Progress report on CB and MZPI radar equipments October - December 1951

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NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

PROGRESS REPORT

ON

CB AND MZPI RADAR EQUIPMENTS

OCTOBER - DECEMBER 1951

OTTAWA

JANUARY 1952

Report ERA-220

<u>Secret</u>

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October-December, 1951

COUNTER-BOMBARDMENT RADAR EQUIPMENT

General

The work during this quarter has been concerned mainly with the computer and those items affected by the change in operating wavelength from 1.25 cm to 1.87 cm and the change in azimuth scan from 10° to 20°.

Antenna

Satisfactory progress was made on the Foster scanner and reflector under construction at McGill University. By the end of December a lightweight reflector had been delivered to NRC in order to facilitate experiments on the positions of the feed horns. By the same time the necessary conical surfaces of the scanner had been made, and the machining of the rotor frame had been commenced.

The work at McGill has been so co-ordinated with the mechanical design of the set as a whole that the Foster scanner noted above can be used as soon as it is completed and tested. The reflector, however, was built before the mounting details could be settled and will have to be modified or replaced in the fully mobile set; this was done to speed up the feed horn design. An even lighter reflector has now been developed.

A series of tests on a mock-up wooden reflector, of the correct size and at the correct wavelength, confirmed earlier findings about the position of the feed horn, but indicated the need for a more accurately constructed reflector before final values could be given. Accurate location of feed horns is necessary to give an accurately known "split" between the two beams.

The possible alternative scanner (the NRC design), mentioned in the last report as being lighter and smaller, but requiring two arrays and a waveguide switch, has been dropped from consideration, at least temporarily. In this scanner the two beams would scan the azimuth sector in opposite directions and would appear as a single beam tracing out a rectangle. In the McGill design, the two beams scan in the same direction and fly back rapidly between scans. Some consideration will show that for the same rotor or scanning speed, a target (in one beam only) will be illuminated at equal intervals of time in either design, but that ground clutter, if appearing in both beams, or interference, will appear at unequal intervals near the edges of the scan in the NRC design, but still at equal intervals in the McGill design. This will result in annoying flicker effects in the NRC scanner at minimal scanning rates. A variable speed drive was fitted to the scanner of the experimental equipment to check the flicker effect at lower scan rates. While the picture detail was improved, the edge flicker became annoying as the scan rate was reduced from 30 cycles per second. Since, for mechanical reasons, a low scanning rate is desirable and flicker effects are the first limit to reduction of this rate, it appears that the McGill scanner is to be preferred. Its excess weight and size are not as significant in the total weight of antenna and rotating mechanism as in the weights of the scanners alone.

Modulator and Power Supply

The modulator and its power supplies are being built in a single chassis. The chassis will be located on the rotating structure below the reflector and immediately behind the main box beam which forms the reflector support. Tentative chassis layouts are being tried in an attempt to utilize the space to best advantage. Difficulty has been experienced in obtaining a suitable cooling fan with 400-cycle motor for the magnetron, and consequently the layout cannot be finalized.

As charging chokes are not available commercially, a choke was built on a "Ferroxcube III" core.

Receiver

The A.F.C. i-f amplifier was constructed and aligned. The Weiss discriminator circuit was chosen because of its freedom from interdependence of alignment controls. Analysis of this circuit indicated that a modification of the MIT version would aid in maintaining symmetry at large bandwidths, but even this modification failed to produce the required 20-mc bandwidth. The remainder of the A.F.C. loop was outlined, further design pending data on the klystron.

Azimuth Sweep

The increase in azimuth scan requirements from 10° to 20° has necessitated alterations both to the antenna structure and the circuitry. Sine-wave sweep is being considered in order to expand the center ten degrees to preserve, as far as possible, the discrimination within this more important part of the picture. The isoceles sweep, required for use with the original scanner, was also used as a basis for control of the azimuth marker. Now that the new scanner employs a sawtooth scan, a triggered sweep has been developed for use in the marker circuit as an alternative to the more complicated isoceles sweep generator.

Goniometers

The over-all error of Goniometer Mk.II, Serial No. 1, has been reduced to 0.7 degree, with the search coil loaded by 100 ohms and all shields in place.

The completion of Serial Nos. 1, 2 and 3 is expected early in 1952.

Construction of the goniometer calibrator is progressing satisfactorily in the Model Shops. Delivery is expected in January. Meanwhile the turntable drive control has been designed, and the phase discriminator circuitry is being developed.

Computer

The mechanical layout of the various servo assemblies in four separate packages, of reasonable weight for man-handling, was completed except for a number of minor items. A wood-and-paper model showing all controls has been constructed and is being studied with regard to simplification and operational convenience.

The more important modifications to the design are as follows:

(a) An A/S—K switching arrangement, by means of which the K computing mechanisms remain dormant except when an extrapolation is being performed

(b) A marker-centering mechanism which, under control of the operator, would automatically turn the antenna to the marker azimuth, and at the same time return the marker to center of scan. This is expected to be useful with the 20° sine-wave sweep

(c) The continuously-adjustable "stop-pot" originally used on the old computer has been modified to include electrical limit stops, as well as the mechanical stops formerly provided.

