Classified progress report no. 16: January-March 1959

National Research Council of Canada. Radio and Electrical Engineering Division

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NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

CLASSIFIED PROGRESS REPORT NO. 16

(JANUARY - MARCH 1959)

OTTAWA

APRIL 1959

FOREWORD

This Classified Progress Report is intended to present a convenient quarterly summary of some of the classified aspects of the research and development program of this Division, for the information of the Services in Canada, the United Kingdom, and the United States, and of laboratories and other organizations in these countries which are engaged in work similar to ours and which have been supplying us with reciprocal information. Unclassified material, whether or not it is of Service interest, appears in our open publications and will not be covered here. The format of this report is such that the account of each project may be separated from the whole without loss of security grading. It is thought that this feature may be appreciated by some agencies, such as the Project Co-ordinating Centre of the Department of National Defence, where they may prefer to file the individual sheets according to their own systems. It also permits us to issue the separate sheets to persons who may have an interest in certain selected projects but who do not require the remainder of the report.

A list of classified reports issued by the Division each quarter is included. There is no automatic distribution for these reports — the circulation list for each is determined by the nature and interest of the work described. Requests for copies of these reports, to be directed to the Document Control Office of this Division, will be given every consideration, subject to security regulations. Recipients of these documents should note that Canadian approval is required for release to other persons, organizations, or governments of any classified information (including this Classified Progress Report) which may be issued by this Division.

CONTENTS

COUNTER MORTAR RADAR (AN/MPQ-501)

Reference: Army. DND Project B22-38-50-01

Period under review: January-March 1959

PURPOSE OF EQUIPMENT

The primary role of this radar is the detection and location of mortars to ranges of at least 7000 meters. A parabolic extrapolation through two points located on the bomb trajectory is made by means of a computer. The mortar location is given as a map grid reference and contour. Range and bearing to the mortar are indicated also. Secondary roles include location of airburst, fall of shot, vehicles, and personnel.

GENERAL DESCRIPTION

The radar was designed for mounting on an AFV 603 armored personnel carrier in order to achieve a high degree of mobility, reliability and protection for operators and equipment. The antenna, transmitter and generator assemblies are mounted outside, while the display and control equipment are inside the body of the vehicle. No cabling or external stabilization of the vehicle is necessary on site; consequently the equipment may go into or out of action with minimum delay and manpower. The design is generally suitable for mounting on the new Canadian tracked armored personnel carrier. Consideration of modifications required to take full advantage of the new vehicle is being continued in cooperation with the vehicle authorities.

STATUS OF PROTOTYPE

The equipment has been located at the National Research Council where it has been used as an aid to the modification of the antenna structure. Maintenance, and investigation of items listed as deficiencies in the trial reports have been continued. Development and assessment of improvements are reported below.

CIRCULAR POLARIZER

A contract was let to industry with respect to manufacture of a polarizer to the NRC design. Moulding material has been purchased. The design of a mechanized mounting facility has been drawn up.

SCANNER

Design changes which make the beam scan symmetrical about the perpendicular to the reflector are being incorporated into the revised structure. A calibrated squint adjustment, with readily accessible control, has been designed.

ANTENNA MOUNT

A modified design eliminates the need for the heavy counterweights presently in use and will provide a more rigid mount.

DISPLAY

Circuit modifications required to provide a variable delay preceding the search range sweep were investigated and a design has been completed.

While useful information on the required storage characteristics is being made available by the present storage tube unit, the direct-viewing type appears less desirable than the electrical-readout type which permits the markers to be handled separately. New tubes are on order and the system will be constructed when they are received.

AUTOMATIC LEVELLING

The system was checked and a small adjustment was made. Subsequent tests indicate that the system is capable of maintaining level to an accuracy of ± 0.5 mil. This results in negligible errors.

PRODUCTION SPECIFICATION

Assistance was provided to ADE in re-writing the production specifications. Several meetings were held between ADE, DEME, and NRC with respect to test equipment. A tentative list has been made.

