SOME DEVELOPMENTS OF THE DECCA NAVIGATOR SYSTEM

I.H.B. Note. — This paper appeared in the « Journal of the Institute of Navigation », London, Vol. IX, No. 4, October 1956, as a series of three articles entitled :

I) Decca for Helicopter Operations,
II) The Use of the Flight Log,
III) Dectra,

showing some of the latest developments in Decca. The first two articles concern more specially air navigation and cartography. The third deals with Dectra, the principles of which have been very briefly explained in I.H.B. Special Publication No. 39. Though primarily designed for air navigation, Dectra can also be used in maritime navigation. Extracts from this article giving useful details regarding this new system are therefore reproduced below.

III. — DECTRA

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I) INTRODUCTION. DECTRA.

The system is primarily designed for the navigation of fast jet aircraft across the North Atlantic, a problem intensified by air traffic control when more than 100 aircraft are in the air at the same time on those routes. It is, however, likely to prove valuable for other similar applications. The trials installation will cover the main route Prestwick-Gander.

2) THE DECTRA SYSTEM.

Dectra is a time-multiplex and frequency-multiplex c.w. phase comparison system with frequencies in the Decca band or in the 90-110 kc/s band allocated for long-range navigational use. There are reasons to prefer the former band, and the trials will employ standard Decca frequencies. To illustrate the principles of the system let us assume that a coverage is required over a central route of some 1500-2000 n.m. length with subsidiary routes disposed either side of it. Dectra employs a pair of stations (master and slave) some 80-100 miles apart astride one end of the central route, and transmitting a frequency F_1 almost continuously from the master station, but with, say, three short breaks per minute during which it closes down and the same transmissions, phase-locked to those of its master station, are taken up by the slave. At the other end of the central route is a similar pair of master and slave stations working on frequency F_2. Frequencies F_1 and F_2 are so chosen that each is an integral multiple of some common sub-harmonic f and $F_2 = nf$, $F_1 = (n + 1)f$. By reception of the continuous F_2 signals from the master station at one end of the route, the F_1 transmission from the master station at the other end is frequency controlled and a relatively stable phase relationship between the f sub-harmonics of the master signals transmitted from each end is established.

Left/right tracking information is obtained by phase comparison either of the F_1 signals emanating from one master/slave pair or the F_2 signals emanating from the other pair; the resulting tracking indication is constant along a hyperbolic line of position which has the two stations in use as foci.

