for photogrammetry, and has shown that the technique used has overcome most of those problems which appeared so formidable at the outset. With the assistance and guidance of the Railway Engineer's Department, a 1/480 plan has been produced almost entirely by photogrammetry to a standard of accuracy acceptable for railway engineering work. This is a remarkable step forward in the photogrammetric field, as well as being a revolutionary departure in railway engineering. It is to the credit of such a farsighted department of British Railways that they were prepared to consider a break from accepted methods, and so willingly to assist the contractors. In so doing, they have created a precedent that may be claimed as an important step forward in photogrammetric technique, while at the same time providing a means of greatly accelerating and simplifying the preparation of accurate plans in the extensive program of new construction and maintenance of British Railways.

THE STEREO-MOSAIC, A NEW MAPPING TECHNIQUE

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EVER since maps were first used, man has been trying, usually with poor success, to introduce the third dimension by such devices as topographic symbols, hachures, or contour lines. Aerial photography viewed with a stereoscope offered the best solution yet devised, but due to the many displacements and scale variations inherent in aerial photos, they were very difficult to use as maps. The mosaic, using only the center of each photo, solved some of the difficulty with displacements and scale variation. However, stereo-vision, the aerial photo's most valuable asset, could not be used with mosaics, so the mosaic has been little used. For a number of years, there has been a search going on, both in military and civilian circles, to find a new type of map which would include both the advantages of the aerial photo and of the planimetric or contour map. Several solutions have been found of which the stereoscopic contour map, using the anaglyph principle, and the mosaic with a planimetric map over-printed, are the most notable. A way has now been found to view mosaics stereoscopically.

This new method has been occasionally used with vectographs, and involves the compilation of a left-eye mosaic and a right-eye mosaic to be viewed simultaneously. If a large mosaic is to be made, it must be broken up into panels, approximately $20'' \times 30''$, which can be placed separately under a large mirror stereoscope. In our first trial, we have used a photo scale of approximately 1:31,680, and made the panels $7\frac{1}{2}$ degrees of latitude by 15 degrees of longitude, which gave approximately the above dimensions. It was necessary then, after assembling the required photos, to cut each photo in half along a line perpendicular to the line of flight, which in our case was north and south.

MAKING THE MOSAICS

The north and south halves are placed in separate piles for use in separate mosaics. A controlled mosaic is then laid, using only the south halves, on the first panel. In order that map symbols may be inked on this mosaic, and later corrected where necessary without damage to the emulsion, a coat of clear lacquer is applied. Standard map symbols are then inked on the mosaic. Picture-pointing is done as much as possible to locate land lines correctly.

In order to compose a stereo-mate for this mosaic, it is then necessary to use

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a large mirror stereoscope, with the outer mirrors 20″ apart, so that two panels may be placed under it side by side without overlap. A diagram of this stereoscope is shown in Fig. 1. The stereo-mate for the first mosaic is then prepared by assembling the north halves of the photos. The two panels are placed under the stereoscope, with the first mosaic, containing the south halves, under the left eye. Stereo pairs are then selected from the north halves, as shown in Fig. 2, and the mates to the left eye photos are cemented to the right eye panel while being viewed through the stereoscope. This is done to insure fusion of the images.

The stereoscopic effect thus produced is a curious optical illusion. A separate geometrical relationship is set up by each stereo pair, and the eyes can compose only one stereo image at a time. However, as the eyes move from one pair to the next, the three dimensional models seem to fuse together producing the effect of a single stereoscopic image.

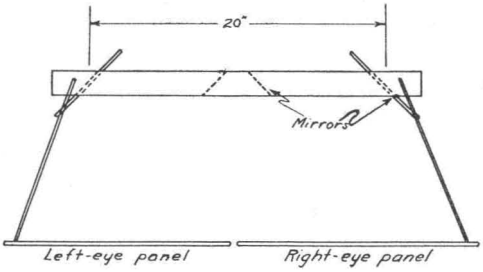

FIG. 1. Large Mirror Stereoscope Used to View Stereo-mosaics.