ANTI-JAMMING MEASURES AGAINST CARCINOTRONS

Reference: Army. DND Project B22-38-20-23

Period under review: January - March 1959

DICKE-FIX RECEIVER

Several fruitful meetings and discussions were held with staff members of DRTE laboratories; as a result there is now general agreement between CAL, DRTE, and NRC that the recommended limiter circuit (using a type-6688 pentode with low plate and screen voltages) is satisfactory.

The Dicke-Fix receiver built for RRE, Malvern, has been received in the United Kingdom in apparently satisfactory condition.

Some samples of a new preamplifier tube were obtained. This is the type-VX3519, with which it should be possible to build somewhat wider input stages than has been possible with the present type-417A tube. Owing to production difficulties the new tubes were not obtained in sufficient time to make any amplifier tests or measurements during the period under review. However, an input bandwidth of 27 mc/s ought to be obtained with no increase in noise figure.

IMPROVEMENTS TO GROUND RADARS

Reference: Navy, Army, RCAF. DND Project D48-38-03-27

Period under review: January - March 1959

AZIMUTH TIME RECORDER

A read-out mechanism will be installed in the azimuth time recorder to make it compatible with the Astrid triangulation system. At the same time, the present 390° helix is being replaced by a 360° helix. It was found that with the use of constant current pulses, the 30° overlap areas were not printing as heavily as in the non-overlap areas. Since the information in the 30° overlap areas may be important in some operational situations, it was decided to abandon the overlap areas.

ECHO MONITOR "EMMA"

Construction of EMMA has been completed and it is being tested. The high and low voltage power supplies, bias supply, focus and brilliance controls, and range delay chassis have been tested and operate satisfactorily. Additional testing will be required before the EMMA receiver and the range and azimuth sweeps are ready.

AUTOMATIC STROBE TRIANGULATION DISPLAY (ASTRID)

Reference: RCAF and Project "Napkin". No project number

Period under review : January - March 1959

During the period under review, tests indicated that the transmission of three pieces of servo information on three carriers did not provide reliable signals at the receiving end. This method of transmitting antenna position has therefore been abandoned in favour of transmitting a signal from a tachometer geared to the antenna servo system and a north marker pulse. At the remote end, the tachometer signal is amplified to drive a synchronous motor with the north marker pulse used for complete synchronism. The synchronous motor drives the resolver providing a sweep for the triangulation display. One complete set of transmission and reception equipment has been built. It has undergone numerous tests and appears to operate satisfactorily.

At the same time, it was found that the filtered output of the Azimuth Time Recorder receiver did not provide reliable signals at the receiving end. The output of an Antenna Pattern Receiver was passed through the transmission system after suitable filtering. It was then possible to obtain reliable signals at the remote end with less complex receiving equipment than with the Azimuth Time Recorder receiver. It was therefore decided to use the Antenna Pattern Receiver in the Astrid system since there are a sufficient number of these receivers available for initial full-scale Astrid tests.

The electronic markers on the two displays have been changed from pairs of dashed lines crossing at the designated point to small circles. This change was suggested after simulated exercises with the displays by teams of radar operators from the Royal Canadian Air Force. In addition, three operator positions on both displays have been fitted with two meters, which read, in rectangular co-ordinates, the location of the joy stick controlled markers.

LOW ANGLE DETECTION

Reference: Army, RCAF. No DND project number

Period under review: January - March 1959

An improved display is being made. Attempts are being made to obtain an improved beam deflection tube. Possibly a modified type-6370 tube can be used.

SOUND-RANGING COMPUTER

Reference: Army. No DND project number

Period under review: January - March 1959

The problems of low-speed storage and high-speed repetitive playback of the data are being considered. These requirements indicate that initial recording should be on a magnetic tape loop and that a transfer of data to a high-speed magnetic drum is required. A system using electronic switching of the reading heads with a display on a multi-beam cathode-ray tube is being investigated.

Consideration is being given to the use of the transistor NOR circuit as the logic element for the computer. Since NOR circuit logic elements operate at lower power levels than diode logic elements, better reliability should be obtained. A six-input, six-output NOR circuit element has been built and tested in several logic circuits, including a binary counter and a binary adder stage. A patchboard has been built to check logic circuit design.

