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Evans, G.

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RADIO AND ELECTRICAL ENGINEERING DIVISION

PROPOSAL FOR A SHORT-SIGNAL INTERCEPT RECEIVER

G. EVANS

OTTAWA

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ABSTRACT

A requirement exists for the rapid development of a shipborne equipment capable of intercepting short-duration signals transmitted on frequencies in the band 1.5 to 30 mc/s. A proposal is made for a receiver built largely of existing equipment, or equipment for which the circuits are in an advanced stage of development, which would be capable of displaying a band of signals 1 mc/s wide, either directly, or on a panoramic display.

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APPRECIATION OF THE PROBLEM

Short-signal transmission is a possible means of communication by submarines. The location of the submarine transmitter, the power being used, and the intended transmission path (which in turn specify the frequency and field strength of the signal) are all unknown.

The problem of short-signal interception is governed largely by the amplitude of the signal field strength that has to be handled. In the United States and the United Kingdom the problem of handling very low level short signals has been studied, and in both cases the solutions are in essence, the provision of a large number of narrow-band receivers whose outputs are stored by magnetic recording. This provides continuous coverage over the band being watched, and in each case an associated panoramic display scans the band in an interval equal to that of the shortest signal. Both of these equipments are large, and intended for shore use. In Canada the problem of intercepting the high field strength signal transmitted by a submarine in the vicinity of a convoy is being investigated by the National Research Council with the aim of providing a shipborne high-frequency direction finder which would be used mainly for convoy protection. This equipment will be a triple-channel broadband direction finder looking at the whole of the desired band continuously, and will rely upon the wanted signal having a higher field strength than any other signal in the band.

In the course of the work on this shipborne high-frequency direction finder a great deal of consideration has gone into obtaining some estimates of the order of magnitude of the various factors involved in the short-signal interception problem. The reasoning that led to the values that have been assigned to these factors is described in some detail in NRC Report ERA-327, and only the values arrived at will be discussed here.

The bandwidth within which the short signal can be transmitted will be at least one megacycle, and perhaps the signal will lie within a megacycle band containing the frequency of a shore station which is being best received by the submarine. Under favourable ionospheric conditions this bandwidth could be much greater, but it seems reasonably certain that any short signal intercept system should have a bandwidth of at least one megacycle.

A rough survey of the frequency band 1.5 to 16 mc/s carried out in 1955 showed that there was an average of about one signal in each megacycle bandwidth whose field strength exceeded 1 mv per meter. The radiated power of the submarine transmitter is not known with certainty but informed guesses have placed it at 200 watts. At a distance of 40 miles over sea water the ground wave field strength for this radiated power is 200 μv per meter at 30 mc/s, rising to 2 mv per meter at 10 mc/s. Tests carried out on the laboratory model of a triple-channel receiver having a final bandwidth of 800 kc/s have shown that a simulated short signal is visible on a cathode-ray tube bearing display if its amplitude is as great as that of the background level composed of the combination of all the other signals in the band. Other laboratory tests have shown that the "Memotron" display storage tube is capable of storing a 100-ms signal, consisting of 1-ms pulses spaced 4 ms apart. It is therefore likely that a short signal transmitted from a submarine at a distance of 40 miles or less will be detectable in a band of signals 1-mc/s wide.

The presence of short signals with amplitudes greater than that of the combined background level could be indicated on a memory display of the rectified output of a wide-band receiver. A raster-type display using a Memotron tube has been developed for this purpose. This type of display would indicate that a high-level signal had occurred, and would give an indication of its duration, but its frequency could not be determined more accurately than within ± 500 kc/s.

A panoramic receiver covering a one-megacycle band would give the frequency of the signal and would be more sensitive, but would not give any indication of the length of the signals. Also, with a discontinuous signal, the probability of intercepting the signal would be lower than with a wide open receiver unless the panoramic receiver was made more complex than is usual. The importance of this disadvantage would have to be weighed against the likelihood of the short signals being discontinuous.

The broadband low-sensitivity receiver is the solution that can be made available most quickly by the National Research Council, and an outline of the suggested system will now be given.

PROPOSED SHORT-SIGNAL INTERCEPT RECEIVER

A receiver is envisaged that will be tunable from 1 to 30 mc/s in 1-mc/s steps, and with a bandwidth of ± 600 kc/s about each megacycle. The output of this receiver is detected and fed onto a raster displayed on a Memotron display storage tube. The time taken to write the raster is 15 seconds and the display is erased every 15 seconds. Provision will be made to stop both erase and writing at will, to allow examination of any suspicious part of the trace. It will be possible to feed a panoramic receiver in parallel with the broadband display.

