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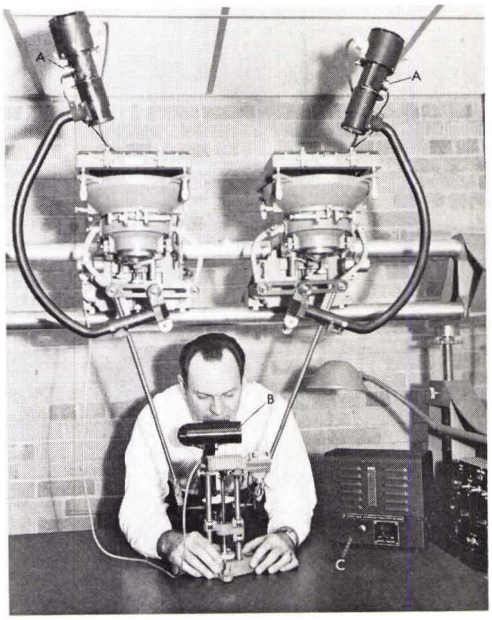
The StereoImage Alternator

Potential successor to anaglyphic viewing

(*Abstract on next page*)



FRONTISPIECE. The StereoImage Alternator system installed on Kelsh K-100 plotter. *A*—projection shutter motors. *B*—viewing shutter assembly. *C*—control logic unit.

INTRODUCTION

EVER SINCE THE introduction of the Multiplex in the mid-1930's, direct-viewing double-projection stereoplotters with anaglyphic filters have been the workhorse photogrammetric instruments for quantity map production in the United States because of their relatively low cost and simplicity of design and operation. For example, the Topographic Division of the Geological Survey now has some 400 improved modern anaglyphic plotters (mainly Kelsh and ER-55), as compared with about 40 of the more complex instruments with optical trains.

Anaglyphic instruments, however, have several inherent disadvantages, which have long been recognized. These may be summarized as follows:

- Low light intensity in the projected model. Most of the light emitted by each projector bulb is wasted by the double filtering before it reaches the observer's eye, requiring him to work either in a dark booth or in a room with a limited level of ambient light. The light loss due to filtering is most serious in the corners of the model.
- Incomplete image separation. The combinations of filters ordinarily used are not completely effective, so that each eye sees not only the principal image but also a subdued disturbing image, intended for the other eye, which ranges in intensity from 10 to 30 per cent of that of the principal image.
- Unequal sharpness of the filtered images. The optimum projection distances are not the same for red and blue light, so that the two images on the tracing table are almost never exactly matched in sharpness of definition. This effect is particularly important at the extreme ranges of projection distance.
- Incompatibility with color photographs. With the introduction of color materials suitable for photogrammetric use, this has become an important consideration.

These shortcomings of anaglyphic stereoplotters have, of course, been overcome in the European instruments which incorporate a separate optical train for each eye, but at the penalty of greatly increased cost and complexity. Much thought has therefore been given to designing attachments which would make the direct-viewing double-projection instruments no longer dependent on anaglyphic filters. Through the years, all of us have heard of *flicker systems*, which would alternately flash the left and right images of a stereomodel on the tracing table for observation, and the general principles of such a system are well understood. But no practical items of equipment have been forthcoming until recently. After the system described here was developed, I was surprised to learn of a

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thesis written by Rudolf Burkhardt around 1940* in which he analyzed the important shortcomings of anaglyphic filtering in quantitative terms and examined the characteristics of several experimental types of what he called "alternating shutters." Although the basic objectives are the same as those which led to the present development, none of the designs described by Dr. Burkhardt have been incorporated in generally available photogrammetric equipment.

Operating Principles

The StereoImage Alternator (SIA) system is illustrated diagrammatically in Figure 1. A rotating cylindrical shutter with equal-area solid and open segments is situated in front of each projection lens, so that the beam from each projector is alternately stopped and released. The two shutters are out of phase, so that one beam is stopped while the other is open, and vice versa. Correspondingly, the viewing shutters open and close to present the proper views to the right and left eyes of the observer. As is well known from movie theory, if the flash rate of successive images to the eyes is rapid enough, there is no impression of flicker but of a steady image. Although the critical flash rate for a steady image varies with the individual observer, a rate of 60 flashes per second will produce a steady image for all.

