TERRAIN REPRESENTATION FROM AERIAL PHOTOGRAPHS FOR AERONAUTICAL CHARTS

Major Robert H. Kingsley and Howard C. Holmes
Aeronautical Chart Service

AT THE present, Aeronautical Charts show terrain features in a symbolized representation quite comparable to ground survey mapping. The emphasis through the use of the more or less standard symbols falls largely on the common hydrographic and cultural features and elevation indication through the use of contours and gradient tints. This article describes a method of showing terrain as an artist portrays it when aerial photography is available as the basis of representation.[1]

In many areas, the accepted symbolized features portray only a portion of the existing conditions that will confront the aerial navigator. The streams, towns and roads many be reasonably prominent yet such other over-all features as outstanding land formations not adequately portrayed through the use of contours, distinctive terrain patterns and areas distinctive through gradations between dark and light tones are a few of the things that are not generally represented yet comprise an important part of the complete terrain pattern as observed from the air. The inclusion of these terrain forms does not necessarily furnish additional features for pin-point identification but would expedite map orientation to a great extent through more ready and positive identification.

In other areas terrain patterns are much more prominent than the features that are normally accepted for symbolized representation. When this condition prevails, a casual glance at an aerial photograph will reveal distinctive minor ridge patterns, vegetated or cultivated areas, unusual rock stratification or countless other readily identifiable patterns while only through a diligent search can the streams, towns, roads and railroads be located on photographs.

Occasionally an area will be entirely devoid of the accepted cartographic features. This is particularly true in arid countries. Roads become caravan routes, cities become nomad encampments, and streams vague dry washes lacking in any normal dendritic pattern. However, in most arid countries there are very outstanding land mark features such as parallel rock strata, domes, old lava deposits, low serpentine ridges, strangely eroded sedimentary rock formations, extensive low escarpments, numerous sand dune patterns, saline basins, alluvial fans, oases, rock outcroppings and a vast number of others. Classification and the adoption of symbols to correctly portray all the terrain patterns previously mentioned would be a near impossible task yet a material loss to the aerial navigator exists because these features are not represented on the completed aeronautical chart. It is the purpose of this article to present a method of terrain representation which depicts all of the existing features through combining the standard cartographic representation with a pictorial representation of the remaining features.

In this procedure a complete ridge pattern, outlines of dark and light areas and the outline of different types of terrain in addition to the features normally delineated on the photographs are transferred to the compilation base along with the other planimetric detail. The planimetric detail, ridge lines, secondary

[1] This type of terrain representation based on tri-metrogon aerial photography with other pertinent features is under consideration on an experimental basis by the Aeronautical Chart Service. Charts of this nature are commonly called "shaded relief charts."

photo control points, and area outlines serve as a controlled position framework. Using these as a guide, personnel with artistic ability interpret the terrain pattern and forms from the aerial photographs and sketch the features on a vellum overlay to the compilation base using a black lithographic pencil. Depending on different conditions, the sketching is accomplished at a scale varying between double and the same scale as the published aeronautical chart. As an expedient very often small areas of the chart are assigned to individual artists. As the small areas are completed they are mosaiced together on a white paper mounted base and touch-up and high lighting is accomplished to give a consistent over-all portrayal. The mosaiced sketched base is then reduced photographically to the scale of the aeronautical chart and a half-tone press plate negative is prepared. Normally the sketched material is printed in brown and replaces the gradient tints on the chart but if it seems advisable to make a color separation on the base between different terrain patterns more than one negative is prepared and the unused portion of each separate negative is opaqued out.

Certain standards are maintained in this sketching procedure in order to insure uniformity and the maximum in final results. The technique of the different artists is standardized through sample sketches of the predominating patterns and numerous comparisons of the small areas in work. Large features and patterns are emphasized and minute features subdued or completely ignored. Terrain pattern in general is emphasized to a greater degree than differences in relative heights because an excessive exaggeration of relative heights

