LOCATING CONTROL POINTS FOR AERIAL MAPPING IN NORTHERN CANADA*

By B. J. Woodruff, Geodetic Service of Canada

WHILE the use of aircraft and photography for survey purposes has revolutionized the methods of map production, both in the provision of detail and speed of operation, it is still necessary "to keep one foot on the ground" in the form of control points. It is the purpose of this article to deal with one form of the location of ground control points, which combines the use of astronomic observations, ground survey and air photography, the last mentioned operation being the means of identification of the point in the high altitude photographs.

Before discussing at length the operations involved in the location of a control point, the definition of a few terms and a description of the basic method used may serve to avoid misunderstanding.

Control points are those points in the territory to be mapped whose geographic co-ordinates have been obtained and sufficient data from ground survey or photography has been gathered to identify the point in high altitude photographs.

High altitude photographs are those pictures both oblique and vertical which provide the topographic detail for mapping purposes. These are taken from aircraft specially equipped to fly at an altitude of 20,000 feet and a series of parallel flights about 25 miles apart provide a series of overlapping photographs embracing the whole area to be mapped. This operation is a major one in itself and may be performed at a different season or a different year to that of the control point location party. Air photographs by this last mentioned party embrace only the locality of the control point and are taken at an elevation of two or three thousand feet.

Assumed latitude, longitude or time is the information gained by preliminary observations or by the scaling of a position from the existing map which gives an approximate position for the point to be located. The final result of the observations at a control point is a correction to these assumed coordinates.

Ball's Method. To fully describe this method of observing and reduction of data would call for a description of greater length than this article permits. In brief, this method is based on recording the time that selected circum-polar stars cross the circumference of a circle subtended by the observer's telescope which is held continuously at a known altitude. One can imagine the observer as being at the apex of an inverted cone with its axis extending vertically into space and recording the time of passage of stars across its circular base. In practice this cone has its sides at a slope of 45° or 60° and in any one set of observations the accuracy of the observation results will depend on the constant use of the same angle of altitude for each star observed. Text books describing Ball's Method deal principally with the use of an astrolabe in which the use of prisms control this angle but wartime conditions have forced the surveyor to use a theodolite. This condition applies to the writer's experience and his remarks will be based on the use of a theodolite or transit for astronomic observations.

In Northern Canada past survey work has been influenced by the demand for data to meet the immediate needs of mining, transport and commercial developments, leaving large areas more or less deficient in information. The rapid extension in the use of air transport and conditions due to the war, has led to a demand for maps and information of the North Country far in excess of the existing supply. Air photography furnishes the details to produce maps to meet

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this demand and ground control points are necessary to ensure accuracy of location and direction. If previous surveys have located natural features such as lakes and rivers, or if towns, roads or any other marks of development have been fixed with sufficient accuracy, these may be used as controls of the high altitude photographs. It is true that these points do exist at widely scattered intervals across Northern Canada but the wide spaces in between furnish an area in which control is needed.

After the cartographer has indicated the amount of control desired and the approximate position of control points, the surveyor is faced with the problems of transport. In Northern Canada this almost automatically resolves itself into the use of aircraft. The prevalence of lakes and rivers ensures landing places and the close association of ground control location to the operation of air photography are factors overwhelmingly in favor of this mode of transport. The only exception to the use of aircraft might be in tidal waters. In this case the rise and fall of the tide and the presence of floating ice may create hazards to landing of aircraft. The use of lakes and rivers close to the coast line for landing places will avoid these dangers and enable the survey party to establish the control station reasonably close to the desired locality.

