to designate the new fields of interest. It would be more appropriate for instance to substitute "chronogrammetry" for "high-speed photography" when used for metrical purposes. A paper will be presented by Mr. Jean St. Thomas at the Society of Photographic Engineers Annual Conference at West Point next Spring, proposing a logical structure of scientific nomenclature to serve as a unifying back-bone for the organizational detail suggested by Shaftan.

It is suggested that work for organizing metrical photography be actively undertaken by committees appointed by the American Society of Photogrammetry, The Society of Motion Picture and Television Engineers, and the Society of Photographic Engineers. Such a joint committee would be the logical body for the preparation of an outline for a metrical photography handbook which might be published jointly. It is *not* suggested that these Societies merge, since each is essentially concerned with branches of technical photographic knowledge of extensive, specialized and non-overlapping nature.

It is further suggested that appropriate inter-society efforts be concentrated on the recognition of the field of metrical photography and photographic instrumentation, and that such recognition be sought at a level commensurate with the mathematical and engineering knowledge necessary to engage in this new professional direction.

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THE MM 100 OPTICAL COMPARATOR*,†

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I. Introduction

THE comparator, sometimes referred to as a measuring machine, is one of the most basic instruments in the realm of research, experimentation, fabrication, production, and manufacture. The measurement of data is a fundamental activity shared by the physicist, chemist, engineer, and instrument maker. The comparator, therefore, is the instrument familiar to, and employed by, men in the fields of science, engineering and industry. Photogrammetry is the science of measurement with photographs. The primary purpose of photogrammetry is to serve the field of science, engineering, and industry in that capacity. While the idea of a comparator precedes the maturation of the science of photogram-

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metry, and while the photogrammetrist employs numerous other measuring devices, the comparator is the instrument fundamental to his field. A comparator is a device for transporting a system of points, lying in a plane, through measured distances in x and/or y directions. For purposes of photogrammetry, a system of images recorded on film define such a plane.

To this end, the film is mounted on a suitable stage that is translated on precise ways by turning screws. A viewing microscope is provided to point on images, and x and y micrometer microscopes and scales to read the amount of translation in the x and y directions between two images, or between an image and a reference point or line.

II. Design Objectives

There are numerous reasonably precise coordinate comparators. These comparators have translations that range from approximately 50 to 400 millimeters. Some move in x and y, while others move only in x and achieve y measurements by a rotation through 90 degrees. Translation to the right or left is considered x while translation toward or away from the operator is considered y. Most coordinate comparators have either a drum or vernier type of micrometer. The simplicity of the drum type is offset by errors of the screw. The functionalism of the vernier type is offset by the insufficient refinement in the x and y verniers and the awkwardness of two widely separated x and y reading microscopes.

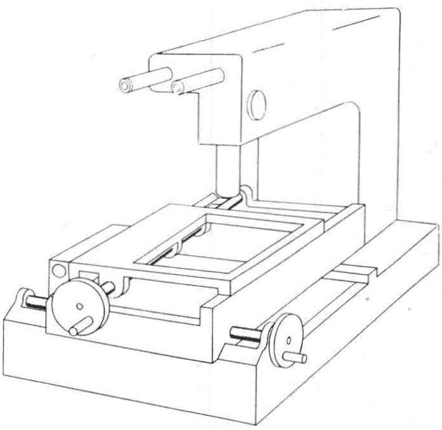

FIG. 1.—Optical 100 mm. comparator.

The MM 100 mm. comparator currently under design consideration is shown in Figure 1. The design is proposed to accommodate 35 mm., 70 mm., and 100 mm. film. The MM 100 has x and y translations of 100 mm., an azimuth rotation through 360 degrees, and a film feed and take-up spool to pass the film between two planar glass plates. The latter feature is not shown in Figure 1. The instrument is intended to combine the best principles of micrometer accuracy, image illumination, convenient operation, and simplicity in a single measuring instrument. The optical system is shown in Figure 2.

III. Micrometer

Interpolation accuracy is achieved through the weak prism translation principle.

A weak prism attached to a drum or scale and movable by rack and pinion is employed to interpolate a point falling between the least graduations of the coarse scale. The principle is based on the deviation δ of a weak wedge with prism angle A. This principle is illustrated in Figure 3. For weak wedges

$$\delta = (n - 1)A.$$

It may be seen that Δ is proportional to x only. δ is constant; therefore $\Delta = \delta x$.