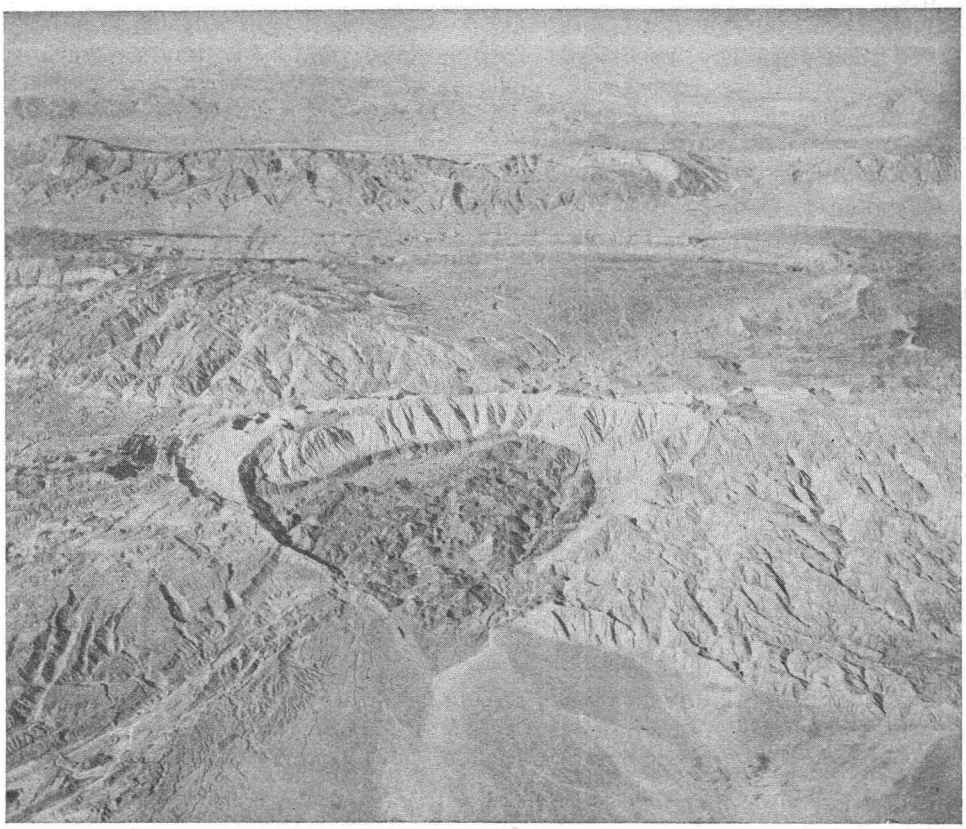

FIG. 1. Typical aerial photograph of the sketched area. Position of photograph indicated by arrow on the left (Fig. 3).

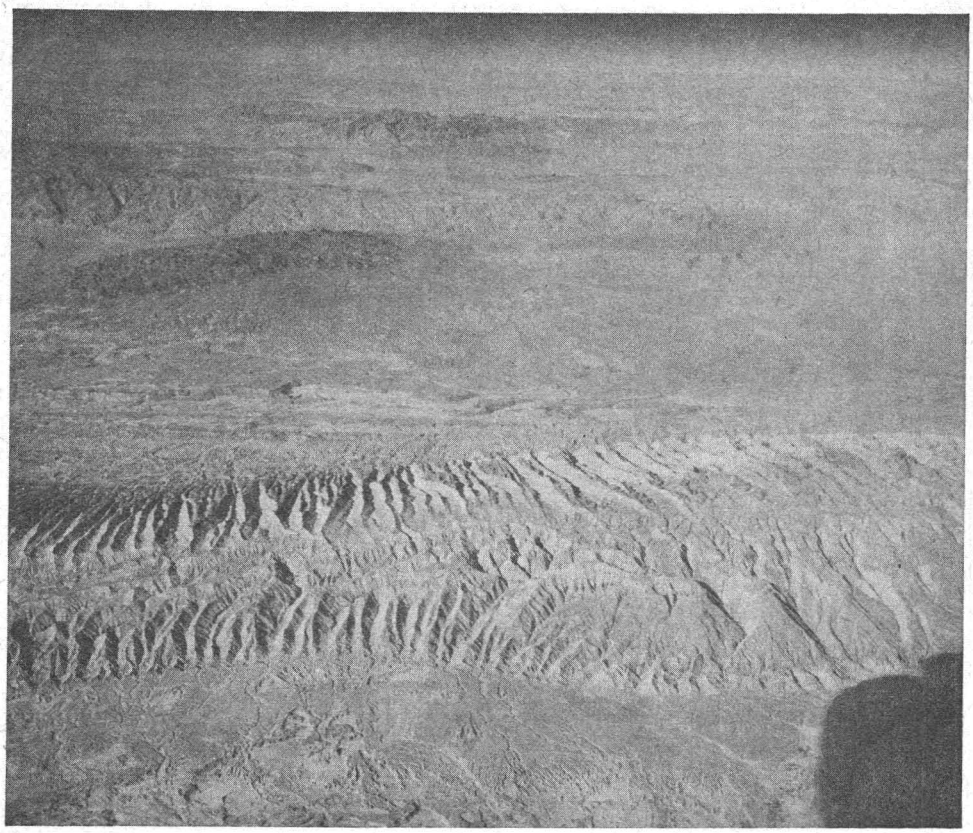

FIG. 2. Typical aerial photograph of the sketched area. Position of photograph indicated by arrow on the right (Fig. 3).

