The Department of Defense realizes that in time of peace it will be quite impossible to provide in advance all of the graphic materials and allied material it would need in the conduct of war. It also is well aware of the vast undertakings in this field which would be required to implement the execution of any war plan. The undertakings would necessarily involve one of the greatest percentagewise expansions of service which confront the Department of Defense in mobilization for war.

It is the policy of the Department of Defense to maintain in time of peace the smallest possible nucleus of facilities involved in photography, mapping, charting and allied fields associated with photogrammetry, which will permit it to meet its special needs, at least a portion of its immediate needs in foreign strategic areas, and which will permit a sensible mobilization of this service in time of war.

The Department of Defense has great faith in and depends heavily upon all of you and your associated industries, to help us insure that we are provided with these necessary tools of war. It expects you to help insure that we are not placed at a disadvantage with respect to any possible adversary. The Department of Defense expects to foster private enterprise and the broadening of the educational base in this specialized field, to insure the adequacy of our resources under emergency conditions.

We all derive considerable satisfaction from the fact that our work, in addition to its defense aspects, contributes greatly in time of peace, to the knowledge of the human race, to the improvement of its welfare, and to the maintenance of peace. Few fields of endeavor can bring more light to areas of darkness where ignorance breeds fear and fear breeds war.

USES OF AERIAL PHOTOGRAPHS IN FOREST RECREATION*

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WORKERS in the field of forest recreation, like those in many other fields, have only begun to explore the possibilities for making advantageous use of aerial photographs.

During this exploratory period, an exchange of ideas and personal experiences may be quite helpful to the managers of recreational areas and, as presently will be shown, may also be of considerable interest to many of those who annually seek recreation in our forest lands. It is hoped that this will be regarded as sufficient justification for the speaker's frequent reference to his own experiences in the ensuing discussion of ways in which aerial photos may be used advantageously by the managers of recreational areas and by recreationists themselves. At the risk of detracting from the technical quality of the article, a rather broad brush will be used in painting the descriptions of forest recreational uses of aerial photos. It is believed that this will best serve to suggest similar uses of aerial photos in many of the other fields of photogrammetry represented at this meeting.

Managers of recreational areas have found in certain instances that aerial photos are of great value in planning future developments. Often existing maps

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NOTE: Comments on this paper are invited. To ensure consideration for publication in the September issue, receipt before July 15 is necessary.

of such areas are obsolete or show insufficient detail as to the position of trees, rock outcrops, brushfields and other pertinent features which register clearly on the photos. Aesthetic, as well as topographic considerations, are of manifest importance in the development of recreational areas, and the former can be assessed much more accurately on aerial photos than on even the best of topographic maps.

A short time ago, the speaker was asked by a Boy Scout executive for an estimate of the cost for surveyors to prepare a topographic map of a newly-acquired 2,000 acre site on which it was desired to build roads, trails, playing fields, campgrounds and buildings. After more mature consideration as to the exact type of information needed, it was decided to use aerial photos in lieu of having a standard topographic map made. At a cost of less than five dollars, prints from existing aerial photography of the area were obtained on which it was possible, with a few hours of stereoscopic study, to formline the area using known spot elevations. In addition, streams, springs, major vegetation types, and existing roads, trails and buildings were delineated. From the resulting annotated, uncontrolled aerial photo mosaic, far more information of the type needed for development of the area was obtained than could have been extracted from an accurate topographic map prepared at considerable cost by ground survey methods. Furthermore, such a mosaic was better suited than a topographic map for use in the field because the wealth of detail and natural appearance of the photographic image better enabled one to determine his exact position at any given time and to interpret his surroundings.

The manager of a recreational area may find further use for an aerial photo mosaic as an attraction to patrons of his area. A neat, suitably annotated mosaic, posted on the bulletin board or in the lounge, is readily interpreted by a hiker who, at the end of the day, wants to show his friends an easier way he found to climb the mountain. It holds a similar attraction for the fisherman who caught a big one in that hole just below the falls, or the golfer who hit into a sandtrap on the seventh hole, or the skier who almost ran smack into a particular tree on that downhill shuss.