A large change in x produces a small change in Δ which permits a large fixed scale to be graduated into microns. This arrangement gives an optical leverage

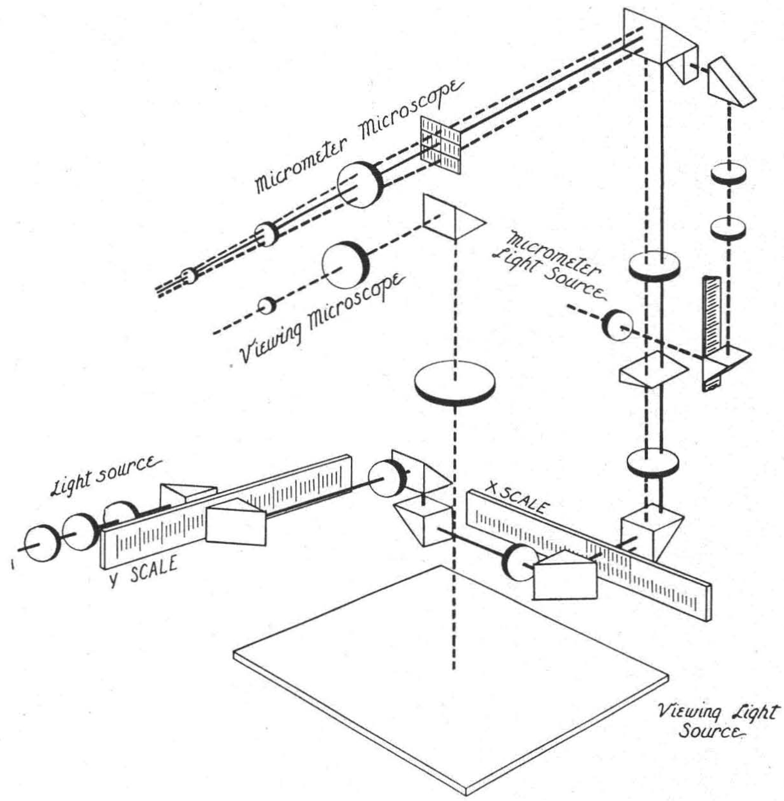

FIG. 2.—Optical diagram.

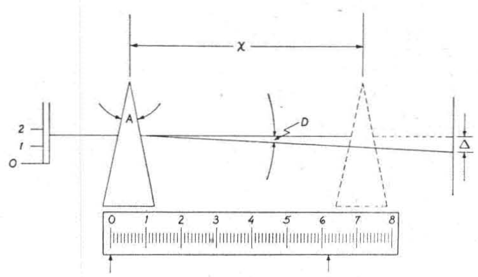

FIG. 3.—Optical micrometer.

that is free from mechanical errors and for this reason is regarded as the most precise of micrometers. The prism is transported with a rack and pinion which does not affect the accuracy of the reading inasmuch as the movement is recorded on a fixed scale. Suppose in the illustration that the index appears in the focal plane of the microscope between 0.1 and 0.2. By turning the coincidence knob, the prism is translated until the index coincides with the coarse graduation corresponding to 0.1. The amount of translation is read on the micron scale which in this case is .062. The reading then is 0.162 millimeters.

Convenient operation of the MM 100 is achieved with a micrometer eyepiece parallel to, and to the left of, the viewing microscope eyepiece.

IV. Optical System

Both the x and y coarse scales and the common micrometer scale are read in the same eyepiece. The viewing microscope is equipped with a rack and pinion for vertical motion, to bring the emulsion surface into sharp focus. To read the coordinates of a system of points, the film is clamped and the zero x line oriented parallel to the x ways by turning the azimuth motion. The selected image is bi-

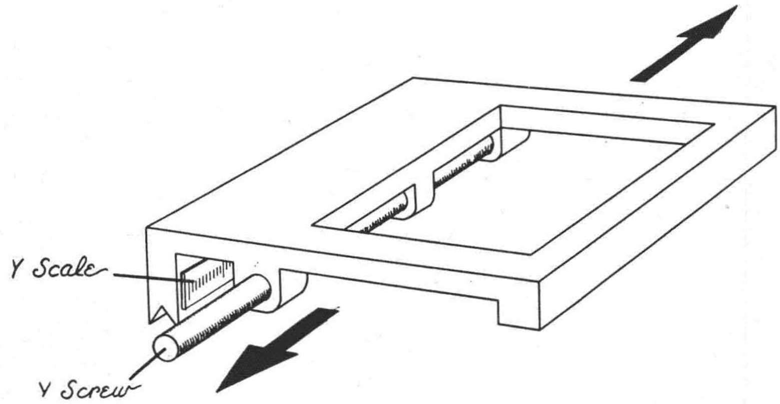

FIG. 4.—*Y* Platform.