Synchronization

The central problem in designing a mechanical system of alternating projection is synchronization. That is, the relationship between the projected flashes and the images received by each eye must be exact and constant. Modern technology has provided the answer to this problem by the availability of miniature stepping motors.

These motors consist of a permanent-magnet rotor and a wired-field stator divided into four equal segments, so that each sequential pulse from the control circuitry imparts a rotation of 90° to the motor shaft. The size 11 and size 8 motors used in the StereoImage Alternator system can respond to pulse rates of 200 and 300 pulses per second, which means that they can operate synchronously at speeds up to 3,000 and 4,500 rpm respectively.

The motors are physically very small, $1\frac{1}{16}$ inches in diameter by $1\frac{1}{8}$ inches long for the size 11 motor, and $\frac{3}{4}$ by $\frac{7}{8}$ inch for the size 8 motor. Both have $\frac{3}{8}$-inch-long rotor shafts. The shutter components are attached directly to the rotor shafts and obviously must be of lightweight construction and dynamically balanced. Operating temperature of the motors is rather high, around 200°F, so that protection from touching by the operator is

Abstract: *The U. S. Geological Survey has developed an image-separation system for viewing either black-and-white or color stereoscopic models on projection-type stereoplotters that does not require the use of filters. Known as the StereoImage Alternator, the system consists of rotating cylindrical shutters in both the projection field and the viewing field, synchronized so that each eye can see only the image from the corresponding (left or right) projector. Although the concept of alternating images for stereoscopic viewing is not new, the system by which they are obtained is both unique and practical.*

J. William Knauf

* Burkhardt, Rudolf, 1941, Untersuchungen zur Frage der Bildtrennung beim stereoskopischen Messen; *Luftbild und Luftbildmessung*, Nr. 21: Hansa Luftbild G.m.b.H., Berlin.

required. Life expectancy at the speeds of operation of the SIA system is predicted in thousands of hours, and the bearings, which are the only wearing components, can be replaced by the manufacturer, as necessary.

Adaption to Plotters

Although the general principles of the StereoImage Alternator were illustrated in Figure 1, the details of adapting it to specific plotters vary with the physical characteristics of each plotter, and usually several configurations are possible, depending on the ingenuity of the designer as well as considerations of practicality and convenience. The examples presented here are by no means exhaustive, and further possibilities are being tested to arrive at the most useful and convenient configurations.

With Kelsh-type plotters, several placements of the projection shutters are possible —in front of the projection lens, between the lamp and the projection lens, and around the lamp. Theoretically, the first two placements are preferable as they can provide 100 per cent separation of images, whereas the third will lead to overlapping images and a disturbing image—but a disturbing image that is small in comparison with those produced by anaglyphic filters, something on the order of 5 per cent instead of 10 to 30 per cent. The Frontispiece shows a complete SIA system as installed on a Kelsh K-100 plotter. Figure 2 shows a projection shutter for use on an M-2 plotter.

With ER-55 (Balplex) plotters the only feasible placement for the projection shutter, without modifying the design of the projectors, is below the projection lens. However, the lenses of these plotters project the entire model at one time, over the full field of the photographs, whereas the area of interest is centered on the tracing table. A shutter capable of stopping and releasing the entire projected beam would be too large and heavy. The problem of adapting the StereoImage Alternator to the ER-55 plotter is therefore solved by incorporating swing suspensions which allow the two small projection shutters, with their longitudinal axes aligned in the y-direction, to move a limited distance in the x-direction. This sort of x-motion is easily controlled by metal roller tapes attached to the tracing table, and the shuttered portions of the projected beams are kept centered on the tracing table. The tapes are hinged and flexible when moved in the y-direction but adequately rigid when moved in the x-direction. Tension of the tapes on the projector, throughout the working range, is negligible. This swing-shutter arrangement can also be adapted to Multiplex projectors.

Fig. 1. Operating principles of the StereoImage Alternator system.

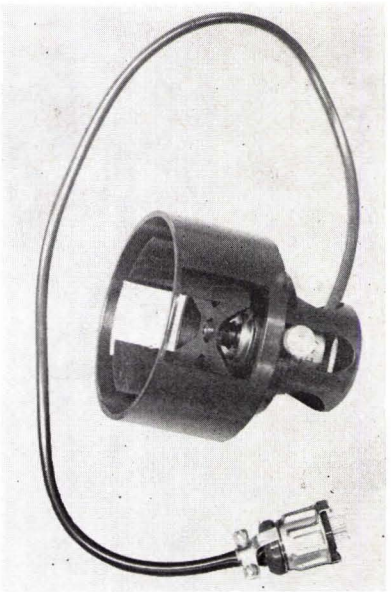

Fig. 2. Projection shutter for the M-2 plotter.