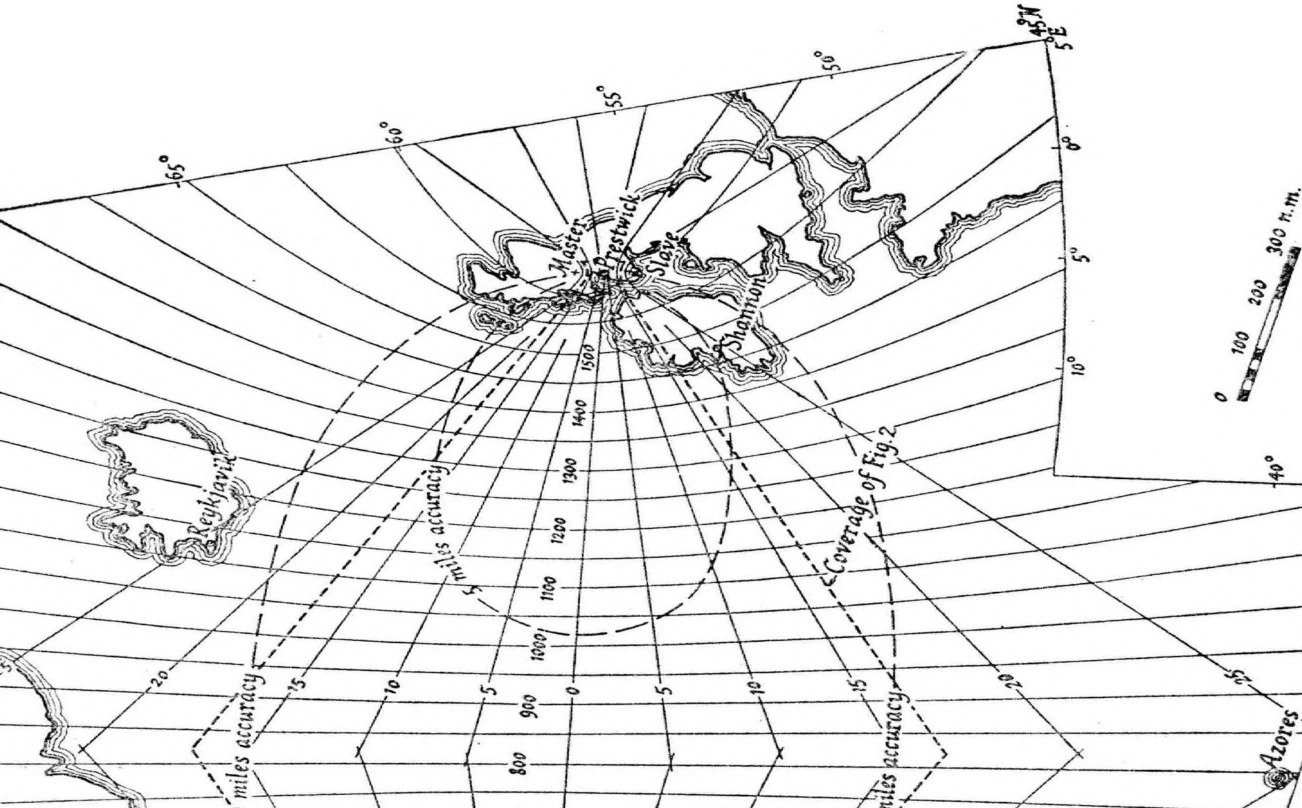
Ranging information to give distance travelled along the route is obtained primarily by reception of the two master signals on frequencies F_1 and F_2, and phase-comparing the f beat-note between them with the f sub-harmonic of one of them. This gives an indication of constant range along a hyperbola whose foci are the two master stations at either end or the route. Because at times reception of the distant master station may be poor and so reliable ranging information may not be obtained, a secondary ranging system is used. This employs a high-stability local crystal circuit in the aircraft; the crystal output on frequency $Nn(n+1)f$ can be divided down to produce a local time standard at either $nf = F_2$ or $(n+1)f = F_1$ for comparison with the strong received signal from the nearer master station, either F_2 or F_1. In this case, a constant range indication occurs along a circle centred on the master station. This so-called single-signal ranging is only required as a stand-by to the standard two-signal ranging system. The airborne display will be by means of the Decca flight log.

3) THE ATLANTIC ROUTE.

The requirements of transmission from the master and slave of a Dectra pair are fulfilled by the transmissions from the purple slave and master station respectively of a Decca chain on the purple (70 kc/s band) frequency. This particular frequency band is propagationally suitable for long-range coverage and Dectra transmissions can be provided by increasing the power radiated from such stations. Owing to the installation of the North Scottish Decca chain, it will be necessary to re-site one slave of the North British Decca Chain to give improved cover off the east coast. This involves swinging the present slave at Newcastle to a site near Sterling and in this new position it will be made into a purple slave station of that chain. It and the master station at Kidsdale will then establish a hyperbolic pattern whose median hyperbola coincides with a great circle joining a point some seven miles south of Prestwick Airport to a point the same distance south of Gander Airport in Newfoundland. The transmissions from these two stations on $F_1 = 70.5375$ kc/s (Decca Group 3) will provide the U.K. Dectra transmissions with radiated powers of 5 Kw. from Stirling and 2 Kw. from Kidsdale as Dectra master and slave respectively.

Suitable sites have been found at Comfort Cove (Dectra master) on the North Coast of Newfoundland and Thorburn Lake (Dectra slave) 5 miles south of Port Blandford to erect a similar pair of stations working on Decca frequency Group 2, purple F_2 = 70.384 kc/s. The two transmitted frequencies are the 460th and 459th harmonics of an f frequency of 153.342 c/s. Similar powers will be transmitted from the Newfoundland pair. Frequency control of the U.K. Dectra master will be achieved by reception of the Comfort Cove signal at Kidsdale and regulating the frequency of the master station crystal of the North British chain there.