Recently, a state park employee, working with the speaker, prepared not only an annotated aerial photo mosaic of the park in which he worked, but also a terrain model of the same area, at the same scale. Through the use of materials and methods developed during World War II, a very realistic effect was achieved by simulating on the model the tone and texture of the various vegetation types as determined from aerial photo interpretation. When plans for development of the park were subsequently being formulated, the terrain model and aerial photo mosaic were found to complement each other admirably, in that the former accentuated topography while the latter exhibited the necessary minuteness of detail. Cross-reference between mosaic and model was greatly facilitated by their being at the same scale.

A further example of the usefulness of aerial photos in developing recreational areas is provided by the attempt currently being made to relocate and intensify the trail net on a certain large National Park. Due regard must be given to a number of factors including scenic qualities of the route, proximity to lake and stream fishing, availability of natural forage for pack animals, directness, and cost of trail construction and maintenance. The existing aerial photos of this extensive area promise to reveal sufficient information regarding these characteristics to greatly reduce the amount of field reconnaissance necessary. Because of the almost complete lack of ground control in the rugged area, aerial photos also provide the best means of preparing an accurate map of

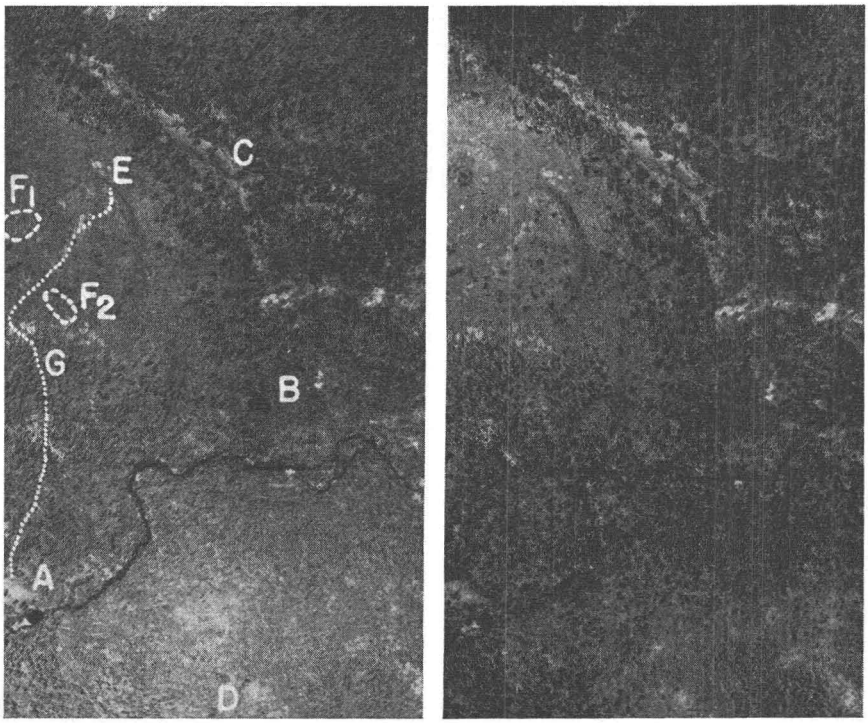

FIG. 1. Stereoscopic study of this area shows it to have such excellent possibilities for recreational development as to justify further investigation from the ground. For explanation of annotations see text.

the trail net once it has been laid out. It is proposed that a trail rider delineate the routes directly on aerial photos as he rides the trails, using prominent features along the trails for reference. Standard photogrammetric procedures will then permit construction of a map of the required accuracy from the annotated photos.

Even in the preliminary selection of a locality suitable for development into a recreational area, aerial photos may be quite useful. Recently a forester who was seeking a recreational area for a group of 4-H clubs mentioned to the speaker that among the primary requirements were: approximately 5 acres of relatively flat, easily cleared land; an adequate water supply; proximity to suitable areas for hiking, swimming and boating; and ease of access to the area either from existing roads or by moderate expenditure for additional road construction. From an examination of existing Forest Service aerial photography covering the vast area within which a suitable camp-site was being sought, enough could be determined regarding the above characteristics to select a few promising areas for further study, including the area shown in Fig. 1.