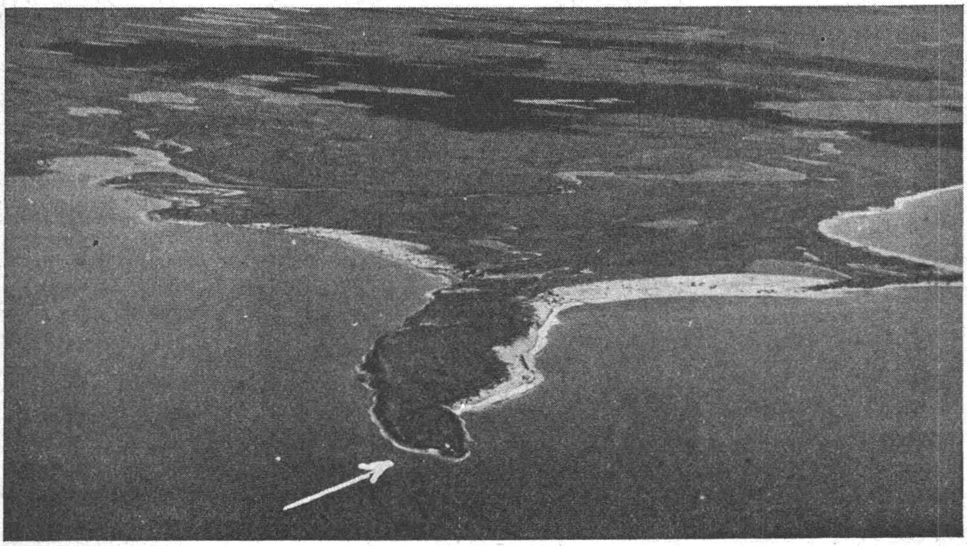

FIGURE I

The most suitable aircraft for this type of survey operation is one capable of landing and taking off on relatively small bodies of water. This qualtiy enlarges the choice of landing places and adds to the margin of safety in the event of an emergency landing. Another very essential detail of the transport problem is the provision of fuel supply and the laying down of gas caches. Most aircraft suitable for this type of work, if not provided with extra fuel tanks, have a range of 400 to 500 miles and will carry from 700 to 800 pounds of equipment. With a normal observing party of two men, two trips will be necessary to transport all the equipment and it is not possible to carry much reserve gas for future flights. The careful consideration and laying down of fuel caches at strategic points will mean the difference between having the aircraft available when needed to transport the survey party and the delay due to its absence in ferrying gas for future consumption.

A close companion of the transport arrangement is the choice of equipment. Here the factors of necessity and weight have to be studied. Very little modification of the technical apparatus is possible but spare parts and replacements should be carried whenever possible. A greater latitude of choice can be used in the less technical but essential matter of shelter, food and warmth. Practical experience and personal tastes will decide what is considered necessary in this matter but due allowance should be made for any prolonged stay which may occur if the transport arrangements break down.

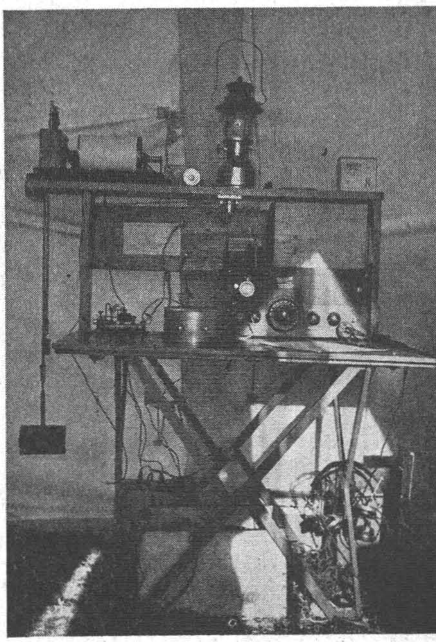

FIGURE II

When assembled, the outfit of a two-man observing party will weigh about 1,000 pounds. Some reduction, amounting in most cases to less than 200 pounds, can be made by substituting stop watches for a chronograph and further reductions are usually made at the expense of comfort and reserve food supply.

