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# Radar

## Partial Release of Some Systems Used by R.A.F. in Defeating the Enemy by Defence, and Fighter and Bombing Attacks

**C**O-ORDINATION of Anglo-American censorship seems to be at an unfortunately low level in comparison with the co-operation existing in other spheres of activity. We state this in view of the release in America of information on Britain's Radar resources whilst the subject is still shrouded in official secrecy in this country. However, as the disclosure was made available to all the world, we, too, publish the information while awaiting the official release.

Radar is a generic term covering all forms of radio-electronic identification and orientation systems. Of these there are a considerable number, many of which are still undisclosable although the basic principle of operation is common to all, and the description of how one device or system operates can be taken as a basis for all others. Briefly, radar can be said to be the application of basic radio principles to the general problems of determining distance in three dimensions of an object which will reflect radio frequency energy relative to an exploring station. The fundamental principles involved are the constant known speed of radio wave propagation and the reflective or echo principle which is a major characteristic of the ultra-high frequencies.

### Two Systems

Without going too deeply into the individual systems, there are two major methods of radar detection which have been employed, either separately or in conjunction with each other. First is the system based on Doppler effect whereby exploring radio frequency energy, continuously transmitted, impinges on the target object whence part of the energy is reflected and its apparent frequency changed. The receiving equipment of

the exploring station measures the difference in frequency between the transmitted and reflected waves in order to determine the speed of the object. Owing to the small changes in frequency, this method is most useful where fast moving target objects are involved.

The second system is based on pulse modulation of the exploring wave emanations, and the determination of the reflected impulses against a time scale. Radio frequency energy is modulated for pulsation intervals of from 1 to 50 microseconds ( $\mu$  sec.) and the pulse ends before the reflected energy returns to the receiver, so that an indicating time scale set against the "blips" shown on the cathode-ray tube screen will determine the distance of the object.

### Time Datum

A fundamental quality in radar is the ability to convert time interval into distance due to the fact that radio energy radiated into space travels at a constant velocity, and that on striking an object is re-radiated in part with no loss of time. The velocity is that of light, which is 186,000 miles/sec., or 327 yards/microsecond. Referring to Fig. 1, if a 1  $\mu$ .sec. pulse is transmitted, the time taken for the pulsation to reach the objective 32,700 yards away would be 100  $\mu$ .sec., and as the reflection will require the same time to get back to the receiver the total time from transmission to reception will be 200  $\mu$ .sec. Since the indicator registers total elapsed time it is usual to calibrate distances (transmitter to

object) as 164 yds./ $\mu$ .sec between the initial and reflected pulsations.

In Fig. 2 is shown a diagrammatic illustration of the cathode-ray screen, across which the exploring wave and reflective pulsations sweep, and upon which the time and distance scales are graduated electronically. Initial and any reflected signals will appear on the screen as vertical "spikes." We will assume that the linear sweep of the wave pulse is 1 centimetre per 100  $\mu$ .sec., and that a pulse of 1  $\mu$ .sec. duration is being transmitted. This pulse will be 0.01 cm. wide on the screen, and during this time the exploring wave will have travelled 327 yards from the transmitter. Assuming that the target object is 32,700

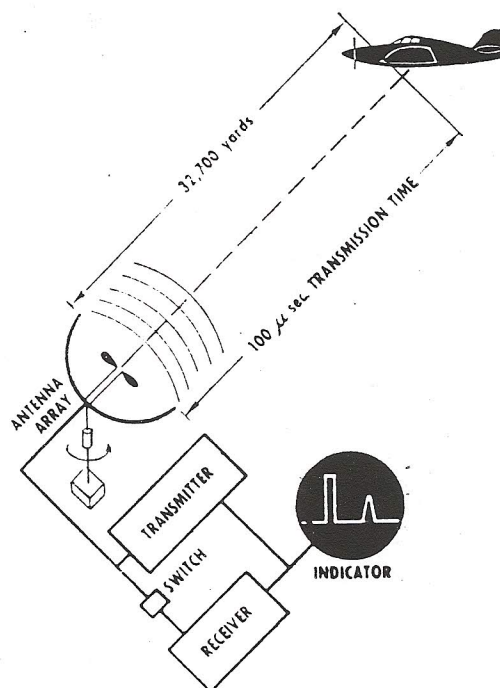


Fig. 1. Diagram of basic radar system showing direction "sighting" and transmission-reception time for range.