necessitates too great an increase in feature scale and this destroys the effectiveness of the pattern representation. In areas where the over-all pattern is more important than the small individual features that comprise it, one consistent representative pattern is carried over the entire area. In the pattern representation, an attempt is made to sketch the pattern at a scale that would best portray the appearance of the terrain when observed at average flight altitude. The larger landmark features and bold relief are shown to scale.

A portion of the sketched base (Fig. 3) of a 1:1,000,000 scale aeronautical chart recently compiled is included to illustrate better the manner in which terrain is depicted by the previously discussed method. It will be noted from the sketching and by comparison to the two representative aerial photographs of the area (Fig. 1) and (Fig. 2) that the terrain is characterized by sand plains, unusual geological formations, rock outcrops and alluvial fans. The normal cartographic representation (Fig. 4) does not illustrate this fact conclusively but through necessity maintains the road, town and drainage pattern which is relatively unimportant due to local conditions. It will also be noted that the contours do not express the nature of the terrain and only vaguely express the shapes. As aeronautical charts are published at comparatively small scales, a rather wide contour interval must be used; consequently contour lines rarely can express true shapes except in a general sense.

At the present stage of development the sketching of the terrain representa-

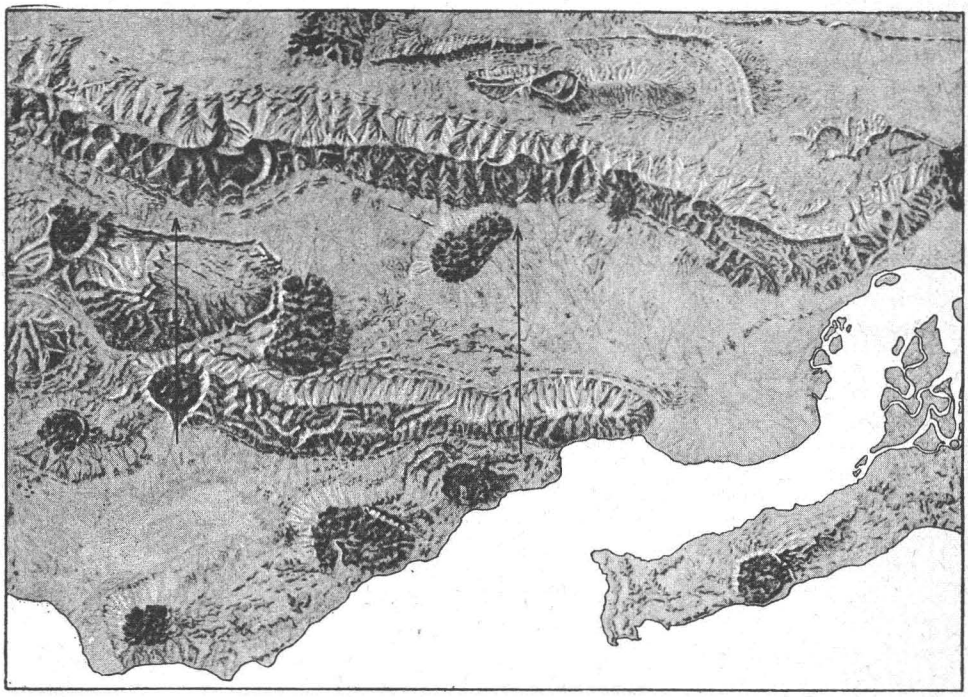

FIG. 3. Terrain representation sketched from aerial photographs. Scale 1:1,000,000.