The change-over from degrees to mils, and from yards to meters, though it has necessitated modification of several gear ratios, has been completed, except for 0-6400 mil counters for which no source supply has yet been located.

Vehicle

Consideration of the choice of vehicle on which to mount and transport the equipment has continued in conjunction with DAD and DVD. No satisfactory solution has been found to date.

MICROWAVE ZONE POSITION INDICATOR MK.II

(Modified A.A. No.4, Mk. VI)

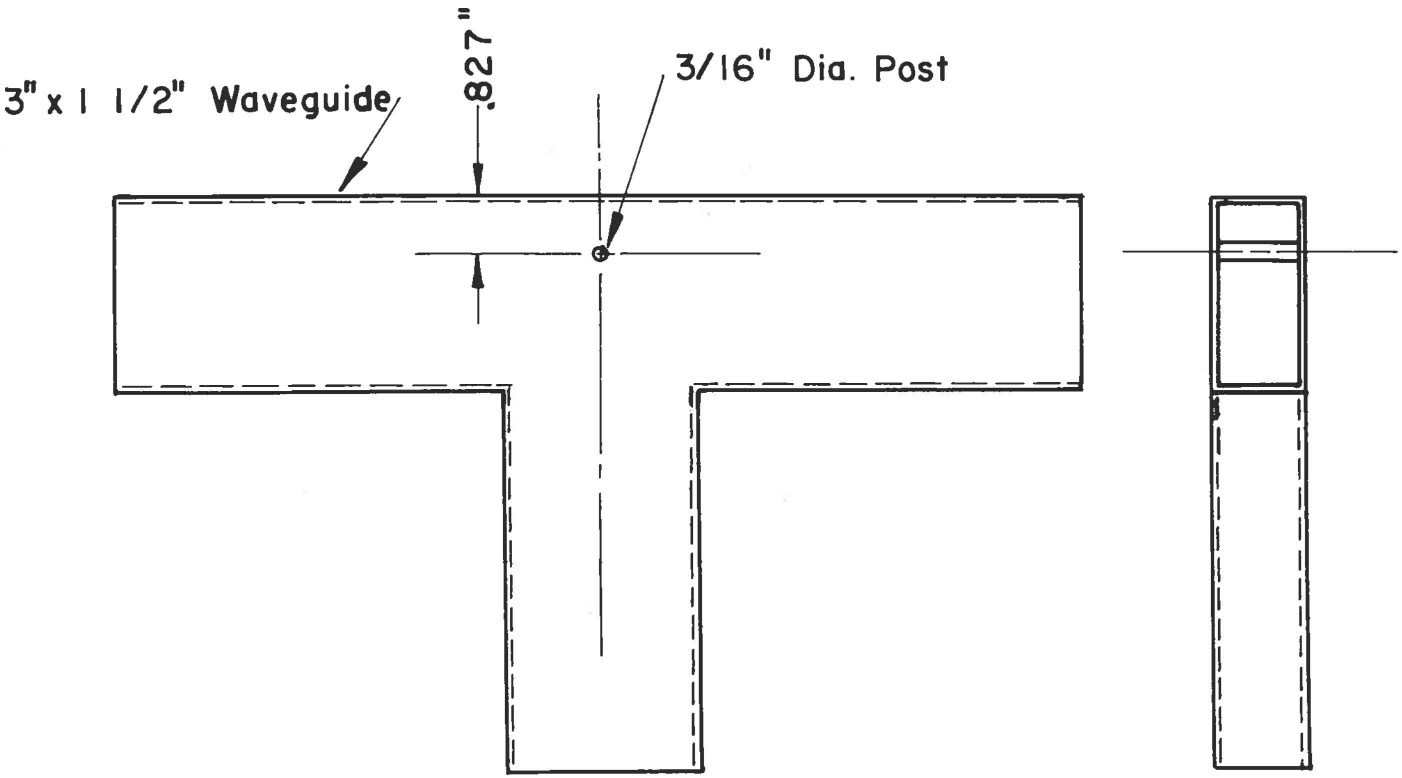
Work on the high-power model has been shelved temporarily, as no military requirement exists at present. Emphasis has been placed upon those aspects for which a requirement has been confirmed, with particular attention to improved over-all performance with power output unchanged and broad banding of r-f components.

Broad-Band Radio-Frequency System

The greater part of the work on MZPI done during the quarter under review was directed towards broad-banding the radio-frequency system. Progress in broad-banding various components of the radio-frequency system was made as follows:

(a) The Rotating Coupler The present rotating coupler, manufactured by Canadian Arsenals Limited, has a six per cent bandwidth centered on λ = 10.6 centimeters, for a voltage standing wave ratio of 1.20. Steps were taken to modify the door-knob transition at both the top and bottom of the rotating coupler in order to increase this bandwidth and center it on a wavelength of 10.7 centimeters. However, this work was dropped when it was learned that Canadian Arsenals had achieved the same end by merely modifying the top of the coupler, which is much more satisfactory from a production standpoint, since the top transition must be changed in any case in order to accommodate the new antenna.

