well as the Goldsboro test has fully demonstrated that major improvements are desirable and possibly attainable. As a result, in April 1956 a second stereo-templet research project was undertaken as a joint responsibility of the Staff Photogrammetry and Instrument Design Sections, and the Atlantic Region Photogrammetry Section. Phase I of the project is to cover the evaluation of available stereo-templet materials and templet-slotting machines in order that the most suitable items in each category may be determined and adopted on a divisionwide basis. Phase II is to determine the accuracy characteristics of stereo-templet assemblies for various combinations of scales, control density and pattern, and sequences of templet assembly. This project while incomplete is mentioned to indicate a continued interest in developing and perfecting the stereo-templet system further.

The use of templet materials and the design and manufacture of studs and cutters particularly suitable for stereo-templets, rather than the continued use of materials designed for use with radial templets, is to be expected. Research tests and production experience will be needed to determine the best use of these improved photogrammetric tools.

*A Do-It-Yourself Terrain Model**

AUGUST E. BATTISFORE,
Cartographer, U.S.N. Hydrographic Office

ABSTRACT: *There are many ways to construct a relief model. Degrees of refinement run from sand-table efforts to precise plastic reproductions. The method presented here lies somewhere between these extremes. Its simplicity permits rapid construction by someone having only a basic knowledge of map reading and little material; yet the same procedure can produce a more complete product depending on the time, skill and material available. The method can be taught "by the numbers" in a basic map-reading course. Even "do-it-yourself" kits could be made—produced complete with instructions.*

TERRAIN models have always appealed to both map makers and map users. During World War II, many models were made by the Navy and reproduced in rubber. These models were beautifully painted to achieve the maximum in realism. Following the war, the Army Map Service began an extensive model program which has resulted in the production of great numbers of excellent plastic relief maps. These maps, made by vacuum forming, from an original carved model, carry all the information shown on the flat map but presented in a three-dimensional manner. Many recent developments have reduced the man-hours required to make these models and subsequent relief maps. However, a need still exists for a simple method that can be used by field units to make models rapidly without special materials, equipment or technical training. Such models, of course, need not equal the accuracy of those now being made by the Army Map Service and the Navy Photographic Interpretation Center, but they would serve many useful purposes.

The method of constructing such a simplified model should be one that can be taught in basic map-reading courses with the materials available at that level.

* This paper was delivered at the Society's 23rd Annual Meeting, Hotel Shoreham, Washington, D. C., March 6, 1957.

Opinions or assertions contained herein are not to be construed as official or reflecting the views of the Navy Department or the Naval establishment. The Office of Public Information, Department of Defense has evidenced that there is no objection to publication on grounds of military security.

It has been found that the construction of a simple relief model is one of the quickest and most efficient ways of teaching a student to interpret topography from a flat map. The current method of cutting out the area enclosed by each contour, stacking these and then carving and smoothing out abrupt steps gives excellent results. Models have been carved or molded directly from aerial photographs, using stereo plotting instruments. Such methods, while quite good, require expensive equipment and highly skilled personnel. In contrast, the method proposed here is one that can be taught "by the numbers" and requires a minimum of material and skill. Before the student is fully aware of what he is doing, a model is completed.

The basic ingredient of the "Do-It-Yourself Terrain Model" is a map. Once the area for which the model is needed has been determined, a map at the scale desired is selected. This map also serves later as the "cover" for the model. If the terrain has a limited range of relief, a certain amount of vertical exaggeration can be introduced. The model is constructed from a set of parallel cardboard profiles cut out and held together by another set of profiles perpendicular to them in a sort of egg crate arrangement. The map itself, or, if desired, a photo mosaic, is placed over this egg crate and glued to the profile edges (Figure 1).

To construct such a model, profile lines are first drawn at intervals across the map. The spacing of these lines depends upon the final accuracy desired and the type of terrain. Generally, a spacing of two inches is adequate for a 1:25,000 scale map. This spacing is not critical, and should be altered when necessary to include abrupt elevation changes. Across this first set of lines, others are drawn in a more or less perpendicular direction. This second set of lines should include any high or low spots in the terrain missed by the first set. Cardboard strips for each profile line are next cut about three inches wide and as long as the profiles to be made. The profiles are drawn on these strips.

