MAPS AND MINERALS . . .

results. As a general rule, traverses should be at right angles to the strike of a formation (such as a line of high ground raised by a "folding" of the earth's surface), but in some folded areas a radial flight pattern may be recommended. Then, again, as happened recently in Northern Europe where the rugged nature of the terrain prevented sufficiently accurate height-holding, a further coverage down steep-sided valleys and along the edges of ravines can be flown at right-angles to the first one at a different altitude.

The electromagnetic detector weighs 1,127 lb and has three main components; an external primary coil, mounted between the trailing edge of the aircraft's wing and the tail, or extended by spreaders along the top of the fuselage; a secondary coil, carried in a streamlined "bird" and towed on 500ft of cable; and an internal electronic installation contained in a large console with a graphic recorder in its face. Into the primary coil is fed A.C. at two frequencies—2,300 and 400 cycles per second—and the aircraft thus becomes the centre of an alternating electromagnetic field, which can penetrate 300ft down into the ground under favourable conditions when the aircraft is at 500ft. If a conducting ore body—such as a copper, nickel or lead sulphide deposit—is beneath, it will have eddy currents induced in it and re-radiate a secondary field, which is detected by the towed secondary coil. The phase-shift between primary and secondary fields is measured and continuously recorded by a laterally-travelling pen on a moving belt of graph paper in the console before which the E.M. operator sits.

The reason for recording phase-shifts at two frequencies is that the response of various conductors varies with the frequency of the energizing field. The low frequency will penetrate more deeply than the high, and therefore the plot of the latter will show up surface conductors such as lakes, swamps and man-made structures as well as surface ore bodies. The low-frequency plot will also show these, but it will react more strongly to deeper—and potentially more valuable—areas of conductivity. It is therefore the simple ratio between H.F. and L.F. phase-shifts which will tend to indicate the best conducting ore deposits.

Flying Technique. There are interesting points about geophysical flying. It is essential that a reasonably constant proximity of equipment to ground surface be maintained, and 500ft ± 50ft is considered suitable for conductivity surveys. Over rolling country, this can mean a certain strain for the crew, though positive and negative g-loads are not serious and the pilot's chief preoccupation is not to let the towed "bird," which flies 250ft below and 200ft behind the aircraft, touch ground. (The "bird" is precisely positioned at a point within primary and re-radiated fields where electrical "noise" is at its lowest value.)

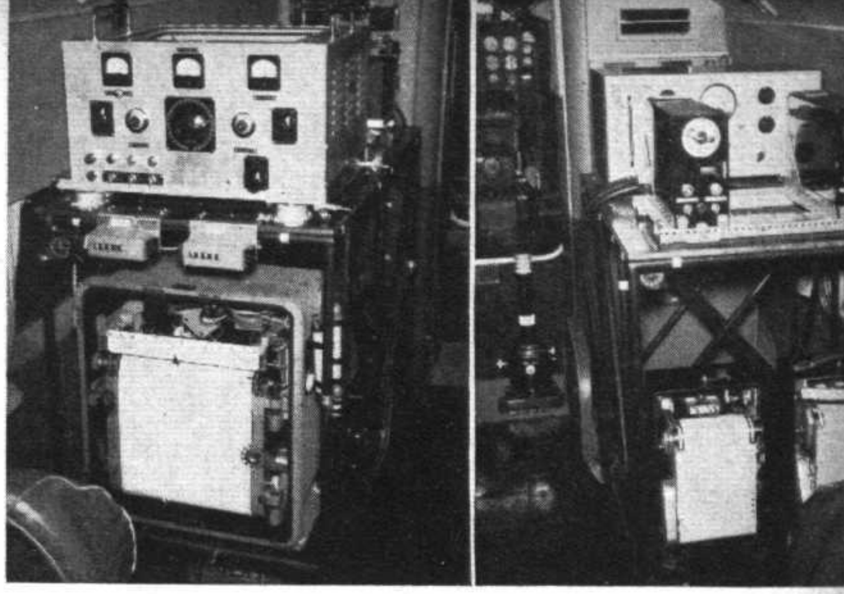
When coverage of the area begins, the navigator becomes the key crewman. He uses large scale 1 mile=$2\frac{1}{2}$in maps, or mosaics, upon which the flight pattern has been ruled, in alternating numbered red and blue lines to eliminate confusion. For complete E.M. coverage a line-spacing of $\frac{1}{8}$ mile or 220 yd is called for, and maximum permissible error is 70 yd to port or starboard of track. If this is exceeded the whole line must be reflown, and the problems involved can be appreciated when it is considered that over a three-mile traverse in hilly country abrupt wind-changes causing alterations in drift are frequently encountered. In order to deal with this, the flying and engineering members of the U.K. company quickly devised and installed a drift sight in their recently-equipped E.M. DC-3; mounted on the scuttle before the second pilot/navigator, it projects a point of light at infinity in the manner of a gyro gun-sight and computes drift alterations very rapidly.