Stereoscopic examination of Fig. 1 serves to illustrate some of the possible uses of aerial photos by those charged with the selection and development of recreational areas. The rather flat, well-drained area occupying some 4 or 5 acres below and to the left of A, Fig. 1, appears to have a park-like stand of coniferous trees with a ground cover of grass and low shrubs. The proximity of this possible camp-site to a large, fast-flowing mountain stream is seen from the photos to offer promise of (1) an abundance of potable water, (2) good possibilities for

stream fishing, and (3) a natural swimming hole approximately 150 feet in diameter. In addition, the lake at B should offer further possibilities for swimming, boating and fishing.

On a map, area C might appear equally promising as a campsite, but the photos show it to be poorly drained and susceptible to heavy mosquito infestations. Furthermore, because C is in a narrower and deeper canyon, snow may be considerably later in leaving it each spring, thus giving it a shorter season of summer recreational use than area A.

With interest centering around area A, a study of adjacent photos might be made, which in this case would reveal a mountain road less than two miles downstream with topography between it and A offering no apparent major obstacles to road construction. Study of Fig. 1 shows that this road might easily be extended upstream from A to the lake at B, but that attempts to extend it still farther upstream might result in major problems because of the presence of numerous rock outcrops. In routing the road from A to B, stereoscopic study suggests that the best balance between aesthetic and topographic considerations might be struck by following the relatively dense timber along the stream bank throughout most of the route.

The two buttes at D and E should offer hikers excellent vistas of the surrounding terrain because their slopes are increasingly steeper toward the top, and there is very little timber near the top to obscure a distant view. Relatively little trail construction to butte D should be necessary because a study of the photos shows that its slopes have numerous open spots. On such small scale photography, it is of course impossible to estimate brush height from stereoscopic parallax measurements. However, most of the brush which must be cleared out for a trail between A and D probably is little more than waist high, for if it were higher, some of the down logs would be so overgrown with brush as to be barely discernible on the aerial photos. (Although some detail has of course been lost in the reproduction of Fig. 1, examination of the original aerial photos showed all down logs between A and D to be clearly discernible from their butt ends almost to their tips, despite the presence of brush. On the other hand, logs encircled at F_1 and F_2 can be seen to be considerably obscured by the taller, denser brush growing on butte E.)

Butte E is clothed with such a formidable brush cover as to require careful selection of a route for a trail leading to it. However, from aerial photo interpretation it appears that the route indicated by a dotted line in Fig. 1 should minimize the amount of brush cutting required as most of the route passes either through existing clearings, or through dense stands of virgin timber beneath which the brush cover is characteristically sparse or absent.

Surrounding topography and vegetation indicate the probability of a sizeable spring at G which might be preferred to the large stream as a source of drinking water for the camp at A. G is seen on the photos to be sufficiently higher than A to permit gravity flow of the spring water through pipes.

The large number of forest recreationists that might be accommodated in the main campsite at A can be expected to constitute a source of considerable demand for pack animals to be used for trips to the back country. The question therefore arises, in deciding on the suitability of this general area for recreational development, as to where sufficient natural forage might be found for such animals. The grass-covered meadow at C appears to offer an excellent possibility in this regard. The aerial photos show that it has an abundant soil moisture supply which should give it great regrowth potential during the summer grazing season, and perhaps a carrying capacity of as high as $\frac{1}{2}$ acre per pack animal per month.

Probably only the two ends of the meadow would need to be fenced as the dense brush and steep topography on either side of the meadow should prevent pack animals from straying for appreciable distances up the slopes.

Because of its swampy nature the meadow may be unsuitable for grazing until rather late in the summer. However, the higher ground in the right center of the stereogram has a considerable acreage occupied by grassy clearings suitable for grazing earlier in the season, although it probably has a carrying capacity of as low as 15–20 acres per pack animal per month. The hobbling or staking of pack animals in such areas might be practiced so as to eliminate the necessity for fencing.