The Dectra transmissions will, therefore, establish a tracking pattern of hyperbolic lines radiating from the base lines on each side of the Atlantic, with a ranging pattern crossing them (Fig. 1). Though primarily designed for the particular needs of jet aircraft across the central Gander-Prestwick route, the Dectra patterns will give similar navigational information from Iceland to the Azores.



Dectra pattern over the North Atlant

The accuracy of fix predicted is shown in the 5-mile and 10-mile contours on the diagrams. The flight log charts will cover the area between the pecked lines.

The problem of air traffic control on transatlantic crossings resolves itself into the lateral separation of aircraft on clearly defined tracks at a desired minimum separation of 2 miles in the terminal areas, where the aircraft converge into ground control. Dectra provides quasi-parallel position lines of high stability separated by a lane of about 1 1/4 miles on the base line. It is proposed that eastbound aircraft should fly on tracks south of the Dectra centre line, while westbound ones fly on tracks to the north; this arrangement allows some scope for pressure-pattern considerations though air traffic control requirements are liable to rule out true pressure-pattern flying. The allocated tracks will be spaced at 1 1/4 Dectra lanes apart, representing a distance between adjacent tracks in the same direction of some 30 miles in the centre of the Atlantic converging to the desired minimum of 2 miles at some 60 miles' range from the terminal aerodrome.

The presentation to the pilot in the aircraft will be by means of the familiar flight log; the complete roll of charts wound on rollers in the cassette will be about 16 ft. long by 10 in. wide, though only some 10 in. width by 4 in. length will be exposed at any time. The pen of the flight log will move across the paper for track while the ranging information will control the pull of the paper past it. From the position of the pen on the chart the pilot will be able to read his distances from Prestwick and Gander, the magnetic course to fly to maintain track and, by interpolation between tracks on the chart, his deviation from his allocated track if any. This is the primary information provided by the Dectra system, but one advantage of the pictorial display is that so much information can be given at the same time.

Fig. 2 shows a general flight log chart of the whole of the Atlantic (hence to a very small scale) which appears on the pilot's roll, and relates to the contingency of diversions. From the position of the aircraft shown on the en-route chart, the pilot will be able to take off immediately the compass course to steer and distance to go to a diversion aerodrome in, say, Reykjavik, Shannon, Azores or Goose Bay. This information will be printed in a distinctive colour on the back of his en-route chart and only revealed when required by switching on the back lighting of the chart. Having established his necessary diversion course the pilot can then transfer his pen position to the small-scale diversion chart and the pen will follow his progress to his diversion aerodrome.

Up to about 100 miles from Gander, let us say, the pilot has been maintaining his pen on the route assigned to him on his flight-log en-route chart. If he is on track 5 westbound, at about this range, he will be funnelled into Gander airport by air traffic control and his flight-log pen will leave the constant-track line as he leaves the hyperbolic position line. Nevertheless, the exact approach route assigned to him can be displayed on the Dectra approach chart for Gander, which will be on his roll (Fig. 3); obeying the ground instructions he can still follow his progress by transferring his position from the en-route chart to this approach chart, and watching his pen along the final stages of his voyage to Gander. At the U.K. end the pilot approaching Prestwick will be in a more fortunate situation since in transferring to the approach chart for Prestwick, he also transfers to a more accurate navigational system for his final approach. Until within some 100 miles or so of Prestwick he will have been flying a track represented by a hyperbola established

