RADAR AIDS TO SURVEYING

By E. G. Bowen, M.Sc., Ph.D.[1]

The rapid development of radar during the war has resulted in the growth of several new techniques many of which have applications outside the military field. One of the most important of these is to surveying. The following account may serve as an introduction to the subject and describes two methods which are being developed by the C.S.I.R.'s Division of Radiophysics for application to the survey of Australia.

The chief contribution which radar can make to survey problems is the direct measurement of distance between two points. This is accomplished by transmitting a short pulse of radio waves from one of the points, receiving it at the other and re-transmitting it back to the point of origin. Knowing the velocity of propagation, the time of transit then gives a measure of the distance between them. The great advantage of the method is that the terrain over which the measurement is made need not be flat or even accessible. What is more, the measurement is made almost instantaneously and may therefore be carried out in an aircraft moving at fair speed.

The Accuracy of Measurement

The accuracy with which distance can be measured by radar depends on:

(a) The precision with which small intervals of time can be measured.

(b) The influence of atmospheric conditions on the velocity of propagation.

The time interval to be measured is exceedingly small, being about ten-millionths of a second for every mile traversed. Using refined methods it is possible to measure such tiny intervals to an accuracy of about one part in 10^9, that is, a few feet in a million miles. Unfortunately, a much lower limit is set by atmospheric conditions, and variations in the moisture content of the air limit the accuracy which can be obtained in practice to about one in 10^5. This is not as good as that achieved by standard survey methods and much research is required to improve it. In special cases, however, radar can make valuable contributions and two of these are outlined below.

Application to Photographic Survey

In making a photographic survey an aircraft flies a grid, taking a series of vertical incidence photographs as it goes. A mosaic is built up from these photographs and an enormous amount of information about soil, forestry, agriculture, etc., can be derived from it. The process of constructing an accurate map from the mosaic can be quite difficult, however. It depends on the existence of recognizable points on the ground whose position is already known from a ground survey. The principal advantage of aerial photography—its speed—is therefore handicapped by the fact that a good map cannot be made until a ground party has gone over the area establishing fixed points.

It would be much more convenient, and certainly faster, if the aircraft could determine its own position every time a photograph was taken. This can be done by setting up two ground beacons A and B at the ends of a known baseline as shown in Fig. 1. Radar equipment in the aircraft is then used to measure the distances d_1 and d_2, from which the position of the aircraft can be calculated. The baseline may be from 100 to 150 miles long and the aircraft can operate up to 200 miles away from either end. With present-day equipment the accuracy is not expected to be much greater than ± 20 yards but this is quite good enough for the 1-in-250,000 maps which are the main concern of the survey of Australia.

Application to Geodetic Survey

It is possible by astronomical methods to determine a position on the earth's surface to an extraordinary degree of accuracy. If two

[1] Chief, Division of Radiophysics, Council for Scientific and Industrial Research.

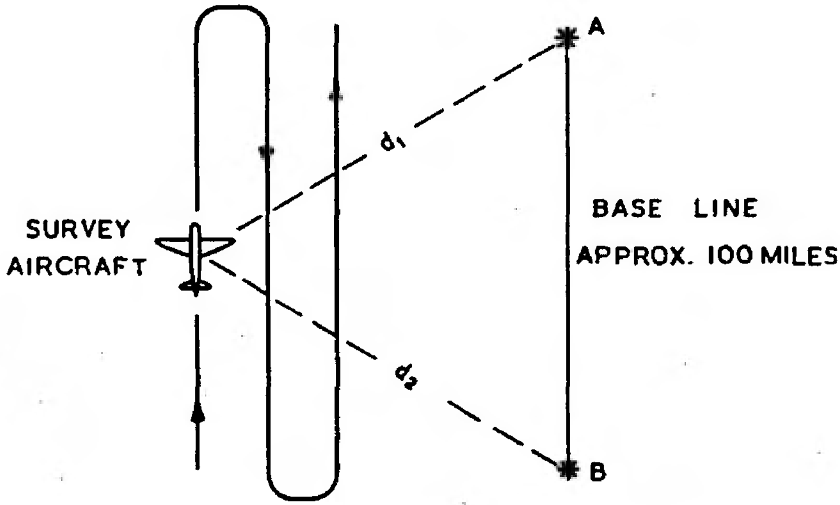

FIG. 1.