It should be emphasized that an aerial photo analysis of the type just given for Fig. 1 cannot be guaranteed as being infallible in every particular, although a remarkably accurate interpretation can be rendered by one who from ground observation is familiar with vegetative and topographic characteristics in the general region under investigation. Worthy of equal emphasis is the fact that such an analysis need not be of 100 per cent accuracy to be of great value. Obviously the final decision regarding recreational development in the area will be dependent upon additional ground study. However, the aerial photos greatly reduce the amount of ground study required in the area, while at the same time they eliminate from further consideration many undesirable areas which might otherwise be the object of much futile study on the ground.

Managers of fish and game, realizing that an accurate periodic inventory of these resources is essential for their intelligent management, frequently use aerial photos as a census-taking device. A major advantage of aerial photography for this purpose is its capacity for "stopping" motion within the area photographed. For example, this permits the aerial photo interpreter to make a leisurely and accurate count of the waterfowl on a lake, without fear that during the process they will take flight or intermingle to the point where he is confused as to which birds have been counted and which have not.

In this connection, it is of current interest to note that during the week that this photogrammetry meeting is in session a continent-wide count of wild geese and ducks is being made by the Fish and Wildlife Service, in major wintering grounds from Alaska to the West Indies. Extensive use of aerial photographs is being made in the rapid census-taking of these migratory waterfowl.

Not long ago a duck census was taken of a lake by means of 35 mm. gun camera photography flown at low altitude. To make sure that the sound of an aircraft approaching at low altitude did not startle the birds and cause them to fly into its path, a jet-propelled photo-plane was used which "shot" the sitting ducks before they could respond to the sound of its approach. Accurate bird counts were then made at leisure by projecting the 35 mm. photography on a screen.

Under favorable conditions, aerial photos can be used to similar advantage in counting a herd of deer or other gregarious game animals. Even salmon counts have been successfully made, in fish ladders and elsewhere, by taking large scale, low altitude aerial photography with a continuous stereo-strip camera and a film-filter combination which will record underwater detail to depths of several feet.

On various occasions, fish and game experts have stated that virtually all lakes suitable for the raising of fish have now been stocked. While this may be true for lakes appearing on maps, there are many unmapped lakes, at least in the western part of the United States, which are as yet unstocked, but which are ideally suited for the production of game fish. The ever-increasing intensity with

which our forest recreational resources are being utilized would seem to dictate the desirability of our stocking all such lakes at an early date. The absence of these lakes on maps usually is attributable to their small size (normally less than 10 acres), their distance from a road or trail, and their obscure topographic location such that they can be seen from only a few vantage points on the Earth's surface.

Vertical aerial photographs not only readily reveal such lakes, but also indicate the best route of approach to them, the likelihood of their having a favor-