From a technical point of view the choice of a control point narrows down to locating an outstanding feature of the natural topography which will be easily recognized in the high altitude photographs; junctions of rivers, lakes with pronounced outlines are usually easily found but the practical considerations of landing and shelter for the aircraft often force a second choice of location and the engineer is constrained to accept an inferior site for control point location to satisfy the needs of safety. Figure 1 illustrates an ideal site at the end of a prominent point, in a large lake, with sandy shores for landing and beaching the aircraft.

As a rule the surveyor will travel with the first trip of the aircraft to the locality of the desired point, and after choosing the location, he is landed with part of the camp equipment and his instruments, while the aircraft returns to the last point of operation to pick up his assistant, who, with the camera, will photograph the vicinity of the station before landing. During this absence of the aircraft, the surveyor may erect or spread out the tent to form an identification mark. In the particular case shown in Figure 1, a white tarpaulin was spread out at the site of the observing instrument. Should time and weather permit, preliminary observations for azimuth and latitude are made. Upon arrival of the second trip all equipment is available, and everyone is concerned with preparations for shelter, food and the technical work of observing. With clear skies in prospect, these preparations are made with the idea of the night's observations predominant and other considerations are secondary. The observing instrument is set up and adjusted and an azimuth mark established. Star lists are consulted to make an observing program. These star lists are made out to show the catalogue number, magnitude, sidereal time and azimuth of stars at each degree of latitude and are available for observations made either at 60°

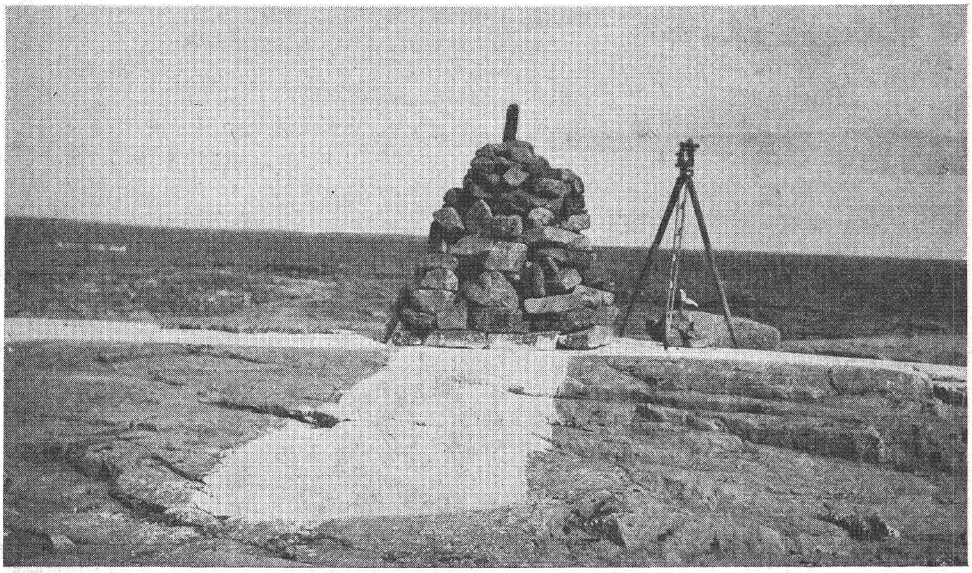

FIGURE III

or 45° altitude. With this program and the assumed or approximate local sidereal time, the observer is able to point his telescope to find and record the passage of the star's image across the horizontal wire or wires of the reticule. The precision chronometer, which is the nerve center of the whole equipment, is always carried with its mechanism locked to prevent damage in transit. With this set and started at the local sidereal time, either by reference to a mean timepiece or by comparison with a standard time signal by wireless, the observer is ready to proceed.

Two methods of recording the sidereal time of the stars and wireless time signals may be used, either stop watch or chronograph. The chronograph method entails a much greater weight of equipment with its batteries, relays and wiring, and its advantages are in the automatic record made of the chronometer time and the observer's signals. A comparative record is also made by the observer and his assistant. This affords an opportunity to clear up any confusion of times recorded by comparison of the two record sheets. The use of stop watches introduces several chances of errors of reading and recording. Careful procedure will guard against these errors but once recorded there is little opportunity of recovery as with the use of a chronograph. Since experience has shown that satisfactory results can be obtained by either method, the saving in weight and simplicity of equipment is definitely in favor of the use of stop watches.