INSTANTANEOUS MICROWAVE DIRECTION FINDER (AN/UPD-501)

Reference: Navy, RCAF. DND Project A12-44-10-03

Period under review: January - March 1959

The purpose of this equipment is to detect a pulsed radar transmission instantaneously and to indicate the bearing in an unambiguous manner. It consists of a four-channel crystal video receiver with the signal displayed on a cathode-ray tube as a radial line. The angle of the line with respect to a reference represents the bearing of the signal.

PROTOTYPE ANTENNAS

Electrical testing of the L-band antennas of both polarizations was completed. The performance of the low-pass filters above the cutoff frequency was found to be rather critically dependent on the source impedance.

ANECHOIC ANTENNA COUPLER

Development of a harmonic generator for conversion of power at 7.0 kmc/s to 14.0 kmc/s was completed. With a low pass filter at the input and a type-1N78 crystal, the conversion loss is about 17 db.

VIDEO DETECTOR MONITOR

This equipment was developed to check the relative performance of crystal detectors without removing them from the antenna. A smaller unit has been developed using a squegging oscillator circuit.

Ku-BAND ANTENNA — 10.5 KMC/S TO 20 KMC/S

This antenna consists of eight horns mounted in four cylinders. The mounting was modified to incorporate an adapter ring. This enables all cylinders to be similar, with the horns mounted in each cylinder at 90°. This is the same configuration as in the cylinders for the other frequency bands.

A report is being prepared on a new crystal mount for this band, which uses unmodified coaxial crystals.

SHORE-BASED HIGH-FREQUENCY DIRECTION FINDER (AN/GRD-501)

Reference: Navy. DND Project A14-38-10-01

Period under review: January - March 1959

The final testing of the recorder units of AN/GRD-501 has been delayed by the moving of Model 3 to HMCS "Gloucester" for training purposes. Tests will be resumed when time is available on the equipment.

Model 1 has been overhauled and a crystal filter unit has been added. Performance is now comparable with that of Model 3.

Two models of the portable, harmonic, field oscillator have been built and tested satisfactorily. One of these models will serve as a sample, if a decision is taken to adopt the design.

The report on polarization error measurements on the eight- and four-element Adcock antennas (ERB-503) was issued (see page 23).

SHIPBORNE HIGH-FREQUENCY DIRECTION FINDER

Reference: Navy. DND Project A17-38-20-19

Period under review: January - March 1959

The aim of this project is to develop a triple-channel direction finder operating over the band 1.5 to 30 mc/s with 1 mc/s bandwidth. The purpose of the receiver is to intercept and give unambiguous bearings of high level signals lasting as little as $\frac{1}{10}$ second and transmitted on frequencies not known to within ± 500 kc/s.

The intermediate-frequency amplifiers for the two direction-finding channels have been built and appear to be completely satisfactory. The sense-channel intermediate-frequency amplifier is also complete but has not yet been tested.

Commercial broad-band balance-to-unbalance transformers have been ordered and delivery is awaited. Further broad-band autotransformers to increase the output from these commercial transformers have been built and extensive tests indicate that these units will be satisfactory. A radio-frequency amplifier covering the 8-16 mc/s band has been designed and construction should start shortly. If the design proves satisfactory three models will be built for this receiver.

The response to the enquiry on a ferrite-core crossed-loop aerial, thought to be available commercially, was disappointing and is not being pursued further.

SHIPBORNE SHORT-SIGNAL INTERCEPT RECEIVER

Reference: Navy. DND Project A17-38-20-24

Period under review: January - March 1959

The general report on this project was issued as NRC Report ERB-498 (see page 23).

At the request of the Royal Canadian Navy the possibility of making a more detailed analysis of high-amplitude short-duration signals with this equipment is being investigated. Two Hughes "Memoscopes" have been ordered to study the feasibility of using triggered non-linear sweep display techniques for this purpose. At present non-linear time bases are being investigated.

IMPROVEMENT OF HF DF TECHNIQUES

Reference: Navy. DND Project A14-38-10-24

Period under review: January - March 1959

Preliminary measurement of variance reduction by time-averaging the rapid fluctuations of the bearing display shows very large reduction (16 : 1) up to 30 seconds, with a further small improvement (2 : 1) out to the maximum time examined of 300 seconds. Further work will be done to determine the effect of time-averaging under a wide range of conditions.