To draw the profiles, a triangle and some sort of straight edge are required (Figure 2). A graduated vertical scale must be placed on one edge of the triangle. Making this scale is the most painstaking phase of the entire procedure. Contour intervals of sufficient number are laid off on this scale to reach from the lowest to the highest elevations on the map. The making of this scale is made easier by locating the index contours first, and then plotting the intermediate ones (Figure 2). The scale is fastened along one base edge of a plastic triangle, face up, on the underside of the triangle. A mark is placed on the edge of the triangle about an inch above the vertical scale. This mark acts as a guide in positioning the map profile line parallel to the straight edge.

A straight edge is needed to guide the triangle. It is convenient to use one long enough to permit taping of the ends to the working surface and yet allow the map to slide beneath the straight edge unhindered by the tape. The base of the triangle is placed against the straight edge. The map is then oriented under the straight edge and triangle so that a profile line is parallel to the straight edge. A guide mark on the triangle aids in this operation. One of the previously cut cardboard strips is then fastened in position under the triangle and against the straight edge.

The vertical edge of the triangle is next aligned with an index contour at the point where it crosses the penciled profile line drawn on the map. A pencil dot is drawn on the cardboard next to the contour elevation on the scale. This is repeated for all index contours crossing the profile line. After checking for errors, the intervening contour lines are plotted. To complete the profile the dots are connected in a continuous smooth line. A vertical line is drawn across the strip at each end of the profile. The cardboard profile and its corresponding line on the map are numbered for later matching.

Additional vertical lines are drawn across the strip wherever profile lines intersect on the map. A line is also drawn the length of the strip about a quarter inch below the lowest graduation on the triangle. This line will serve as a guide later for cutting of slots to hold the profiles together.

The foregoing procedure is repeated for all profile lines on the map, including the outside edges. Slots are cut to the pencil line on each strip where intersections are indicated. The cuts are made from the bottom on all East-West profiles, and from the top on the North-South profiles. If desired, the cardboard strips could be