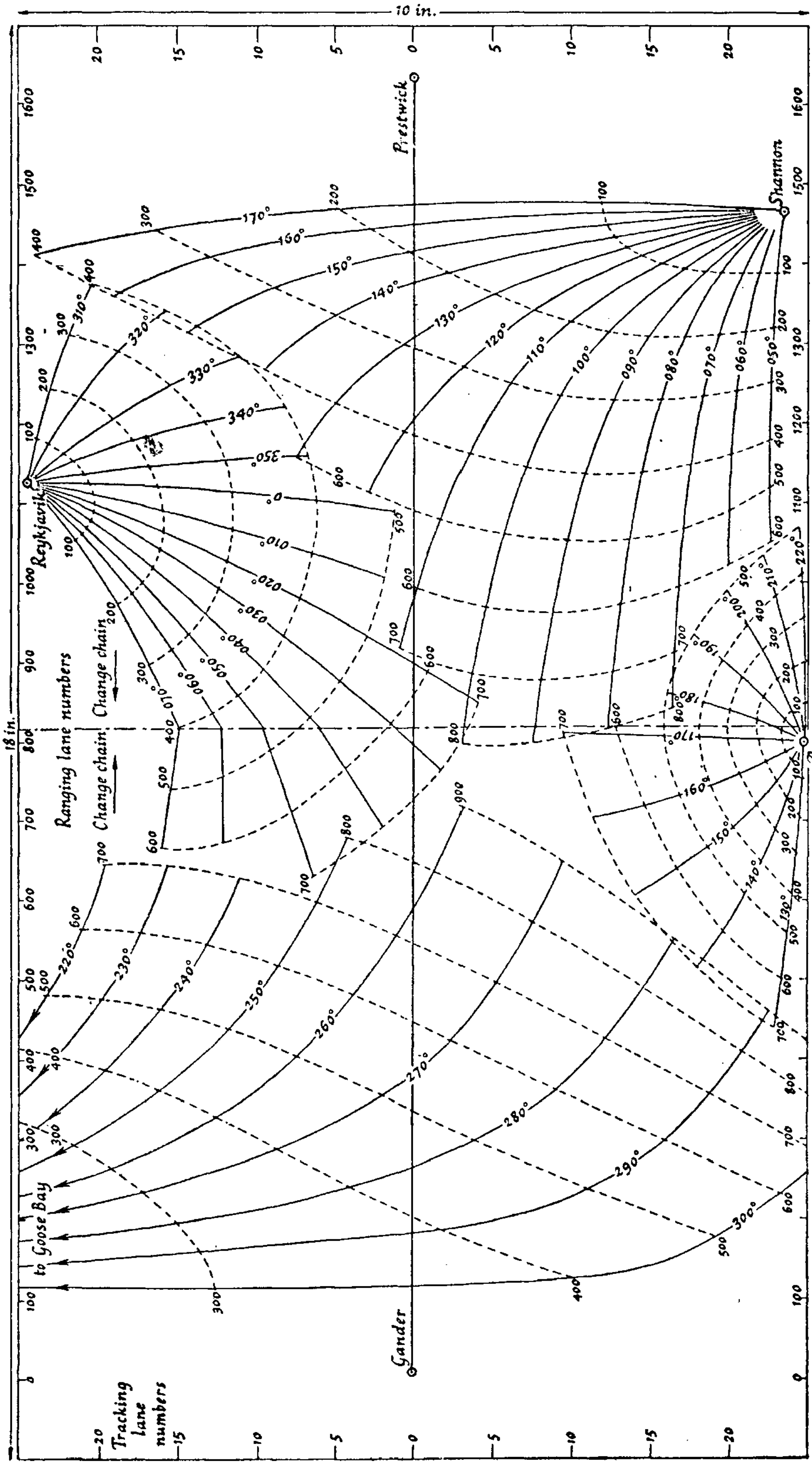


Fig. 2.
Diversion flight-log chart.