Preliminary study of slow fluctuations on transmissions from WWV has begun. There is some doubt as to the validity of relating such measurements to actual tilts because of the large effect of site error on a narrow-aperture antenna.

The digital bearing averager is now complete, except for the printer which has not yet been received.

SELF-MONITORING DEGAUSSING SYSTEM

Reference: Navy. DND Project A17-44-35-01

Period under review: January - March 1959

A closed-loop system for automatic degaussing of the magnetic field of a ship is under investigation. It is being designed to null the difference between the field of the ship and the field of degaussing coils. The detector is a magnetic-field gradiometer which is mounted on the ship's structure. This detector, through a suitable amplifier, adjusts the degaussing current to null the difference field.

Most of the necessary equipment for a full-scale system has been procured. The gradiometer will be a modified form of a commercially made second-harmonic magnetometer. Modification of this instrument in our laboratory is nearly completed. The amplifiers will be those already used in the MCB-159 minesweeper degaussing equipment. They consist of a three-stage magnetic amplifier and a motor-generator power-output stage. A complete amplifier system of this type has been brought into the laboratory. The characteristics, both of individual stages and of the whole system, have been measured carefully. This amplifier system after slight modification appears suitable for use in the closed-loop system.

Future system development will consist of larger scale laboratory tests, first on the gradiometers themselves and then on the complete closed-loop system. Preliminary planning has also been done for full-scale ship trials.

DYNAMIC CHARACTERISTICS OF THE INDUCED FIELD IN FERROMAGNETIC BODIES

Reference: Navy. DND Project A12-05-60-04

Period under review: January - March 1959

No work was done on this project in the period under review.

AIRBORNE HOMING SYSTEM FOR MG-2

Reference: RCAF. No project number

Period under review: January - March 1959

Components for a second model of the S-band feed, built to close tolerances, are being constructed.

MODEL ANTENNA STUDIES FOR HMCS "ST. LAURENT"

Reference: Navy. DND Project A12-55-40-16

Period under review: January - March 1959

The proposed broadband HF antenna system (see NRC report ERB-499, page 24) for the destroyer escort DE-257 class, which was described in the previous issue of this report, has been accepted by EEC/Royal Canadian Navy. Arrangements are being made by EEC to fit a DE ship with a folded-foremast and sleeve-antenna for operational evaluation.

A study is being carried out to determine the feasibility of using a "notch" as an LF antenna (to replace the existing flat-tops) for the DE-257.

ECM ANTENNA SYSTEM FOR B-52 AIRCRAFT

Reference: USAF. No DND project number

Period under review: January - March 1959

The radiation patterns obtained previously on the slot-antenna system were analyzed in order to determine the feasibility of using this type of antenna in an ECM system. No new measurements were conducted during the period under review.

ECM/DF ANTENNAS FOR P2V7 AIRCRAFT

Reference: RCAF. No DND project number

Period under review: January - March 1959

At the request of the RCAF, the antenna system is being modified to permit continuous operation over the frequency band 1 to 10 kmc/s.

The feed configuration under development consists of a double-turn spiral antenna located in a cylindrical cavity. Inside the cavity is a cone. The apex of the cone is located at the input terminals of the spiral. Both VSWR and radiation patterns have been measured on a number of different feed configurations. All the feeds gave an acceptable VSWR, and an attempt is being made to improve the patterns at the high end of the frequency band.

JAMMING STUDIES

Reference: DRB. DND Project D48-44-20-01

Period under review: January - March 1959

The aim of the project is to study the use of carcinotrons and other devices for jamming and to develop experimental jamming equipment.

The study is concerned with both the properties, capabilities, and limitations of the more promising generators of jamming signals and the manner in which such signals affect various systems, so that the feasibility of jamming can be predicted. The knowledge of what may be expected in the way of jamming by a hostile force, and the susceptibility of our defences to such jamming, is necessary in defence system planning.