Viewing-shutter Assembly

As shown in the Frontispiece the assembly containing the pair of viewing shutters is attached to the tracing table. A closeup of the assembly is provided in Figure 3. Here again the design is only one of several possibilities. Others could include spectacle frames, har-

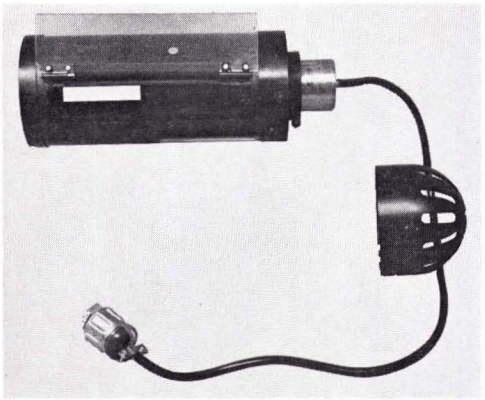

FIG. 3. Viewing-shutter assembly removed from the tracing table.

nesses, and head gear, with cylinder, disk, or belt shutters. The present design, however, has served adequately for all the installations thus far. It does not require the operator to wear anything extra and avoids the problem of interference with glasses that the operator may already wear. Moreover, the viewing field is kept centered on the tracing-table platen.

A single rotating cylindrical component contains the rectangular slots and solid segments that provide the shutters for both eyes. Thus only one motor is needed for the viewer. In the mechanisms described by Dr. Burkhardt, a separate motor or actuator was used for each ocular shutter. The eye slots are made rectangular rather than circular to eliminate the need for an eye-base adjustment. An outer protective shell houses the rotating component and the motor. The motor and attached shutter can be rotated within the housing to adjust for optimum orientation, for either normal or pseudoscopic viewing.

The shutter assembly is attached to the tracing table by a hinge block which contains a square telescoping tube that permits adjustment of the viewing distance from the platen. A friction hinge permits the operator to adjust the viewing angle as necessary. The assembly can also be rotated around the tracing table for observations from the rear of the plotting table.

System Adjustment

As already noted, the viewing shutters are instantaneously adjustable by rotating the motor housing. Similar rotational adjustments are provided for the projection shutters. With the system in synchronous operation, it is only necessary to rotate the motor housing of each projection shutter (with the other projector turned off) until no light is visible through the shutter intended for the other eye—that is, until complete cutoff is obtained. The motors can be stalled without damage and will realine themselves in the sequential operation when released. Once adjusted when placed in operation, the system seldom needs readjustment.

Operation Evaluations

Production units of the SIA system have been in daily use since November 1965 with no appreciable downtime due to malfunction of the system. Operators who have tried the SIA system report favorably on the brightness and sharpness of the models, and that they are able to compile with more assurance from models that they would ordinarily class as difficult.

The practical advantages of the SIA system can be summarized as follows: (1) The projected model is more than twice as bright as an anaglyphic model, and the light loss due to the viewing device is negligible. (2) Model definition is improved. (3) The system is compatible with color photographs. (4) No filters or spectacles are required. (5) Light balance is less critical. (6) Image separation is complete.

Conclusions

The SIA system was developed in the Topographic Division Research Center of the Geological Survey at McLean, Va. It is being installed on plotters in the Geological Survey and elsewhere as a standard accessory. Although the specific details are subject to change with further development, patent protection is being sought by the U. S. Government on the basis of the development described here.

Technical details about the SIA system are not given in this report as these can be obtained on request to the U. S. Geological Survey. After all, the little girl had a point in her book report when she said, "This book tells me more about penguins than I want to know."

Finally, it should be noted that the possibility of obtaining a stereoscopic image by alternate projection of two perspective views was first described by J. C. d'Almeida, who also invented the anaglyphic system of stereoscopic projection. In his treatise entitled "A New Stereoscopic Apparatus," dated 12 July 1858, d'Almeida stated, "Small electromagnetic mechanisms would completely solve the problem."