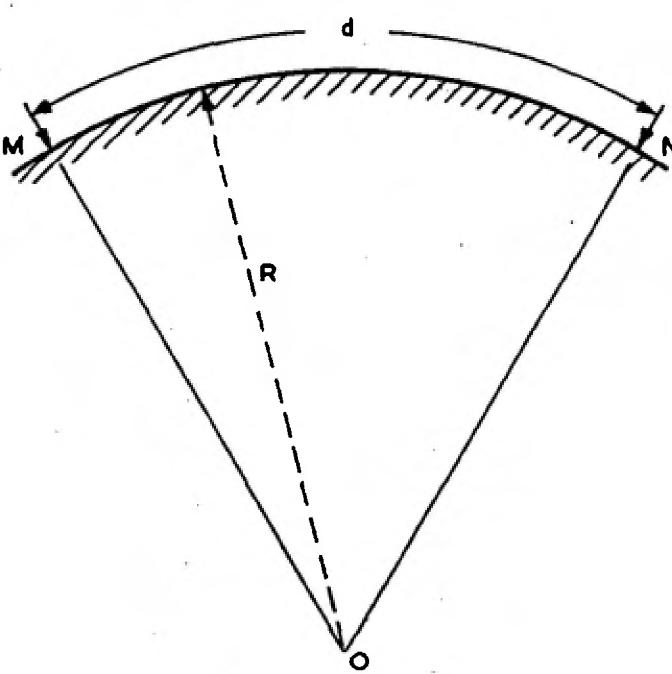

FIG. 2.

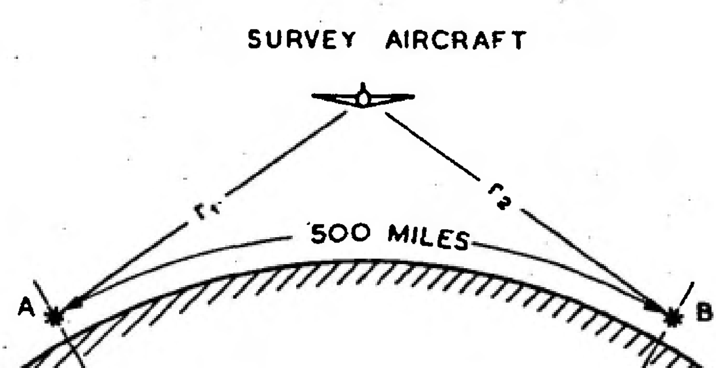

FIG. 3.

points M and N (Fig. 2) are fixed in this way, the distance between them is not necessarily known to the same order of accuracy. This distance can only be found if the radius of the earth in that part of the world is already known precisely. To solve the problem a direct measurement of the distance "d" is required. For points some 400 or 500 miles apart the methods of ground survey are long and arduous in a country like Australia with much inaccessible terrain. Here again radar provides a method by which a baseline up to some 500 miles can be measured in a single afternoon. The method is illustrated in Fig. 3, the principles being similar to those employed in photographic surveying. The ground beacons A and B are placed at the selected points and an aircraft is flown midway between them measuring the line-of-sight distances r_1 and r_2. Knowing the height of the aircraft, the ground distance can be calculated. It is expected that an accuracy of ± 10 yards in 500 miles can be achieved with the equipment now being built and it is possible that this can be improved to ± 5 yards in the near future.

These applications are not the only ones likely to be of assistance to the surveyor. There are many others such as the determination of levels in inaccessible country by means of the radar altimeter, but all of them will require much laboratory development before they reach the practical stage.