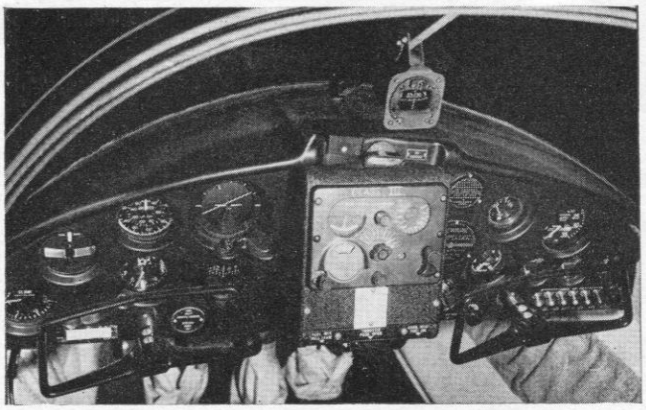
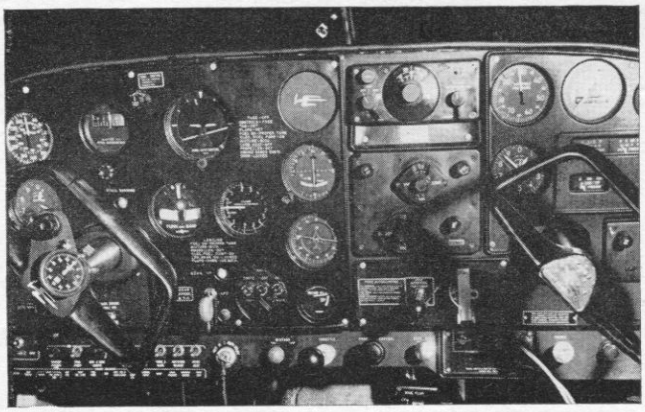




LEFT: *This Aircoupe has the simplest kind of VOR. Either R/T or VOR can be tuned, but not both together.* RIGHT: *Full flight panel on a Comanche—360-channel VHF, 190-channel standby VHF, VOR with ILS localiser, ADF and Markers*

NAVIGATION — 3

Radio Navaids

by Richard Serjeant

THE EASIEST WAY to understand how radio aids work is to imagine flying on a dark night over completely featureless country. A long way off, but just visible, is a tower with a powerful light on the top. To get to our destination we simply fly towards the light. Now if there is a radio transmitter instead of the light, and we have a device in our aircraft that will point towards it, we shall be able to fly to our destination even if we cannot see it, and this is the principle of Automatic Direction Finding (ADF), usually known as the Radio-compass.

A beacon transmits a continuous signal in all directions equally (Non-Directional Beacon, NDB), on a definite fixed frequency. It also transmits its particular call-sign, or "Ident", in slow Morse: for instance "EPM" for Epsom, and "IOM" for the Isle of Man. The aircraft is equipped with a means of tuning these various beacons in such a way that the pilot can hear the identification signal of the beacon, and at the same time a needle swings round and indicates its direction, as compared with the heading of the aircraft. For instance, if the needle points 45 deg. to the right, as in Fig. 1, we shall turn our aircraft to the right through 45 deg. and then it will be pointing exactly at the beacon (Fig. 2).

FIG. 1—*How the radio-compass appears when the ADF beacon is 45 degrees to the right of the line of flight*

FIG. 2—*The ADF beacon is now straight ahead*

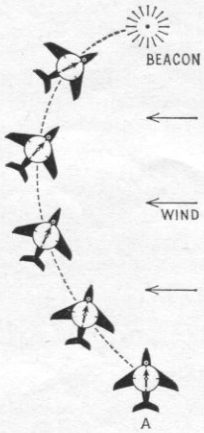


FIG. 3—*Uncorrected ADF drift*

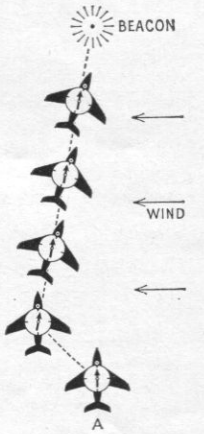


FIG. 4 — *Corrected ADF drift*

It might be thought that so long as we keep the needle at zero (as in Fig. 2) we must be flying in a straight line towards the beacon, but in fact this will only be true if there is no wind tending to blow us off our course. A glance at Fig. 3 will show that a wind from one side will lead to a curved course with the radiocompass needle at zero all the time—and the stronger the wind the more curved the course will be. To fly a straight course we have to assess the drift and then allow for it, keeping the needle a few degrees the opposite side of zero (Fig. 4).