Jamming tests on the AN/SPG-48 radar were concerned with denial of the ability to set and maintain a range gate on a target by use of FM-by-noise jamming. The tests were extended somewhat to include the effect of target velocity in more detail. The assumption that noise jamming would be easily tracked in angle in the absence of modulations specifically designed to degrade it was confirmed by experiment. Quantitative measures of the effect of the various anti-jam circuits of the radar were obtained. The tests should be completed soon. A report on these tests is in preparation. A jamming demonstration was staged for RCN personnel in which bombing and guided missile attacks were simulated at a number of instants during each attack.

An AN/APG-33, airborne, fire control radar and test bench were received on loan from the RCAF. With the aid of this equipment it is planned to become more familiar with the practical aspects of jamming such a system, with emphasis on angle track jamming. The radar is being checked out for satisfactory operation, and the staff is becoming familiar with the equipment.

A 6000-volt 0.5-ampere rectifier-filter unit for the carcinotron test bench, using silicon rectifiers in place of the vacuum tube rectifiers, was constructed, and operation was judged satisfactory. A non-linear voltage divider was constructed which, when used with the travelling-wave-tube amplifier, allows extension of the linear range of modulation input vs. output voltage relationship from 11 db to 32 db.

ANTENNA FOR X-7769 CARCINOTRON JAMMER

Reference: DRB. DND Project D48-44-20-01

Period under review: January - March 1959

L-BAND HORIZONTALLY POLARIZED ANTENNA

During the period under review patterns were taken on slot antennas mounted in various positions on a model C119 aircraft. It was found that the nose of the aircraft was the most favourable location, and a considerable number of nose-mounted slot configurations were investigated. No completely satisfactory coverage has been obtained as yet, but the results are encouraging enough to warrant continued investigation.

VULNERABILITY OF THE DOPPLER DETECTION SYSTEM TO COUNTERMEASURES

Reference: DRB. DND Project D48-44-01-01

Period under review: January - March 1959

The purpose of this project is to study the Doppler Detection system with a view to determining what countermeasures might be used against it, how effective they might be, and what might be done to counter them.

Liaison with AFHQ and with CAL of Toronto is being carried out to assist in preparation of specifications for the proposed service models of countermeasures set AN/ALQ-501. This will be a superregenerative repeater jammer for use by the RCAF.

The study of the vulnerability of the communications system of the Mid-Canada Line is complete except for a small number of measurements. A report on the results is in preparation.

Considerable work has been done on the study of portable ground-based jammers and their possible effect on the Doppler Detection System. Initial calculations covering the propagation losses, power requirements, as well as size and weight of portable power sources have been made.

A third backward-wave amplifier has been produced by Varian Associates and delivered to this Division for testing. Decisions as to further development have been postponed until data on the performance of the tube has been obtained.

INSTANTANEOUS MICROWAVE FREQUENCY INDICATOR

Reference: DRB. No DND project number

Period under review: January - March 1959

The purpose of this project is the development of an instantaneous microwave frequency-indicating device based on the principle of amplitude comparison of the detected and video-amplified output of a set of bandpass filters with overlapping pass bands. This type of frequency indicator is closely related to the Instantaneous Microwave Direction Finder. However, because there are losses in power division and padding that are not present in the direction finder and because the antenna gain is expected to be lower, radio-frequency amplification is required to maintain sensitivity equal to that of the crystal video receiver of the direction finder. Radio-frequency amplification is provided by a broad-band permanent-magnet-focussed travelling-wave tube.

At the end of December an S-band frequency indicator made up of four hybrid rings with wide-band phase shifters was being tested. It was found that the maximum error was high (150 mc/s). It has not been possible to reduce this error significantly at S-band, although a substantial reduction was made at L-band. It has been concluded that stripline construction techniques are not at present sufficiently precise for this application. It was found, from measurements with a small sample of type-1N23B crystal diodes, that the change in reading when crystals were changed in the hybrid-ring frequency indicator was about four times as great as in the directional-coupler and filter-frequency indicator.

