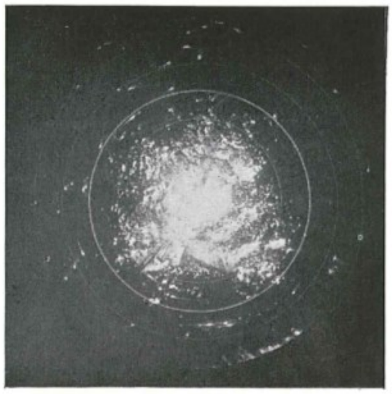
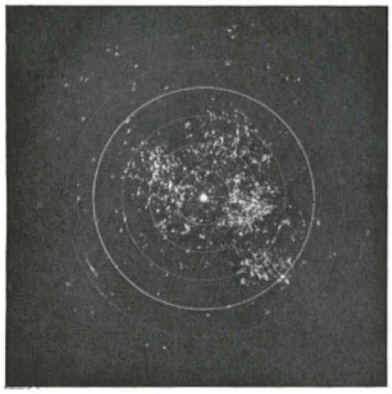
Raw radar signal processing facilities

CLARITY and absence of ambiguity, essentials in a modern radar display, are achieved by subjecting the received radar echoes to one or a number of highly developed video processing procedures. These eliminate unwanted returns and interference from the display picture.

The following facilities can be supplied with Marconi radar systems.



Raw radar.



MTI cancellation.

Display photographs (23 cm-band radar) illustrating the effectiveness of the MTI system for permanent echo cancellation.

Moving Target Indication (MTI)

A fully crystal-controlled MTI system is incorporated in Marconi 50 cm radars. MTI can also be supplied with 23 cm radars. The system is an especially efficient version of the 'coho-stalo' technique, employing triple pulse cancellation.

A coherent IF reference oscillator (or 'coho') is phase-locked to the transmitted pulse and stabilized in frequency by a servo-controlled crystal local oscillator (or 'stalo') which also supplies the mixer of the receiver. The phase relationship of successive echo pulses to the reference oscillator is the basis of the system. In the case of stationary objects this phase relationship is unchanged from one echo-pulse to the next. For moving targets there is a change in phase between successive echo pulses, due to the change of range in terms of wavelength.

The echo pulses are fed, together with the coho signal, to a phase detector which produces pulses proportional to the phase difference. These pass to a cancellation unit in which one train of pulses is delayed and subtracted from the succeeding train.

Echoes from stationary objects, having suffered no change in phase, are cancelled and only those from moving targets remain. The feature of the Marconi system is that the cancellation procedure is repeated a second time (using a carrier of a different frequency and utilizing the same delay cell). This provides a 6 dB improvement in cancellation ratio upon the single-cancellation system.

After the cancellation the signals are detected and the video passed to the displays. A gating system can be included for switching MTI in and out over selected ranges, a 'clutter gating' system can also be incorporated whereby the clutter itself switches the system over to MTI signals, switching back to uncancelled signals in areas where there is no clutter.

The MTI equipment consists of 3 or 4 standard rack-cabinets occupying a minimum of floor area. One cabinet will normally be sited with the transmitter/receiver and the remainder with the display equipment at the remote operating position.

PRF stagger and PRF discrimination

Conventional phase-comparison MTI systems of both the coho-stalo and fully coherent varieties, although capable of removing fixed target clutter very effectively, suffer from a defect known as 'blind speeds'. This occurs when the radial velocity of the aircraft target causes it to move an exact even number of half wavelengths in distance in the time between successive transmitter pulses. Under such conditions the received signal maintains a constant phase relationship to the MTI reference signal and is therefore removed by the cancellation system as though it were a fixed target.

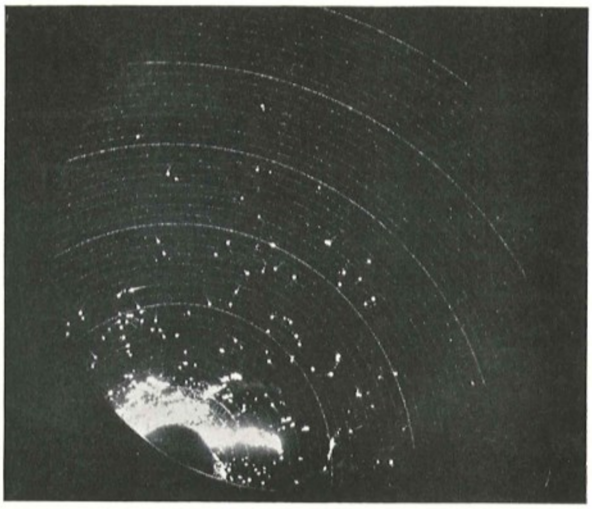
Such blind speeds will occur at regular intervals along a velocity curve and, due to the threshold sensitivity of the radar receiver, will be in the form of blind velocity gaps, each a few knots in width.