A block schematic diagram of the proposed system is shown in Fig. 1. From the output of the second mixer of a Racal RA17 receiver, a frequency band 2.5 mc/s ± 600 kc/s is obtained which is fed through an isolating cathode follower to another mixer. The frequency of the oscillator feeding this mixer is 2.5 mc/s, and the output of the mixer will be two bands, both 0 to 600 kc/s, which are fed into an amplifier whose bandwidth is nominally 10 to 500 kc/s, but which actually gives a useful output up to 700 kc/s. The output of the amplifier is detected and fed to a raster displayed on a Memotron tube. The broadband output of the Racal receiver is fed back into the receiver possibly through a cathode follower, and feeds the narrow-band portion of the receiver. An output is provided for attaching a 1-mc/s-broad panoramic receiver which is always tuned to cover the band 2 to 3 mc/s.

Various parts of this system have been tried out. It appears from laboratory tests that the selectivity available at the output of the RA17 second mixer is adequate, and there is a bandwidth of 1 mc/s, or slightly more, available. The 10 to 500 kc/s amplifier and the Memotron raster display have been built as part of the shipborne high-frequency direction finder, and can be duplicated. It is probable that suitable panoramic receivers are available.

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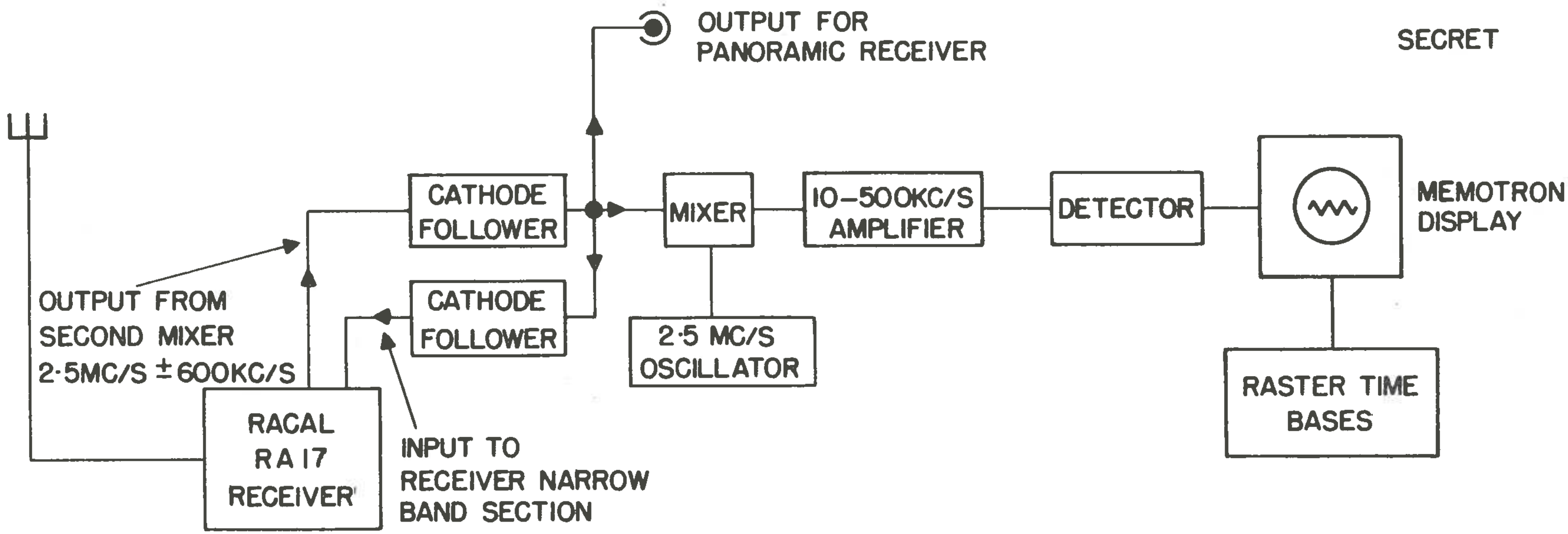

FIG. 1. SCHEMATIC DIAGRAM OF PROPOSED SHORT-SIGNAL INTERCEPT RECEIVER