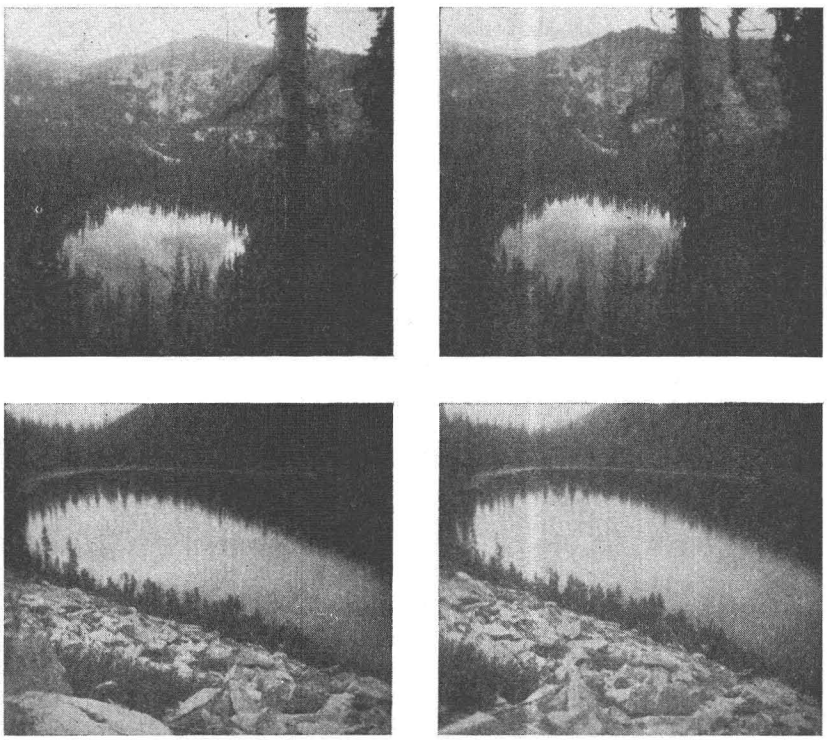

FIG. 2. Stereograms of two unmapped lakes, ideally suited to the production of trout but apparently known only to the aerial photo interpreter.

able food supply for fish, and, within certain limits, even the type of fish with which they should be stocked. For example, stagnant-appearing lakes may be suitable for catfish or bass, but unsuitable for trout; and lakes which, as seen from the photos, have no sandy inlet, may discourage spawning by rainbow trout without thus affecting eastern brook trout which will spawn in the lake itself.

Experience in the Sierra Nevada and Rocky Mountains has demonstrated that lakes situated above 8,000 feet in elevation ordinarily must be 25 feet or more in depth if trout in them are to survive the winter freeze. By coincidence, this corresponds quite closely to the maximum depth at which underwater detail can be discerned on panchromatic aerial photography, thereby further enhancing the usefulness of aerial photos to those interested in determining the suitability of lakes for the production of fish.

Fig. 2 shows two lakes, each of which is within $\frac{1}{2}$ mile of a trail and 6 miles of a road. The lakes do not appear on any maps of the area, and are sufficiently

well hidden topographically that their existence seemingly is known only to the aerial photo interpreter.

In 1940, the speaker obtained permission from the fish and game commission to stock the lake shown in the top illustration of Fig. 2 with one-inch rainbow trout, after a preliminary trip to the lake had shown it to be completely devoid of fish. On his first return to the lake in 1948, he was rewarded with the catch shown in Fig. 3, which represents approximately 2 hours of fly-fishing from the bank of the lake at mid-day. Judging from the presence of numerous fingerlings in the lake in 1948, the rainbow trout were reproducing themselves satisfactorily, as was predictable on aerial photos of the lake from the appearance of its sandy inlet.

The lake appearing in the bottom illustration of Fig. 2 was not stocked until 1949, but equally gratifying results are anticipated in due time.

Aerial photos of these lakes are omitted from publication for "security" reasons as no one else seems to have found the lakes as yet. It is hoped that by the time others have found them the speaker will have completed the stocking of several other barren lakes which he has recently "discovered" from aerial photographs and later visited on the ground. On the first trip to each of these lakes, aerial photos of the area were taken along as they proved to be extremely useful guides for determining the best routes of access to the lakes.

In this connection it should be pointed out that the recreationist who has not yet tried to use aerial photos of his forest playground while in the field has an enjoyable experience awaiting him.

FIG. 3. These rainbow trout were one inch long in 1940, when they were used to stock the previously barren lake shown at top of Fig. 2. They averaged 20 inches when caught on a fly 8 years later. The lake, less than 5 acres in size, apparently has never been fished except by those briefed as to its whereabouts by the aerial photo interpreter who discovered and stocked it.

Let us consider the hiker, for example, who enjoys tramping through Nature's rugged wilderness areas just for the thrill of seeing unexpected horizons unfold before him. The speaker likes to include himself among this group of enthusiastic explorers. However, he must confess that too often the awe-inspiring horizons have failed to materialize because, in his complete ignorance of the area, he has unwittingly selected a route which terminates in an impenetrable brushfield or swamp, or up against a sheer bluff some distance short of the objective. Nor has this difficulty always been obviated by sticking to the blazed trail and following the signposts. He recalls particularly a 30-mile trek through Desolation Valley Primitive Area of the High Sierra where the trails forked repeatedly and, in many instances, anonymously, and where snow obscured most of the blazes and ducks on the rocks. With the aerial photos as a guide, it would have been quite simple from stereoscopic study to pick a traversable

cross-country route that would have led the hiker past many scenic wonders, and thence to a suitable campsite by nightfall. In contrast, the day was largely spent in searching for the trail, only to lose it again or, as in one case, to verify a suspicion that some practical joker had interchanged the two signs at an important trail junction. As a result, the objective of the day's hike had not been reached when darkness fell, and the night was spent huddled in a cave at an elevation of 9,000 feet.