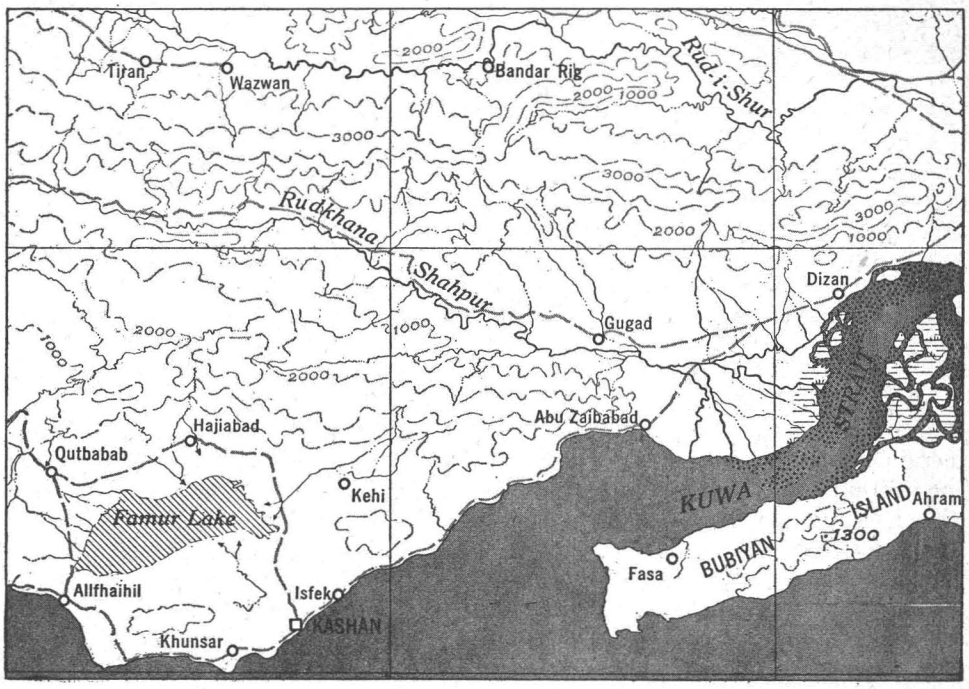

FIG. 4. Identical area (Fig. 3) compiled through use of standard cartographic symbols. Scale 1:1,000,000.

tion is shown on the aeronautical chart in the place of the contours and gradient tints. Although it is thought the sketching better portrays shapes and forms, contours and gradient tints serve the purpose of enabling the pilot to maintain sufficient ground clearance. It is thought that chart requirements can not be fulfilled without incorporating some indication of elevation along with the terrain representation. Experiments are being conducted here and elsewhere wherein gradient tints are combined with the sketched terrain representation. Some problems arise in connection with the selection of color tints that will not reduce the effectiveness of the sketched terrain representation. As a substitute for the principal effective value of contours and gradient tints prominent clearance figures in the center of each thirty minute block of the graticule have been shown on the aeronautical overprint. Normally the overprint includes radio and airport data. Available spot elevations indicating all reliable strategic elevations are shown on the chart base. The clearance figures indicate the highest known elevation in each thirty minute block of the graticule and are shown to the nearest hundred feet for accurate elevation information and to the nearest thousand feet together with a plus or minus mark for approximate elevation data. As an example, if the highest elevation in a 30 minute block of the graticule is known reliably to be 5,300 feet, a large 5 followed by a smaller 3 is shown in the center of the block; if from approximate source material the elevation is known to be between 7,000 and 8,000 feet, a large 8 followed by a smaller $\pm$ is shown in the center of the block. Clearance figures, although not completely accomplishing the same objectives as contours and gradient tints do seem to have some good points in that they are very easy to interpret and read at a glance, compilation and reproduction procedures in connection with them are greatly simplified and if the clearance figures are shown on the aeronautical overprint, they may be revised along with any revision of the aeronautical overprint. A disadvantage lies in the fact that the highest elevation is not localized except within the 30 minute block of the graticule. However the sketched terrain representation will usually indicate the high areas and occasionally spot elevations are available for the high points of the terrain.

Obtaining personnel to perform the sketching for this type of terrain representation has presented no great problem. Of course, cartographic and reproduction planning and photo interpretation under adverse or unusual circumstances necessitates considerable experience; these however, are supervisory operations. To be able to draw the features that are seen on the photographs is the major requirement of those actually engaged in the work. Experience has proven that many individuals possess the necessary artistic ability and that the women, that are engaged in this type of work at the present, have produced satisfactory sketching in less than a week after familiarization.

The procedures applying to elevation data, compilation, sketching and reproduction previously outlined are in the experimental stage at the present. Undoubtedly revisions and refinements should be made to meet every demand upon an aeronautical chart. However, it is the purpose of this article to present an answer to a definite void that exists in present day charting rather than a procedure of compilation refined in every detail. Present day air navigation seems to call for chart detail that can be interpreted quickly and a consistent portrayal of identifiable ground features along the entire flight route. Terrain representation as this article has attempted to describe makes it possible to clearly depict those ground features and patterns that are the most identifiable from the air, and in areas where significant cultural and hydrographic features are lacking that aeronautical chart does not deteriorate in its usefulness.