The blind speeds are dependent upon the transmitted wavelength and the pulse recurrence frequency. The longer the wavelength and the higher the PRF, the fewer and further apart will the blind speeds be.

Marconi 50 cm radars have been designed specifically for air traffic control and continuity of tracking is important, particularly in terminal areas. The use of such a long wavelength, plus the comparatively high pulse recurrence frequency employed with low-power Radars S 232 and S 264, has meant in the past that blind speeds were not normally met. However, the increased output power and operational range capability of the Radar S 264A series has led to the use of a lower PRF and this, coupled with the higher climb-out speed of modern aircraft, has increased the possibility of experiencing blind speeds.

In cases where these are likely to be troublesome an additional PRF unit may be added to the Radar S 264A series to raise the first blind speed above any likely to be experienced within the range of the MTI gate.

Blind speeds are avoided by the use of a PRF stagger technique where the transmitter firing time jumps between two different PRF values on successive pulse periods. Two different series of blind speeds therefore exist but as these occur on alternative traces and an aircraft can only be in one blind speed at a time, it remains visible on the display. The signals from the receiver are unstaggered before being presented to



The display shown left illustrates the effect of pulse interference.
On the right is the same display with the interference suppressed, using the Type SM 300.

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the MTI system and the displays, so that the staggering process has virtually no effect upon an existing system. A stagger ratio of 5/4 is employed with a nominal PRF of 385 p.p.s. and this combination raises the first true blind speed to over 800 knots. Other stagger ratios may be required at different PRF's.

In addition, pulse recurrence frequency discrimination (PRFD) is also included in the PRF unit to remove pulse interference caused by the other radars operating on the same, or neighbouring, radio frequencies.

The pulse recurrence frequency discrimination passes to the radar display only those signals which are at the same PRF as the radar itself, other short pulses being rejected. The system will therefore remove interference caused by the reception of pulses from other radars provided that their PRF's differ from that of the radar to which the PRFD is fitted. In order to ensure that there is such a difference a number of different quartz delay lines are available for the PRFD with delays differing in steps of 16 microseconds.

The PRF unit (S 7001) can be used with either new or existing Radars S 264A and operates in conjunction with the existing Radar Distribution Unit SJ 1000.

The whole PRF unit is housed in a single rack cabinet which is designed to be installed adjacent to the radar distribution unit.

Pulse interference suppression

A similar one-parameter anti-clutter device is the Pulse Interference Suppressor Type SM 300. This unit operates on the video responses in such a way that only those occurring at the pulse recurrence frequency of the transmitter are passed to the display system.

The unit has been used with considerable success against multiple secondary radar responses such as occur where the airborne equipment, being within range of several ground stations, causes responses to be received by other stations than the interrogating one.

Effective protection is also given against direct pulse interference from other radars on different pulse recurrence frequencies which, due to high siting, prove troublesome.

The Type SM 300 is a compact rack assembly.

Circular polarization

Elimination of precipitation returns can be greatly assisted by circular polarization of the radar signals. This is effected by fitting a circular polarization filter between the aerial feed system and reflector. The filter consists of a grid of slats at 45° to the plane of polarization of the feed.

The signals from the feed are split by the filter into two components. One component, normal to the slats, passes through the filter unaffected, *i.e.* under free-space conditions. The other component, parallel to the slats, is effectively in a waveguide, where phase-velocity is less than in free-space velocity. The dimensions of the filter are such that this component emerges from the filter leading 90° in phase on the unaffected component. The resultant of the two polarized waves, at right angles to each other and 90° out of phase, is a circularly polarized wave of predetermined screw-sense.

Reflection of a circularly polarized wave from a spherical or circular surface results in a reversal of screw-sense in the reflected wave. On re-traversing the polarizing filter, the reflected wave becomes plane-polarized again but is now at right angles to the radiating plane of the feed system and is thus not accepted. This is the effect upon returns from moisture droplets.

Irregularly shaped objects such as aircraft and ships give a plane-polarized reflected wave. After passing through the filter the reflected wave is circularly polarized, with one component acceptable to the feed system.

It can thus be seen that the energy received back from the desired targets using circular polarization is less than without polarization for the same transmitted power. The system is only practicable where some degradation in extreme range performance (due to the attenuation of transmitted and received signals by the polarization filter) is permissible.

Marconi

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