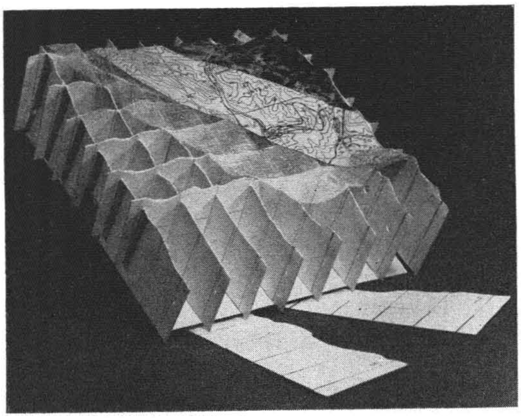

FIGURE 1

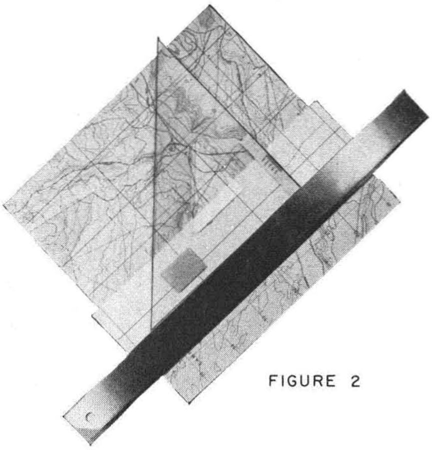

FIGURE 2

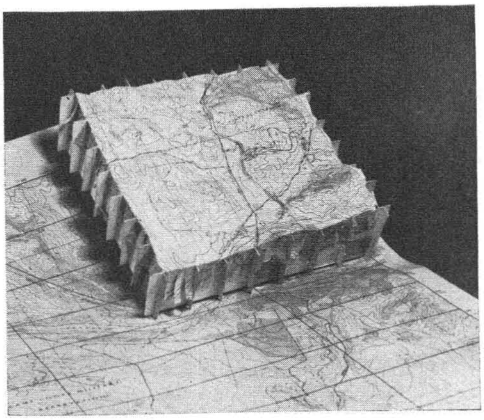

FIGURE 3

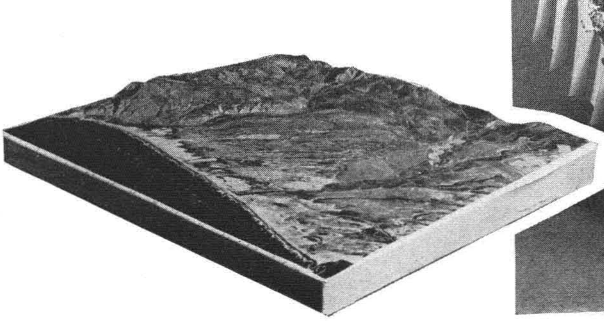

FIGURE 4

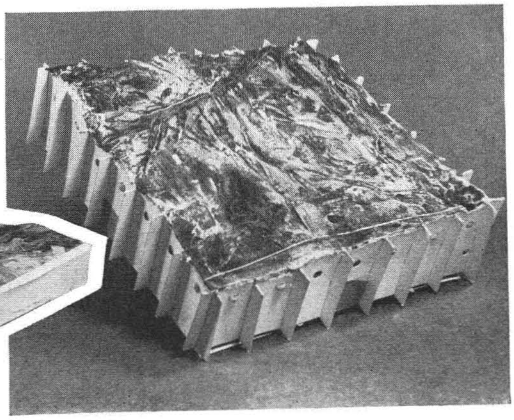

FIGURE 5

over the map neat lines and slots cut along the neat line for ease of assembly (Figure 3). The strips are assembled in "egg crate" fashion by fitting the slots together. Cardboard pieces are cut to the shape of any appreciable water or flat surfaces to be laid in position on top of the assembly. It is necessary to remove a thin strip corresponding to the thickness of the piece from the top of the supporting profiles.

The complete assembly is then fastened to a large enough piece of cardboard, plywood or whatever is convenient, for rigidity and proper alignment of the profile strips.

A thick coat of rubber cement is applied to the top edges of the cardboard profiles, the outer sides of the framework, and the back of the map. After drying, the map is placed in position and pressed into contact on all profile edges. The overhanging margin is slit at intervals to aid in fitting the outer edges. A sheet, or strips, of cheesecloth brushed with rubber cement and applied in like manner before fitting the map will add strength to the model. If a photo mosaic is available at the same scale as the map, it can be cemented to the profiles instead, in the same manner as the map (Figure 4).

A preferred method of fitting the map to the assembly involves a little more time but may well be worth the effort (Figure 4). The profiles are cut out carefully so that the scrap pieces are intact. The latter are then slotted and put together in the same way the profiles were. The resulting assembly is a negative of the profile assembly. Glue is applied to the edges of the profile strips. The back of the map is thoroughly dampened and placed in position. A few thicknesses of cheesecloth are laid on top of the map for cushioning and the negative assembly is pressed down on top of the map. Weights are used to hold the two assemblies together until the map is dry.

The horizontal error caused by stretching a flat map over the surface of such a model is not as large as might be expected.

Because of the simplicity and flexibility of this method of making a terrain model, many variations and improvements are possible. If time is extremely limited, only the high, low and index contours need be used in drawing the profiles, and the spacing of the profiles could easily be increased to three inches. If time is not critical, profiles may be closely spaced in key areas of the model or throughout the entire model. The spaces between the profile strips can be filled in with plaster to create a model without using a map or mosaic covering. Wet sand can also be used as a very rapid way of building up a fairly realistic model. If plaster is used, small drains may be carved, and realism introduced by the judicious use of paint, colored sawdust, coffee grounds, and so forth (Figure 5).

If the demand justified it, maps could be printed with certain information that would assist one in the preparation of such models. A vertical scale could be printed in the margin. A light overprint of profiles could be added to the map or printed on the reverse side.

Finally, complete assembly kits with instructions, cement, and a flexible plastic sheet with the map imprint could be prefabricated and furnished "knocked down" for assembly by the user in the field.

Certainly a terrain model constructed as described here is not a first-order graphic, but anyone constructing it will know his terrain when he has finished; and, like a provisional map, if you have it when you need it, it is better than the best, too late.