Should the chronograph method be used, the movement of a pen or stylus is controlled by electrical connection to a break switch mechanism within the precision chronometer. In action the chronograph record will indicate the even seconds with the minutes marked by the inclusion of the 59th second. Also included in this circuit is a break switch key which in the hands of the observer will signal the instant of the star's passage arcoss the wires of the diaphragm of the theodolite. It also is used to record the comparison of standard radio time signals. This data of the local sidereal time of the passage of recognized stars with the use of Ball's Method of calculation, results in the determination of both latitude and longitude of the observing station, and to a secondary degree the azimuth of the stars observed.

Although the accuracy of the observations is dependent on the use of a constant angle for the observing telescope and a very small change in this angle from star to star will result in large discrepancies, several years' practice of this method show that with 16 to 20 stars observed it is possible to locate a point to approximately one second of arc. Figure II illustrates an arrangement of the recording equipment with the chronograph set on the shelf above the table, its chains and weights hanging to the left. On the table to the right is the wireless receiver for time signals with the precision chronometer and relay on center and left. Below the table are the batteries of the chornograph circuit.

With the preparations for stellar observations made and, if weather permits completed, the attention of the party is turned to a ground survey of the locality to obtain sufficient data to make a sketch and description of the station and also to locate and construct a monument to identify the point. These marks may be pits, mounds, posts, bronze markers set in boulders or cairns, depending on the conditions and material at hand; the prime requisite being permanence and prominence. Figure III is an illustration of a cairn erected beside a bronze tablet set in the rock directly below the instrument. The white-washed strips radiating from the cairn are to facilitate recognition from the air.

With favorable conditions of weather and transport it is possible to complete the operations of control point location within 24 hours, and under these conditions the observing party puts up with the minimum of sleep; however, as every field man knows fine observing weather is more often the exception than the rule and for an entire season an average of two to three points observed per week would mean unusual progress.

In northern latitudes the period of the summer solstice presents some difficulties for the observer. The almost continuous daylight during this season reduces the observing period to an hour or two at midnight when the sun has disappeared behind the hills; only the brighter stars are visible against the northern sky which will exhibit the lighting effects of sunset or sunrise. There is a slight compensation in the longer period of daylight available for transport and preparation but not enough to make up the loss brought about by the lack of time for making observations. On a clear night about three hours will enable the observer to record sufficient stars for control point location but the presence of drifting clouds will often double this time and sometimes extends the period from shortly after sunset to nearly sunrise.

The vagaries of radio reception in the Arctic often prove a source of worry.

The brilliant display of the northern lights, while interesting and beautiful in itself, will usually mean poor conditions for the reception of time signals and since a record of time signals is an essential adjunct to the astronomic work, an otherwise perfect night's work may be ruined by the lack of time signal records.

When the field season's work has been completed, the data obtained by the control party are reduced to the latitude and longitude of each point with records of azimuth lines shown in descriptions, sketches and photographs. Since the high altitude photographs consist of vertical and oblique views to the right and left and cover the territory in which the control point is located, we might assume that recognition of the control point in these views would be a simple matter. This is true only when the path of the high altitude flights is relatively close to the location of the control point and when conditions on the ground are similar for both operations. Snow and ice-covered topography will be unrecognizable in photographs taken in the summer season and a difference in water levels may materially alter the outlines of the shores of bodies of water.

When it is possible to provide the control party with copies of the high altitude pictures covering the locality of the control point the problems of identification are simplified. Landing places shown in these photographs can be chosen and the exact spot of observation marked with an assurance and accuracy not always possible in any other method.

ANSWERS

1. c
2. b
3. b
4. a
5. d
6. c
7. c
8. a
9. c
10. (1) b
    (2) c