(b) The Duplexer A broad-band duplexer, using a Type 1B58 T/R cell and two $\lambda g/4$ spaced anti-T/R cells, Types 1B56 and 1B44, has been designed around a modified shunt-tee junction. A simple modification of a shunt-tee junction by the use of one 3/16 inch diameter post will give it the properties of a 120-degree Y-junction over a ten per cent band centered on 10.7 centimeters; i.e., the shunt arm and either of the other two arms will be electrically interchangeable. This junction did not break down when power-tested at two megawatts peak power. It is possible, using this junction, to have $\lambda g/2$ spacing between the anti-T/R tube nearest the junction to the T/R tube mount without any physical interference. A sketch of the modified shunt-tee junction appears on the following page.



MODIFIED SHUNT-TEE JUNCTION WITH PROPERTIES

OF A 120-DEGREE Y-JUNCTION

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(c) Magnetron Coaxial-to-Waveguide Transition A change in the magnetron coaxial-to-waveguide transition is required to eliminate the high voltage standing-wave ratio at the low-frequency end of the band. The present transition has a narrow-band outer conductor choke which must also be changed. A transition to suit these requirements has been constructed, based on Radiation Laboratory Drawing No. 6392C (NRC No. 10954). Inductive waveguide posts have been substituted for inductive irises. Using a coaxial "flat" load, the voltage standing-wave ratio is better than 1.08 from 10.2 to 11.2 centimeters. This transition uses a direct-contacting split-finger center conductor. A capacity-type of coupling for the center conductor could possibly be used with inferior voltage standing-wave ratios at the band edges.

(d) A-F-C and Signal Mixers A waveguide signal mixer has been constructed from an MIT design (p.189, Vol. 16, Radiation Laboratory Series, "Microwave Mixers"), and has been tested over a ±4 per cent band. For a matched crystal at band center there is a 0.6 decibel loss at the band edge (voltage standing wave ratio = 2.1). The local oscillator radiation is excessive in this mixer. In addition, work is under way on a signal mixer adapted from a mixer designed in the H. A. Wheeler Laboratories (Reports 145, 154, 164, 165, 168). It is proposed to construct an automatic-frequency-control mixer similar to the signal mixer.

* * * *

Other work done during the quarter under review is as follows:

(a) 1B27 T/R Cavity The present duplexer in use on the MZPI set uses an REL Type 64 T/R cell installed in a high-Q cavity. Tuning is accomplished by means of two threaded "slugs" in the sides of the cavity. There are two conflicting requirements for these slugs: that they be a tight fit to prevent excessive I^2R losses, and that they provide easy cavity tuning. The REL Type 64 cell is not temperature compensated, so that there is a slight mistuning of the T/R cavity as the operating temperature of the radar rises. The new high-Q 1B27 T/R tube has a tuning mechanism built in the tube which varies the spacing of temperature-compensated cones.

In order to make field comparisons, a cavity to suit the Type 1B27 tube was constructed, having the same transformed cavity conductances as the REL Type 64 in its cavity ($g'_c = 0.27$). In this way the direct-coupled leakage and insertion loss would be alike for both T/R cells. The tuning range of the Type 1B27 tube in this cavity was from 10.0 to 12.0 centimeters, approximately. The signal-mixer loop-angle was changed to give equivalent low level performance for both cavities. So far, no power tests or field trials have been made. The price of the Type 1B27 tube is close to that of the REL Type 64.

(b) Local Oscillator Cavity Modification The tuning of the local oscillator has been greatly simplified by a modification to the local oscillator cavity. (Previously the single radio-frequency loop fed local oscillator energy to a coaxial cable T junction from which two cables coupled one to each mixer.) Two diametrically situated radio-frequency loops are used to feed local oscillator power to the AFC and signal mixers separately. These two separate loops and cables serve to decouple the mixers.

(c) Misalignment of Chokes and Flanges Tolerances on choke and flange waveguide junctions have been set up to eliminate the possibility of resonant losses and sparking associated with misalignment in conjunction with close spacing (cf. p.292, Vol. 9 Radiation Laboratory Series, "Microwave Transmission Circuits").

(d) Radiating Flat Load A broad-band radiating flat load has been designed for use on the MZPI non-resonant array. Matching was done with two pairs of inductive posts and the load was made weatherproof by cementing a rectangular box of Plexiglas over the open end. Field patterns of the complete array with the radiating load termination showed no measurable alteration in the radiation pattern by the installation of the radiating load.

Sweep Delay Unit

The new cascode preamplifier increased the detection range of the radar beyond the limit of the PPI sweep, making it necessary to increase the maximum range displayed. To accomplish this with least modification of the existing equipment a sweep delay unit was developed.

The unit delays the initiation of the sweep for a predetermined interval (10,000 to 110,000 yards) after the transmitter pulse. This delay can be calibrated by reference to the PPI calibration rings. The unit is packaged in a small chassis designed to mount on existing screws on the sweep chassis.

A large number of chassis and modification kits were assembled on a special contract from the Army. Assistance was given, as required, during modification of the radars.

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