sected with the cross-hairs of the viewing microscope. The coincidence knob is turned until a coarse graduation coincides with the index mark. The x and y coarse graduations are made to coincide with the index mark in two separate turns of the coincidence knob. The coarse graduation and common micron scale are read and recorded for each corresponding coincidence. This operation is repeated on each image in the direct and reverse positions. The reverse position is an azimuth rotation of 180 degrees. The x and y coarse scales are glass with a least graduation of one-tenth of a millimeter (0.1 mm.). The micrometer scale is graduated into one hundred parts, each division representing one micron. The micrometer scale is attached to the coincidence wedge so that when a coarse graduation is separated one division, movement of the wedge, which intercepts the light path from the coarse scales, causes the micron index to read ± 100 microns, depending on whether coincidence is executed positively or negatively. The x and y scales are illuminated with a common light source located on the x platform. The optical relation and common magnification of two scales having mutually orthogonal translation are achieved by superimposition of an image of the y coarse graduations on the surface of the x scale just above the x graduations. The y scale is attached to the y platform. The y platform is shown in Figure 4. The surface of the y scale moves in the focal plane of a lens fixed to the x scale. The collimated bundle of light including the y coarse graduation is made,

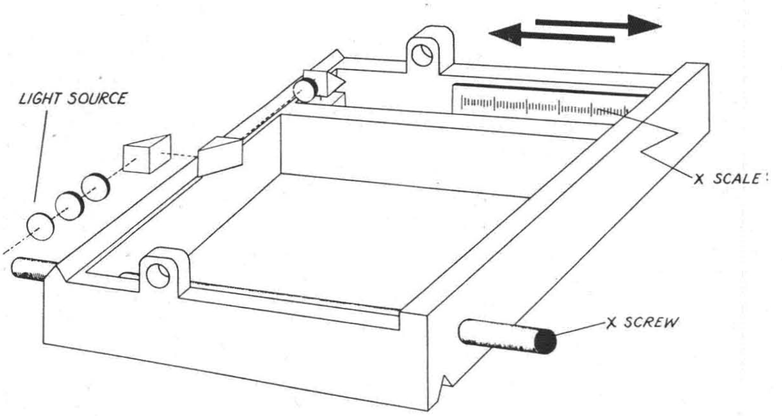

FIG. 5.—*X* Platform.

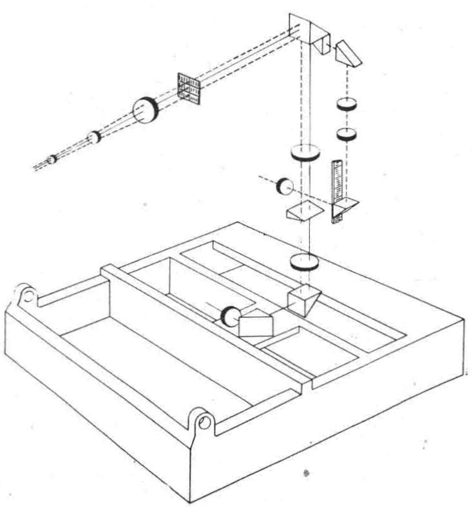

FIG. 6.—Base and optical micrometer.

through use of prisms attached to the x platform, to be collinear with the axis of a second lens attached to the base. The x scale attached to the x platform moves in the focal plane of the second lens, and therefore the image of the y scale is superimposed on the x scale above the x coarse graduations. The x platform is shown in Figure 5. The y scale lens on the x platform and the x scale lens on the base have the same focal length so that the images of the y graduations have a one to one ratio to the x graduations. The light rays between the two lenses are collimated and therefore are independent of the variable distance due to x translation. Thus the two scales are optically linked at a common magnification despite orthogonal translation.

The x scale lies in the focal plane of the reading microscope objective attached to the base. The base platform is shown in Figure 6. The images of the two scales, formed by the microscope objective after passage through the optical wedge, and the image of the micron ladder lie in a common focal plane where they are viewed through the reading microscope eyepiece. The micron ladder is illuminated from the side, and the viewing stage from the bottom.

This concludes a brief description of the design considerations of the MM 100 mm. comparator.

DISCUSSION OF MR. FISCHER'S PAPER: PHOTOGEOLOGIC INSTRUMENTATION IN THE U. S. GEOLOGICAL SURVEY

Bertil Hallert

IN HIS paper, Mr. Fischer mentioned the use of the mirror stereoscope and the parallax bar for the determination of elevation differences on the ground, from approximately vertical aerial photographs. Because, up to now, only the x-parallaxes seem to be used for such determinations, I will briefly mention how the quality of the results can be considerably increased if the y-parallaxes are also taken into account. Some other related questions will be discussed.

In my teaching work at Ohio State University it was necessary that I use the mirror stereoscope and parallax bar as the main stereoscopic instrument because none of the ordinary high precision stereoscopic instruments were available. The German phrase "In der Not frisst der Täufel Flöhen" is a good expression in such situations.

This simple instrument—the mirror stereoscope and parallax bar—has also

NOTE: Following Mr. Fischer's reading of his paper at the Semi-Annual Meeting, a discussion was invited. At that time Dr. Hallert made some remarks. Due to the interest in his statements then and later indicated, Dr. Hallert, after his return to Columbus, embodied the statements in this paper and also included other material—*Editor*.