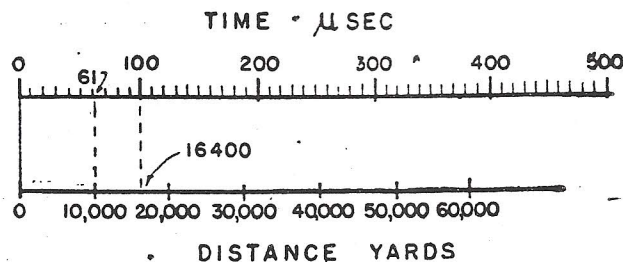
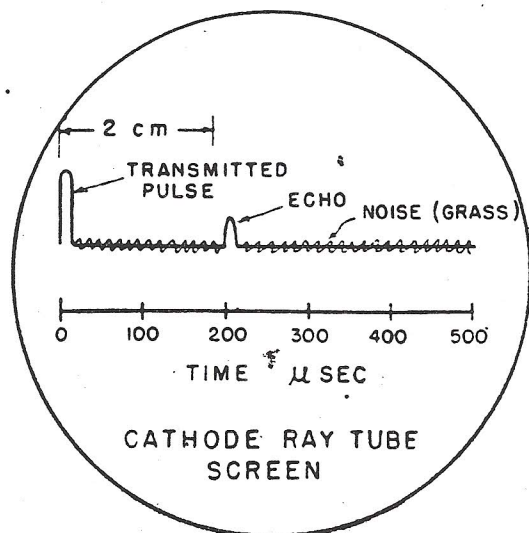


Fig. 2. Initial and reflection "spikes" shown on the C.R. screen can be read against a time-distance scale for determining range. The diagrams are reproduced from Electronic Industries, N.Y.



## RADAR

yards distant, the pulse will arrive at the target in the time that the wave sweep across the screen moves 1 centimetre; further, the waves will move an additional 1 cm. before the reflected signal is received back, so that the interval between the initial and reflected "spikes" appearing will be 2 cm., corresponding to 200  $\mu$ .sec., and this interval read against the time-distance scales will show the object's distance from the exploring station to be 32,700 yards.

Orientation in elevation and azimuth, or altitude and bearing, is a simple extension of "tuning." The exploring wave emanates from a transmitter capable of being "sighted" until the maximum receiving strength is attained. Once this is determined the bearing in azimuth can be read relatively to true north or any other convenient datum similarly to a sighting compass. Again, when the transmitter is elevated to obtain maximum reflective reception, the angle of elevation  $\theta$  can be resolved in conjunction with the known range of the object to give altitude by the simple equation: altitude = range  $\times$  sine  $\theta$ . A further method of determining orientation of the target makes use of a graticule on the cathode-ray screen (Fig. 3) upon which intersections of co-ordinate wave pulsation produce bright spots whose position is then read off against range and azimuth scales.

### In Operation

So far we have said nothing about the romance of the use of radar nor of the "blood and sweat" efforts made to get it in operation in time for our meeting the enemy's attacks. Nevertheless, this story is a great and magnificent epic of British technical achievement and the foundation of our air power operations in, literally, all its forms. Without radar the Battle of Britain might never have had the chance to be fought; the bombing of Germany never accomplished; the sinking of U-boats by aircraft never achieved. Truthfully and without "window dressing" radar can be said to be one of the greatest scientific achievements of all time.

For the instigation and development of radar, and for the courageous conviction of its use, this country's indebtedness must primarily go to two men—Sir Robert Watson-Watt and Air Chief Marshal Lord Dowding. To the former is due the respect for secretly and quietly working for many years to overcome the enormous problems involved in perfecting the system after having conceived it. To the latter is due the homage for having dared to stake his country's existence on a revolutionary concept of warfare. These men should never be forgotten.

Primarily, our use of fighter aircraft for defence was dependent upon their control by G.C.I. stations (Ground Control of Interception), where the relative positions of our own and enemy aircraft was registered by radar. Knowing the positions by the indications on the screens, the controllers could direct our fighters by radio telephony to exploit any advantage of position, or to make the most