But where does one who is interested in thus using photos in the field procure the stereoscope and aerial photographs?

A stereoscope is not needed for this kind of field work, as will be attested by many a good aerial photo-interpreter who has achieved "naked eye" stereo vision. By holding corresponding images on a stereoscopic pair of aerial photos approximately $2\frac{1}{4}$ inches apart, a foot in front of the eyes, and normal to the line of sight, an observer can, with practice, make the topography stand out in bold relief. Even if a stereoscope is readily available, such additional information as may be obtainable through its use ordinarily does not compensate for the inconvenience of carrying and using it on such a hike.

As for procurement of the aerial photos, prints for virtually any forested area in the United States can be purchased by a private individual from the appropriate government agency (PHOTOGRAMMETRIC ENGINEERING, Vol. XIII, No. 1, Page 157) at a very reasonable cost—usually about 50 cents per print of an area covering some 9 square miles. Alternatively, the speaker has found it possible, on occasion, to borrow the desired photos from the files of local lumbermen or forest officers.

Forest recreationists have recently shown interest in using aerial photos not only in hiking, but also in the pursuit of several other sports.

Hunters of game birds and animals have found that, in certain instances, they can recognize on aerial photos of areas, with which they are unfamiliar, the combination of vegetation and topography which will be most likely to harbor their quarry and which at the same time will offer favorable shooting conditions.

Trout stream fishermen, who until recently believed that certain streams flanked by deep, steep-walled canyons were completely inaccessible have, from a study of aerial photos, found routes of entry and exit which have permitted them to fish virgin waters.

Alpine mountain climbers are able to pick routes for scaling peaks from a study of aerial photographs. One such group is currently compiling "A Climber's Guide to the High Sierra" in which it is contemplated that liberal use of aerial photos will be made "for reconnoitering peaks and checking their descriptions." (*Sierra Club Bulletin*, April 1949).

Recently a member of a mountain-climbing expedition was killed in a fall while the group was scaling a peak in a very remote area. At the request of the victim's parents, a special aerial photographic mission was flown for the purpose of finding a route by which their son's body could be returned to civilization.

A group which plans to make extended explorations of a remote mountain range is currently attempting, from a study of aerial photos, to locate alpine meadows and flat-topped glaciers along the route where air drops of supplies can be made, thereby minimizing the amount of back packing required. A pilot who has been briefed from aerial photographs as to where such air drops should be made, and who takes annotated copies of the photos with him during the flight, is much more certain of dropping in the pre-arranged spots than if he were guided only by the characteristically inaccurate maps of such remote areas.