VOR

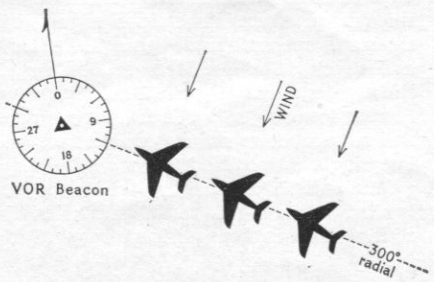
Although ADF gives a continuous indication of the beacon's direction it gives no positive indication of a straight line approach path, and the receiver can be quite difficult to tune owing to interference from static and from other signals. It was mainly to overcome these difficulties that VOR (Very high frequency Omnidirectional Range) was introduced.

The VOR beacon radiates (in effect) 360 beams or "radials", any one of which can be identified by the aircraft's receiver and followed. The set is easily tuned to a particular beacon and the Morse signal identified. The dial has a needle which becomes centralised when the aircraft is on the indicated radial, and there is a movable scale of degrees to select radials.

For example, let us suppose that we are approaching Biggin Hill from the North. We tune our VOR receiver to 115·0 and hear the call-sign "BIG" in Morse. We then turn the knob in the lower left-hand corner of the VOR dial until the needle swings into the centre, and we can then see (Fig. 5) that in order to reach Biggin Hill we must fly on a heading of 180 deg. If now we stray to the right of this line the needle will move to the left, and *vice versa*. In other words, to follow a radial we follow the needle, and so long as the needle stays in the middle we shall be exactly on the the radial, irrespective of the wind. Fig. 6 shows an aircraft flying along the 300 radial to a VOR beacon; you will see that a wind is blowing from the right, so in order to keep that needle centred we have to turn

FIG. 5—*VOR dial and radial selector*

FIG. 6 (BELOW)—*Flying on a VOR radial*



the aircraft's nose a little into wind, and perhaps fly on a compass heading of 310 deg. The VOR operates in the Very High Frequency band; this means that it is comparatively free from interference, but as the signals do not follow the curvature of the earth like ADF they are effective only at rather short distances when the aircraft is at low altitudes.

It will be seen that these devices greatly simplify navigation, provided that the pilot knows how to use them and that he has suitable charts showing exactly where the beacons are and giving other information about them. A radio-aid map bears very little resemblance to an ordinary flying map, as can be seen from Fig. 7, which is a small section of the Jeppesen Airways Manual, showing the NDB at Liverpool, giving its *frequency* (349·5 kc./sec.) and its "ident" ("OE", with the Morse signal as well). There is another NDB at Wallasey (331·5, "WAL"), but Wallasey also has a VOR, shown by the bigger graduated circle; it has the same "ident" ("WAL"), but a frequency of 114·3 Mc./sec.

There is quite a lot more information on this little section of map. For instance look at the heavy line connecting Liverpool and Wallasey. The "11" in the middle tells us that the distance between the two points is eleven nautical miles; the other figures on this line are the magnetic headings both ways, correct at the time this particular revision was issued. Many other standard routes are also shown, and it can be seen that Liverpool itself has a Homer service operating on 119·85 Mc./sec.

Using these "navaids" it is also possible to get cross bearings from other beacons, and so determine one's actual distance from the destination at any particular time. If there is only one navaid this means some rather fiddly re-tuning, but in fact many of the more sophisticated modern light aircraft have ADF and *two* VOR receivers.

An extension of the VOR system, usually only found on light aircraft fitted for airways flying, comes into operation at one's destination and is designed for precision approaches to land. This is known as the Instrument Landing System (ILS), and provides radio beams exactly in line with the runway in use, so that the pilot can fly down the beams to within a few feet of the runway itself.