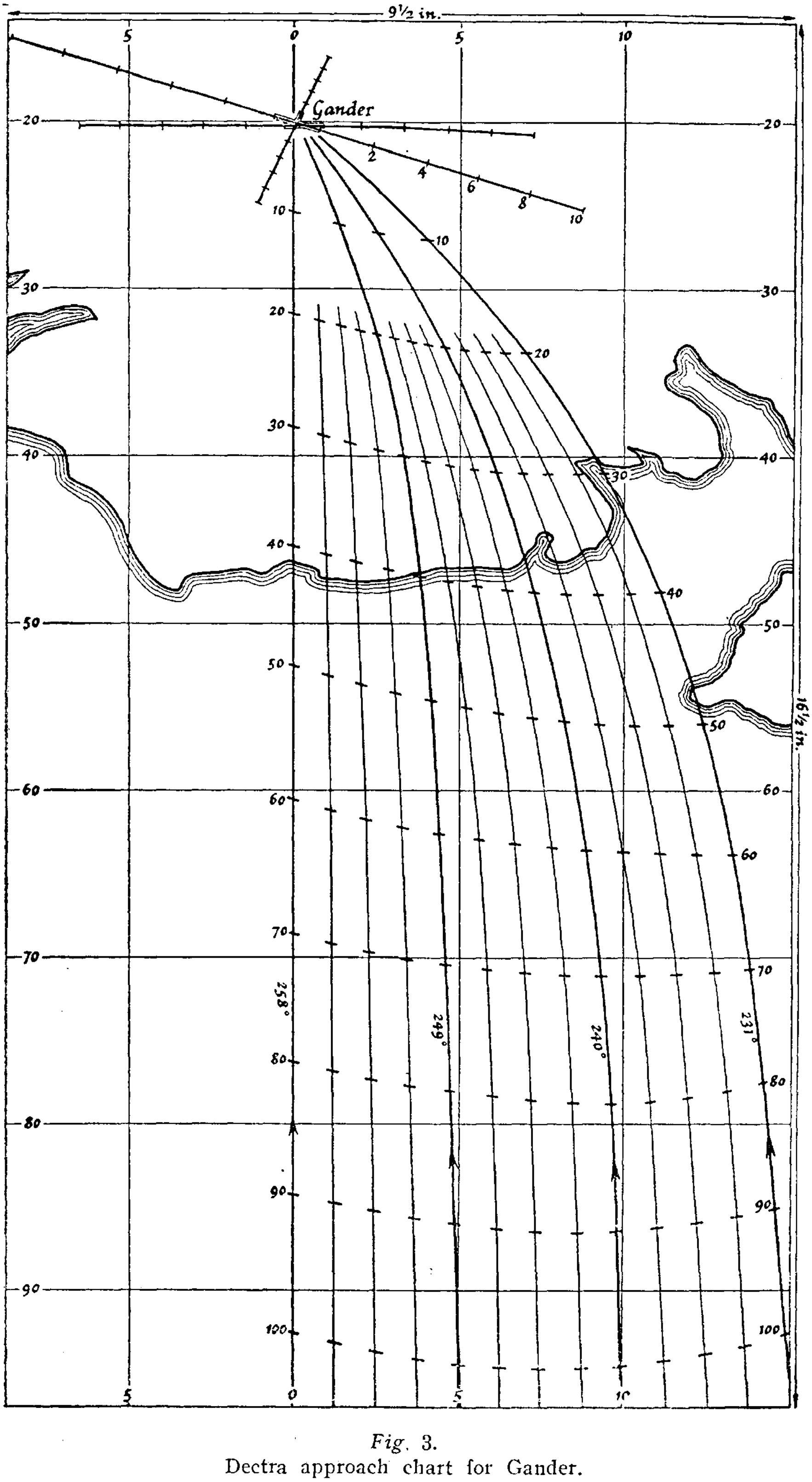


Fig. 3.
Dectra approach chart for Gander.