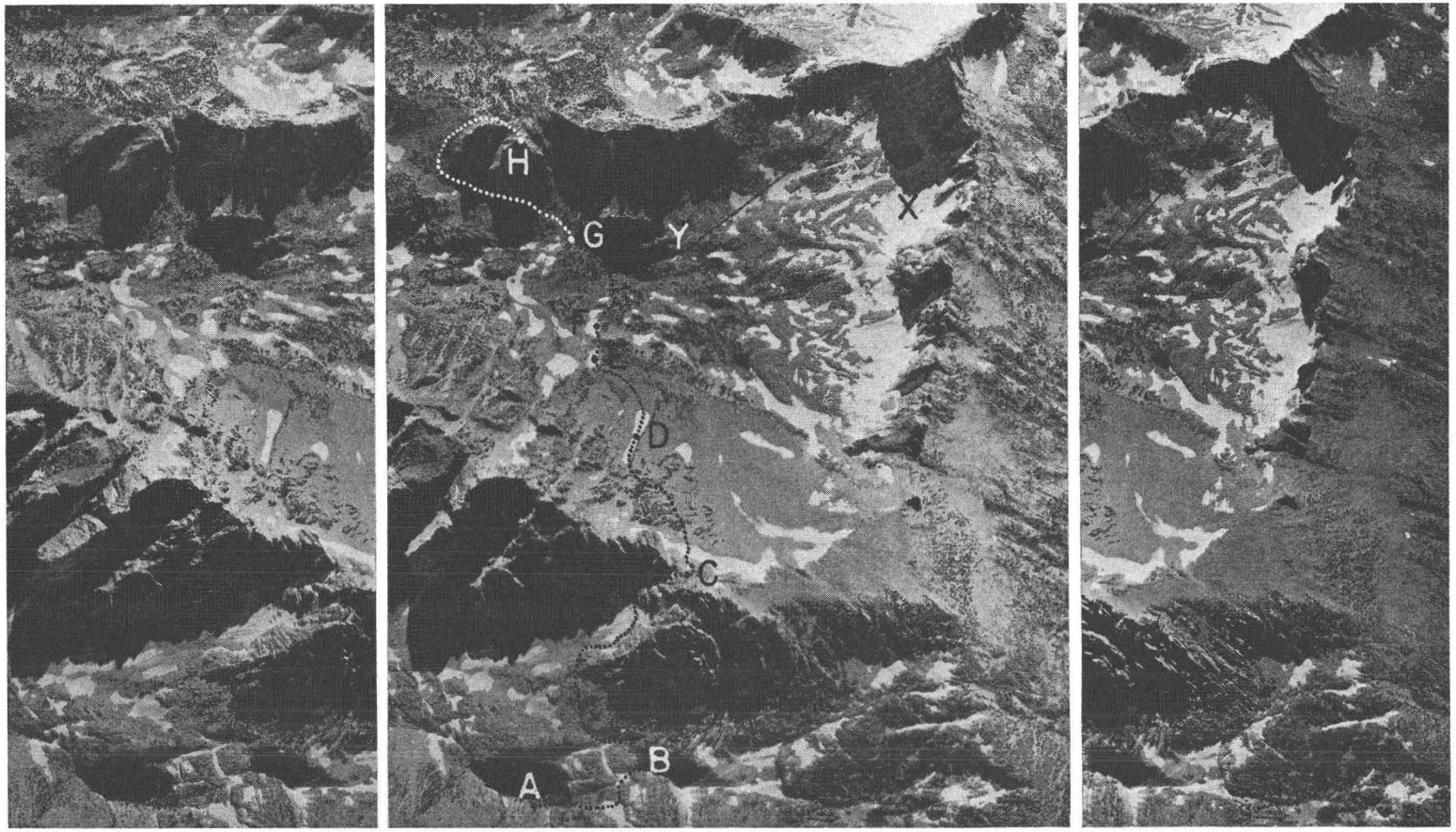

FIG. 4. For a discussion of the multifarious uses of aerial photos by those recreating in the area shown by this stereo-triplicate, see text.

By way of illustrating some of the foregoing uses of aerial photographs by recreationists, let us assume that a hiker, equipped with photos, identifies his present position as point A, Fig. 4, and that he wishes eventually to climb the peak at H. He can readily determine from stereoscopic study of the photos that the route indicated by the dotted line offers fishing and swimming possibilities at B and G (note absence of lake bottom detail), a relatively low and easily traversed pass at C, and enjoyable opportunities for sliding down snowbanks in a sitting position at D, E, and F. He can determine from further examination of the photos that the swampy area between D and E can be skirted and the talus slope between B and C can be traversed, although the head of the talus slope may cause some difficulty, because of its characteristically small rock particle size and increased steepness. The hiker can use talus slopes appearing in the stereogram as ready guides for estimating the steepness of other slopes and of snowslides, since the angle of repose of the central portion of a talus slope has been found almost invariably to be $35° \pm 2°$. With careful study, the hiker can also ascertain that, along the entire route, the only trees capable of providing him with sizeable branchwood fuel for a campfire, are between points A and B.