Flying geophysical coverage can be likened to a protracted low-level bombing run lasting perhaps eight or nine hours; and a very high degree of skill is necessary to keep within height and track limits. The aircraft is literally "hopped" from one identifiable ground feature to the next, the navigator pointing out landmarks to the captain and drawing his attention to the next point on track. The exterior equipment reduces a DC-3's cruising speed by some 15 kt, and stick forces are slightly higher; booster pumps are switched on, mixture set in auto-rich and convenient engine settings for the low-level run in are 2,100 r.p.m./28in Hg. With one eye on the radio altimeter and both hands on the column, the pilot lifts the aircraft over rising ground with up to 35 or 36in boost, and throttles back slightly going downhill on the other side.

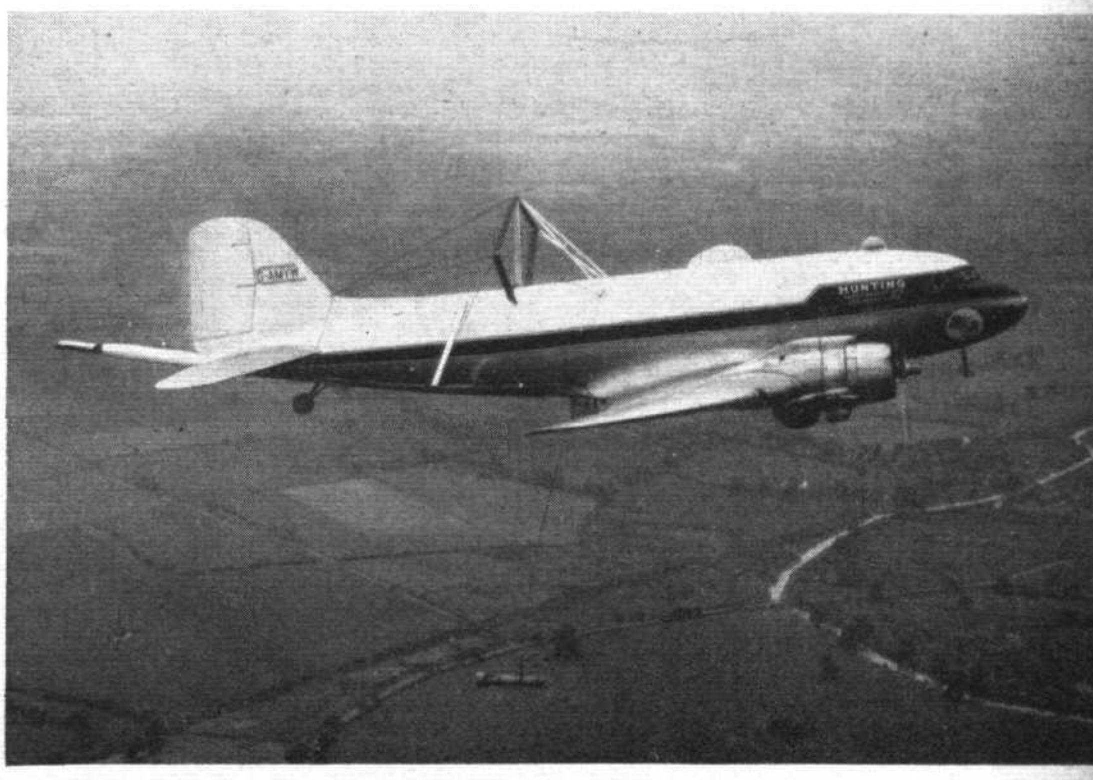
With every type of mineral survey flying it is essential to know exactly which ground-point gave rise to each geophysical measurement, and therefore a vertically-mounted 35 mm Vinten positioning camera is carried. This takes overlapping exposures of track made good, and after a specified number of frames exposed (usually ten) it emits an electrical pulse which makes a fiducial mark on the edge of the recorder graph paper. Radio-altimeter readings are also continuously recorded beside the E.M. high and low frequency phase-shift measurements, and so when the reduction stage is reached, proximity variations can be compensated for.

The E.M. equipment used by Group companies was developed by PSC Applied Research, Ltd., of Hunting Associates in Toronto, and in the Canso aircraft of Aeromagnetic Surveys, Ltd. (Hunting Associates' geophysical specialists), has uncovered ore deposits worth many millions of dollars in Canada alone. Under favourable conditions, 1,500 line miles a day have been flown by them (not taking transit or positioning turns into account), though five weeks is reckoned to be the usual period for a 10,000 line-mile survey—allowing for bad weather.

So successful were the tests of the recently introduced equipment in Hunting Geophysics' E.M. DC-3 over the southern half of the Isle of Man, during which all known ore bodies were pin-pointed and others hitherto unknown revealed, that a contract has been placed for the coverage of the remainder of the island. After this, the aircraft is scheduled to go abroad for an extensive period.



Two views of the E.M. "works" aboard a Survey Prince. At right, the recorders of the scintillation counter and radio altimeter; on the left, the magnetometer console.



The Hunting DC-3 equipped for mapping and survey work. On top of the fuselage are masts for E.M. equipment; protruding from the tail is the fixed detector head of a magnetometer on a 12ft boom; and trailing below the aircraft is the bomb-like sensing coil.