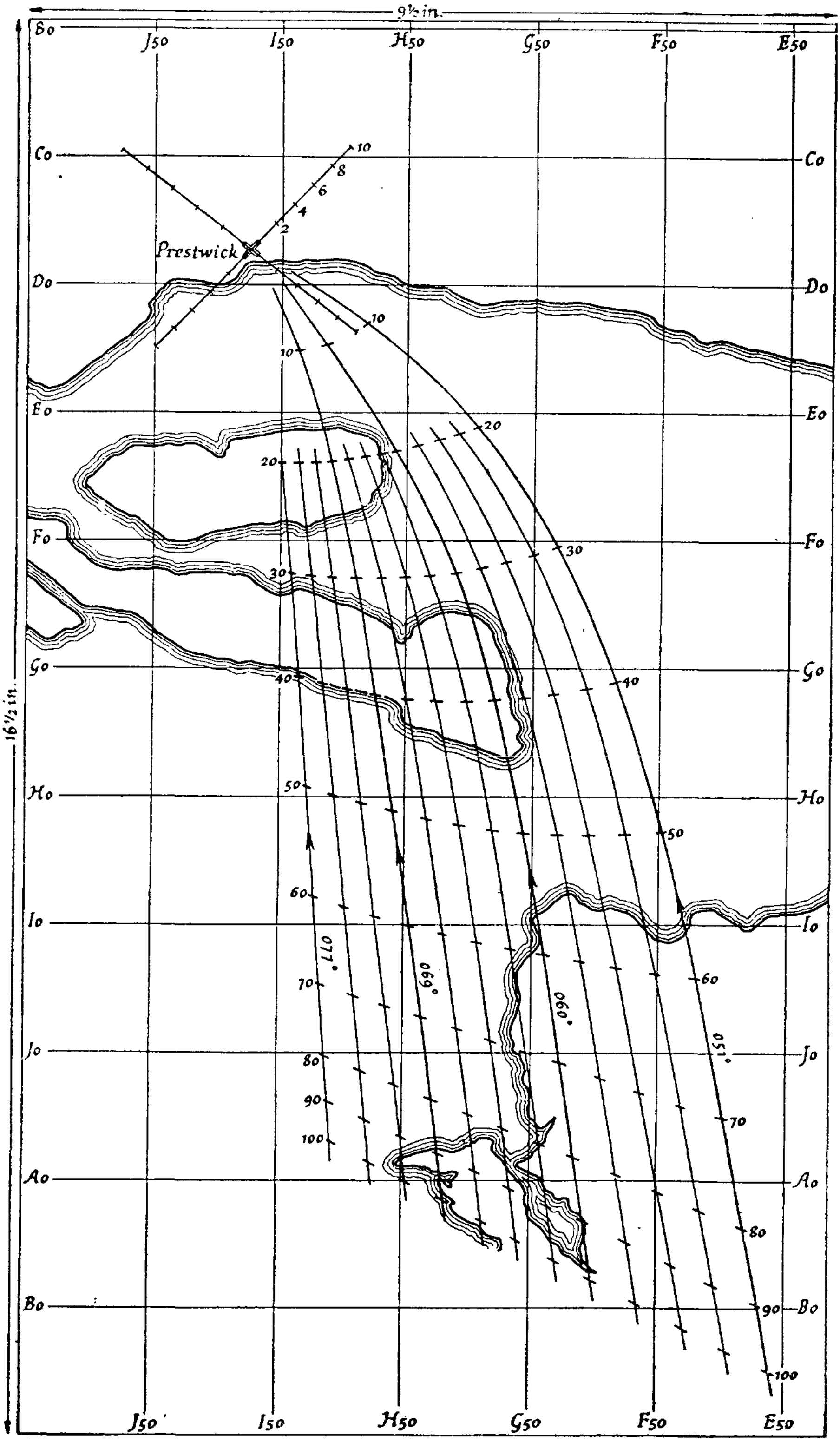


Fig. 4.
Flight log approach chart (Chain 3).

between the master and slave stations of the North British Decca chain, these being the Dectra slave and master respectively. He has therefore been flying a purple *Decca* lane. On his flight-log approach chart the red and purple patterns of the standard Decca chain are superimposed and the pilot can identify his position in the Decca patterns. By throwing a switch the flight log becomes operative on normal Decca to control his final approaches shown here (Fig. 4).

The integration of Decca and Dectra for terminal area navigation and Atlantic crossing respectively is therefore complete; and the Mark 10 Decca receiver with the addition of a ranging unit forms the Dectra airborne equipment.

Fortunately the Comfort Cove and Thorburn Lake sites in Newfoundland are in ideal positions to form the pair of a Decca chain covering eastern Newfoundland; it is therefore a simple matter technically to integrate Decca with Dectra there by the addition of red and green Decca slave stations.