If on the other hand, this hiker had neither the aerial photos nor previous familiarity with the area, he might very likely spend many futile and hazardous hours in trying to find a passable route over the first ridge, since C appears to be the only point on the stereogram at which the ridge might be safely crossed. Furthermore, he might pass literally within a stone's throw of some very scenic or otherwise interesting spots, such as the lake at B, without knowing of their existence. Finally, the advent of darkness might leave him with a very unhappy choice of campsites as regards availability of fuel and freedom from strong winds or cold air drainage.

Referring again to Fig. 4, the relatively smooth, flat area extending for some distance to the right of D offers good possibilities for an air drop of supplies in the event that extended explorations are to be made in the area. Surrounding topography is favorable for the relatively close approach of aircraft to the ground, thus increasing the accuracy of the drop and perhaps reducing damage to the contents, but even if the cargo should land some distance from the intended point of impact it can be found quite easily in such a relatively smooth and barren area.

Those who prefer to do their mountain climbing from an armchair may find it exhilarating to try to pick stereoscopically the best route from A to the top of the 12,000-foot peak appearing in the upper right corner of the stereogram (Fig. 4). Study of this peak's conspicuous shadow (labelled "X") serves to accentuate some of its rugged features which might otherwise be overlooked. The rock glacier below and to the left of X is not recommended as a route of approach to the peak.

The primary objective of many mountain climbers is to photograph scenic wonders from spectacular vantage points. In figure 4, a typical objective might be a photo taken from the top of the afore-mentioned 12,000-foot peak, showing the lake nestled beneath it. But will intervening terrain obscure all or part of the lake? If, on both members of a stereo pair of aerial photos a line is drawn connecting the peak with the upper end of the lake at Y (Fig. 4), this question can be answered in the negative for, when viewed stereoscopically, the line appears to float well above all the intervening terrain. Had the line appeared to intersect the ground at some intermediate terrain feature, the two points would not be intervisible.

It is also apparent from the aerial photos that shadows from nearby peaks

fall across the lake during much of the day, from which the photographer can estimate the most suitable time of day to be atop the peak, from the standpoint of photographic light.

Although many more instances might be cited showing uses which already have been made of aerial photographs, either by the managers of recreational areas or by recreationists themselves, these examples should suffice to indicate possibilities for their more extensive use in the future.

In the foregoing discussion, an enthusiastic attitude has purposely been assumed in an effort to stimulate greater interest in the use of aerial photographs in forest recreation. Some final words of caution are considered appropriate, however. A history of the growth of photogrammetry shows many instances in which aerial photos have been oversold to workers in a particular field, many of whom have had no previous experience in using them. As a result, their first efforts to use the photos frequently have been miserably unsuccessful because (1) they have expected too much from the photos, and (2) they have known too little of how to extract from the photos such information as is available. As a consequence of their high hopes and initial failures, they have been greatly disillusioned and have thereupon abandoned further consideration of aerial photos as a useful tool.

To prevent repetition of this misfortune, it is hoped that the field of forest recreation will attract to it in the near future a number of professionally trained photogrammetrists who can make solid progress as a result of their appreciation of the potentialities and limitations of the aerial photographs.

The field of forest recreation is increasing in importance at a rate commensurate with the rapid increase in our population and amount of leisure time. The consequent urgent demand for development and maintenance of our forest recreational resources poses many problems which can best be solved through the intelligent use of aerial photographs.

NEWS NOTE

PRODUCE NEW 16 MM. PROJECTION LENS

On January 9, Bausch & Lomb Optical Company of Rochester, N. Y. announced that a unique, high-speed lens for 16 mm. movie projectors is now in production. The news release reads as follows:

"Designed especially for serious amateurs as well as professional users, the six-element, anastigmat f/1.6 lens is the only one of its kind on the market today.

"Developed over the past two years by Bausch & Lomb Optical Company, it rivals the firm's professional Super Cinephor model used in hundreds of large movie houses throughout the U. S. Its sealed, one-piece mount fits all sound projectors with the standard one and 3/16th-inch barrel.

"Known as the Super Cinephor '16,' its surfaces are coated to provide maximum light transmission and clear, sparkling images in all corners of the screen. The two-inch lens is in full production for immediate distribution."