Reduction in the decoupling from the transmission line to the filter and considerable reduction in the size and complexity of the frequency indicator was achieved by successively shunting filters across the transmission line. The point in the filter at which the connection is made is approximately the high impedance point for off-resonance frequencies. Two or three groups of filters are connected in parallel to avoid cascading filters with overlapping pass bands. The total loss due to decoupling and power division in this configuration is 12 db. The tangential sensitivity is about -72 dbm, the limit set by TWT noise. The maximum direct-reading error is ± 30 mc/s. This is roughly twice the error of the directional-coupler and filter-frequency indicator when the latter is optimized. However, the error can be reduced by using a calibration curve. With such a calibration curve it seems likely that the error will not exceed ± 15 mc/s, allowing for some error due to differences between crystal detectors. That is, it is expected that it will be possible to calibrate the frequency indicator and have the calibration hold within ± 15 mc/s when crystals are changed.

CLASSIFIED REPORTS ISSUED

Burtnyk, N. — Measurement of Polarization Errors of an Eight-Element and a Four-Element Adcock Antenna (ERB-503, Confidential)

Results are presented of polarization error measurements made on a fat four-element and a thin eight-element Adcock antenna system, each feeding an identical twin-channel direction-finding receiver. The effect of random polarization of the received wave on the variance is investigated and comparative "bearing versus time" records for the two systems are shown.

Cox, L.G. and Evans, G. — The NR33 Intercept Receiver (ERB-498, Secret)

A description is given of a shipborne receiver intended to reveal the presence of high-amplitude short-duration signals in a one-megacycle band of signals situated in the band 1 to 30 mc/s.

Cumming, W.A. and Barnes, J.C. — A Displaced-Phase-Center Antenna for Airborne Early Warning (ERB-506, Confidential)

An earlier report, ERB-464, "An Antenna for Airborne Early Warning" describes a 675 mc/s airborne radar-IFF antenna which was developed at the request of Lincoln Laboratory. After delivery of this antenna in November 1957, a request was received from Lincoln Laboratory to develop a second antenna in which it would be possible to displace the center of radiation electrically from its normal position at the midpoint of the aperture plane. This feature was required in connection with experiments being carried out in an effort to reduce the platform motion noise associated with an airborne moving target radar. The required displacement can be obtained by making provision to excite the antenna in two independent modes: one, which produces an even aperture function, and the other, which produces an odd aperture function. By exciting only the even function the phase center remains in the center of the aperture, while if the even and odd functions are excited simultaneously and in the correct phase, the phase center is laterally displaced. In the present case the desired odd and even excitation was achieved by dividing the antenna into two

parts which could be excited in phase to produce the even function, or out of phase to produce the odd function. The result is an antenna similar to the earlier Mark II-A antenna — that is, a parabolic cylinder having a width of some 16 feet, a focal length of 51.25 inches, and an overall height, including the vertical-beam forming plates, of 4 feet. The antenna is horizontally polarized, and in free space provides a sum-channel gain of 22.4 decibels above isotropic, and a difference-channel gain of 19 decibels.

This antenna was delivered to Lincoln Laboratory in May 1958. A pattern study was later carried out in our laboratory, using a 1/10-scale model of the antenna and a 1/10-scale model of the WV-2 aircraft, in order to assess the performance of the antenna - air frame combination. The results of this model study, together with details concerning the design and operation of the full-scale antenna are presented in this report.

Wong, J.Y. A Proposed Broadband HF Transmitting Antenna System for the Destroyer Escort DE-257 Class (ERB-499, Confidential)

A broadband HF transmitting antenna system has been developed for the destroyer escort DE-257 class, consisting of three antennas, folded-foremast, sleeve-funnel, and conical monopole. The results of model impedance and radiation pattern measurements of the three broadband antennas are given.

Wong, J.Y. Evaluation of the HF Antenna System for HMCS "Bonaventure" by Model Radiation Pattern Measurements (ERB-504, Confidential)

The performance of the HF antenna system for HMCS "Bonaventure" is evaluated by model radiation pattern measurements. The significant information from the patterns is obtained by the method developed at the U.S. Naval Research Laboratory. The performance of each of the 26 antennas evaluated is presented in graphical form on two figures.

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