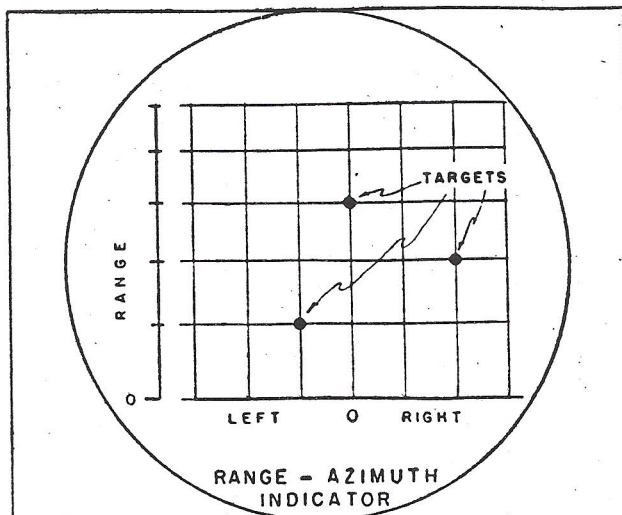


Fig. 3. Screen graticule on which target indications appear giving their position as co-ordinates of bearing and range.

rapid interception. In this manner a second-by-second portrayal of manoeuvres was registered at the G.C.I. stations, and although the attacking aircraft might change course, the fighters could be re-directed accordingly absolutely immediately. The Few could not have prevailed without this operational government.

Later on came airborne interception equipment (A.I.), which comprised a radar set in the aircraft by means of which the target objective could be registered, stalked and attacked. A.I. sets were the reason why our night fighters scored such overwhelming victories against the *Luftwaffe* night raids and resulted in their being discontinued.

These are but two applications of radar. There are the devices by which aircraft identification could be made friend from foe; there are also the P.P.I. (plan position indicator) sets by means of which bombing or navigation through cloud and at night can be achieved with a precision far in excess of that possible with direct visual methods even under optimum conditions. Again, there is the equipment whereby our aircraft have been able virtually to scour the enemy ships and U-boats from the seas.

In reflecting over this wonderful story one should not pass over the radio manufacturing concern of Pye, Ltd., to which very great credit should go for the development and manufacture of the G.C.I., the A.I., and the P.P.I., in conjunction with the Government research establishment at Bawdsey under the control of Sir Robert Watson-Watt, and in conjunction with Professor J. D. Cockcroft, of St. John's College, Cambridge. However, in paying this tribute it must be pointed out that whilst Pye, Ltd., developed the G.C.I. and A.I. equipment, the leading British television manufacturers were also engaged in the development of radiolocation devices of which there are some hundreds of types.

## NEW AIRCRAFT TYPES

THE Air Ministry has released data of several aircraft types, one a new machine which had hitherto been secret, and the others new versions of existing types.

The Westland Welkin is a high-altitude single-seater fighter with two Rolls-Royce Merlin engines. On the starboard side there can be a 72 or a 76, and on the port side a 73 or a 77. The port engine in either case drives the cabin supercharger. Armament is four 20 mm. cannon in the nose, and the loaded weight is 17,500 lb. Maximum speed about 385 m.p.h., and maximum range about 1,500 miles. The wing span is somewhat impressive for a single-seat fighter, viz., 70ft. This, of course, is due to the great operational height. The wing area is 460 sq. ft. The pilot is accommodated in a pressure cabin. Only a small number were built, and the machine did not go into combat service.

It is disclosed that the Short Sunderland Mark V has four

Pratt and Whitney engines of the R-1830 type. Max. bomb load 2,000 lb. The machine carries depth charges, and the armament comprises one 0.303 Vickers gun in the nose turret, four 0.303 Brownings in the tail turret, and two 0.303 Brownings in the mid upper turret.

The Handley Page Halifax VI has four Bristol Hercules engines of 1,800 h.p. each. Its maximum bomb load is 13,000 lb. At a gross weight of 68,000 lb. the maximum speed is 312 m.p.h. and the range over 2,000 miles.

The Vickers-Armstrongs-Warwick V is a general reconnaissance bomber. The interesting point is that it has two Bristol Centaurus VII engines of more than 2,500 h.p. each. The maximum bomb load is 6,000 lb., and the machine can carry mines or depth charges. The gross weight is 45,000 lb., and the maximum speed 295 m.p.h. This type is in service with Coastal Command in South-East Asia.



*See*

## BRITAIN'S AIRCRAFT EXHIBITION

*at the John Lewis Ltd. Bombed-out Site  
Oxford Street London W.1.  
(from June 21st, onwards)*



This is the most interesting exhibition staged in London for many years. An outstanding exhibit is the sectioned working "Bristol" CENTAURUS sleeve-valve engine on public show for the first time. Other exhibits include the famous "Bristol" Beaufighter; the Halifax III and the Walrus—both powered by "Bristol" engines; and a Wellington wing with a "Bristol" Hercules engine fitted. Models of projected "Bristol" civil aircraft are also features of interest.

*Famous aircraft and engines*

**Bristol**

*... for civil air transport*