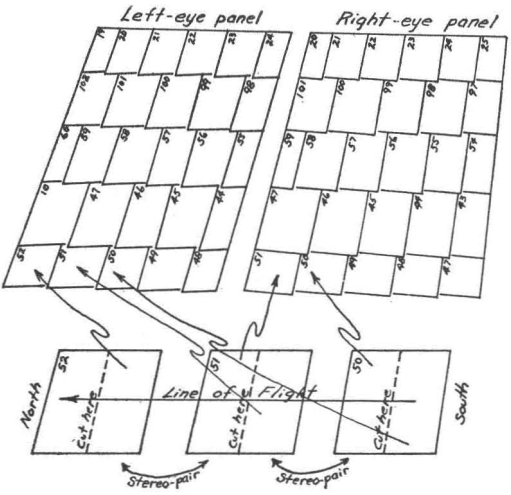

FIG. 2. Arrangement of Photos in a Stereo-mosaic.

REPRODUCTION

The next step in the process is to copy and reproduce the mosaics. Because they were designed for use as maps, and not for detailed photo interpretation, less refined methods of reproduction may be used than is customary. Experiments have been made to see if photostats could be used, because of the low cost and simplicity of this process. It was found that in making the negative and then the positive, there was a marked increase in contrast and much detail was lost. It was therefore decided to use low contrast photos in the original mosaics, and then to make a low contrast diapositive print of the finished mosaic photographically with a large copying camera. This diapositive copy is then used as the negative for photostatic reproduction, with a more acceptable degree of contrast.

The half-tone process could be used where large quantities of copies are needed.

The original mosaics may also be copied on transparencies so that they may be projected on a screen before a group. Color can be added by applying photo tinting paint to the right-eye panel, and then making the transparency on color film. Transparencies of a portion of a panel, a complete panel, or a group of panels may be made. By use of two projectors and polarizing filters, the mosaics

can be projected on a screen in three dimensions. A screen painted with a metallic compound, such as aluminum bronze, and polarizing spectacles are necessary for viewing this three dimensional image.

APPLICATIONS

Applications for this new method are numerous, and the military possibilities are obvious. The method was especially designed for National Forest administration. The first use planned is for range inspection maps.

Left-eye and right-eye prints of a range allotment may be mounted on opposite pages of a looseleaf notebook, and a folding mirror stereoscope may be placed over them for examination in the field. Range-management map symbols may be added to the negative of the right-eye print. Inspection data may be written on the right-eye print with red pencil, to replace the overlays, always difficult to use, which are now standard practice. These data can be filed and a new print used each year, or they may be erased with a solvent.

A second application will be for use as timber maps. Descriptions of timber tracts will have much greater meaning when accompanied by mosaics showing topography as well as timber types, and all the fine photographic detail which a map cannot show.

It is also possible to use stereo-mosaics as fire-finder maps. A stereoscopic image will help a fire lookout in interpreting topography much better than the standard map, and will aid in training new men in the geography of their areas. In this case, the stereo-mate for the mosaic must be mounted on a folding map board beside the fire finder, with a folding stereoscope attached. Fire control symbols would be placed on the stereo mate. A wall map made from these mosaics would be useful to a fire dispatcher and administrator alike. The panels of the left-eye mosaics, which contain the standard map symbols, may be mounted on a wall, by hanging them on hooks. Whenever it is desired to examine a particular area in three dimensions, the panel can be removed from the wall and placed under a stereoscope with its stereo-mate.

In each application, the left-eye mosaic would contain the land lines and standard map symbols, and the right-eye mosaic would be used to apply specialized symbols and colors. In this way, only one copy of the left-eye mosaic would need to be kept on hand, and a different right-eye mosaic would serve various functions such as grazing, timber, fire, land status, etc.

TECHNICAL PROBLEMS

The following technical problems were encountered during the development work:

1. Scale variations due to differences in elevation are very troublesome in laying a controlled mosaic of mountainous terrain. Rectified prints should thus be used wherever possible.

2. Much care is needed in lining up the stereoscopic model when the mosaic is laid. A person whose eyes are accustomed to stereoscopic vision has considerable tolerance, and can make the images fuse even though the photos are not perfectly lined up. In order to make stereo-vision possible for untrained eyes, the lines of flight between nodal points should be marked on each photo, and these lines should then be made to coincide as the photos are cemented one on another.

3. Under the present system of north-south flight lines, the stereo model must be viewed at right angles to the line of flight, or east and west. As this makes map reading difficult, it is thought that lines of flight should be planned on east-west courses in the future.