The complete ILS has two beams: the

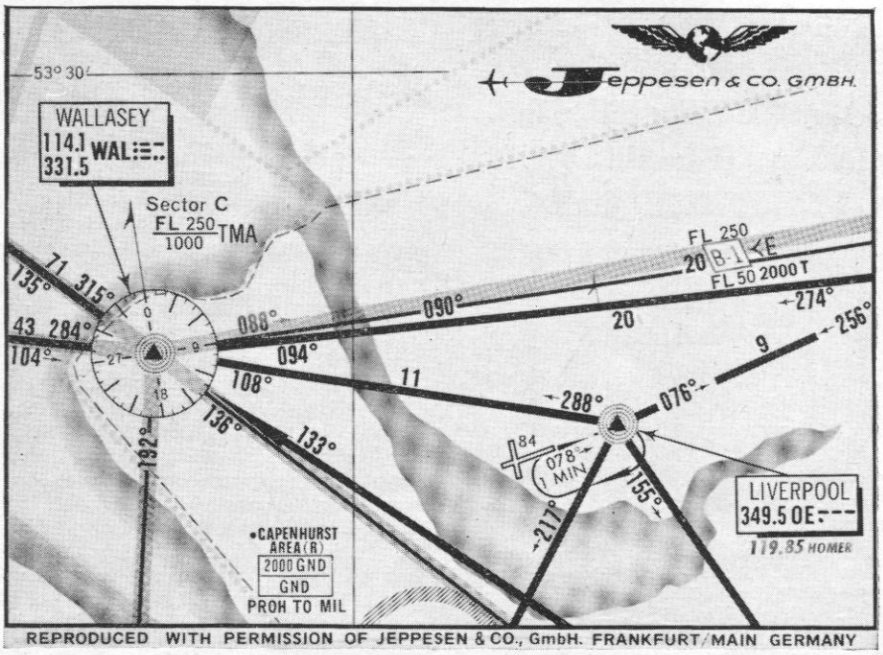


FIG. 7—*Section of radio-aid map covering the Wirral peninsula and Liverpool*

Localiser works on the ordinary vertical VOR needle and shows the pilot whether he is to the right or left of the runway centre-line; and the *Glide-path* operating a horizontal needle which tells him whether he is above or below the correct line of descent. Most ordinary VOR receivers can be tuned to the ILS Localiser beam; the rate of descent then has to be decided by the pilot in the ordinary way, which is not usually very difficult, or sometimes it may be advised from the ground by radar information.

Marker beacons

Really full equipment will include *Marker Beacon* receivers. Fan Markers give *en route* fixes, as the aircraft passes over them, in the form of a series of Morse signals. On the final approach to land similar Morse signals, usually with a display of little flashing coloured lights, indicate the *Outer Marker* and the *Middle Marker*, at fixed distances from the runway, and sometimes an *Inner Marker* at the runway threshold. Each airfield will have definite heights to be observed at these points, based on the shape of the local countryside and on various obstructions, and the details of these can be seen in constantly revised publications like *Jeppesen's Guides*.

This brief outline of radio aids for light aircraft would not be complete without mentioning two others. DME (Distance Measuring Equipment) gives an immediate visual indication of one's true distance from the beacon. Now common on light aircraft in the U.S.A., it is only just beginning here, but will probably be standard in a few years' time. For aircraft flying standard routes it would be hard to beat *Decca*, which actually draws a line on a map to show the pilot exactly where he is within a given area. The equipment can be hired for about £600 a year.

In the next article of this series I shall take you on a short flight in a modern fully equipped light aircraft, and this will demonstrate many of the devices I have mentioned.

Acknowledgment: Figs. 1–6 are reproduced from the author's book *Private Flying for Leisure and Business* by permission of the publishers, Nicholas Kaye Ltd.

Icelandair's new Friendship, the first of two, in temporary Dutch marks (RIGHT), *PH-FGR; and with its permanent registration, TF-FIJ (Photo: G. Ballantyne)*