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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. 3  
(OCTOBER - DECEMBER 1955)

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JANUARY 1956

NRC # 35392



## 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 Coordinating 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.

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## CONFIDENTIAL

### COUNTER MORTAR RADAR (AN/MPQ-501)

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

Period under review: October-December, 1955

#### 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 is 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.

While the equipment is designed specifically for the AFV 603 vehicle, the construction would make other mountings feasible, as was demonstrated during engineering trials when a modified 2½-ton truck chassis was used.

#### STATUS

During 1953 and 1954 field trials were held, following which a contract for a prototype was let. NRC personnel have been actively associated with the engineers engaged in the production design. In addition, development on several items has continued at NRC. This is reported below.

##### Display

Agreement on the increased CRT voltage was followed by modification of the video and sweep circuits to provide greater output compatible with the 11-kilovolt potential being applied to the final anode.

##### Rack Design

Details of the rack design were checked by handmade sections of the hinged

portions. By means of this design it was possible to improve the accessibility of the individual sections of the electronic control unit greatly, and at the same time keep the unit compact.

### Goniometers

The phasing networks for the 2000-meter goniometers were investigated with a view to simplifying the alignment procedure. This work was not completed during the period.

### Transmitter

Acceptance tests were performed on six new magnetrons. Four were completely satisfactory, one was unacceptable because of an external mechanical defect although the tube operated satisfactorily, and one tube was inoperable — presumably gassy, from its behaviour.

Discussions were held with the magnetron manufacturer on the problem of "magnetron heater power versus anode power input", and agreement was reached on values of anode current at which heaters would be switched off and restored, together with workable tolerances. It is still believed that "snap-on" of power, as recommended by the manufacturer, has certain hazards as an operating procedure for the Services.

A change was made in the protective reactor for the hydrogen thyatron anode. A saturating "Ferroxcube" toroid will be used, rather than an air core unit to reduce anode heating.

On the recommendation of Hammond Manufacturing Co. the working stress in the Teflon insulation of the pulse transformer was reduced from about 1200 to 800 volts per mil. Deterioration of the pulse shape was held to a minimum by grading the insulation — a practice usually avoided with Teflon because of manufacturing difficulties.

### Video Amplifier

Canadian Arsenals Limited proposed a new video amplifier circuit to replace the one presently in the radar. The proposed circuit uses newly developed tubes which were not available when the NRC circuit was designed. Screen bypassing is now done by low-impedance power supplies rather than by electrolytic capacitors. The new tubes can provide better limiting and a reduction in the number of amplifier stages required.

The proposed circuit was constructed and pulse-tested at NRC. The rise-time

and gain characteristics of the amplifier did not meet our specification. Several sections of the amplifier were redesigned, resulting in improved performance. These changes in the circuit were discussed with CAL staff and a revised circuit was produced by CAL.

It was decided that azimuth gating of the received signals would be applied in the IF amplifier rather than in the video amplifier. This eases the design requirements of the video amplifier considerably.

#### Computer

Drafting of the mechanical assemblies is being continued, with the range unit and the elevation unit (except for the timer) ready for detailing. A nomograph which would fit on the time dial and indicate shell velocity directly was designed. This would eliminate one dial setting by the operator. It was discarded by DAD in favor of a separate chart. Assistance with the azimuth unit was requested by CAL, and NRC has agreed to help with this unit, up to the assembly drawing stage. A model of a proposed azimuth control and centering device was constructed and demonstrated to CAL. This is now being incorporated in the azimuth unit.

#### Antenna Mount

At our suggestion some changes were made in this part of the equipment. Two radius rods are now employed to eliminate the eccentric loading which arose previously with one only. Also, the box-beam mounting was modified to give maximum resistance to overturning loads.

ACQUISITION RADAR MODIFICATIONS (AN/MPS-501B)

Reference: Army. DND Project.....

Period under review: October-December, 1955

ANTENNA MODIFICATIONS

A request was received from the Canadian Army to redesign the slotted-waveguide feed for the antenna of the AN/MPS-501B radar, in a manner similar to the re-design carried out on the antenna for the AN/MPS-502 radar (cf. Classified Progress Report, April-June 1955, ERA-289 — SECRET).

Since the antenna on the 501 radar is of the same type as that on the 502, it will, likewise, radiate second-order beams. These beams have given little or no trouble in the field so far, but it is felt that they should be removed in view of the radar's susceptance to jamming.

Modification of the feed using a parallel-plate horn, and tests thereof, are nearing completion.



AREA MOVING TARGET IDENTIFICATION

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

Period under review: October-December, 1955

The purpose of this investigation is to determine the performance to be expected from an Area MTI system when added to a radar set such as the AN/MPS-501B.

Pending the outcome of trials of the RCA prototype Area MTI equipment at Canadian Arsenals Limited our work on this project has been suspended.

REMOTE RADAR DISPLAY

Reference: Army, RCAF. No project number.

Period under review: October-December, 1955

The remote display system was developed to provide a compact equipment capable of relaying a PPI picture from a radar site to any convenient location by means of a coaxial cable or a wide-bandwidth radio-frequency communication link. The radar display must be reproduced without appreciable loss of quality or accuracy.

The second experimental model of the remote display equipment is under construction. Several circuit modifications have been incorporated to improve the stability of the system, and the size has been reduced by a more compact physical arrangement.

When the equipment is completed it will undergo further accuracy and stability measurements.

LOW-ANGLE DETECTION

Reference: Army, RCAF. No project number.

Period under review: October-December, 1955.

A military requirement exists for an acquisition radar designed specifically for good low cover on aircraft targets, and capable of sufficient resolution to permit weapon control radars to acquire the target very rapidly. An experimental radar (LAD) was assembled from available components of the AN/MPQ-501B radars with the aim of gathering sufficient experimental data on the low-cover possibilities of high-resolution radar to enable a complete proposal to be formulated.

Operation of the equipment showed a need for a reversible azimuth drive to facilitate calibration and test during the experimental phase only. This was incorporated.

The elevation motor torque is inadequate for operation in very cold weather and the motor is to be changed. A uniline was added in the waveguide system and has proved satisfactory.

The memory tube was bench-tested and the writing gun of one of the tubes appears defective. Signal attenuation is higher than expected and noise is below the theoretical level. The storage target may be responsible.

SOUND-RANGING COMPUTER

Reference: Army. No project number.

Period under review: October-December, 1955

DIGITAL

Because of the wide range of the magnitudes of the numbers involved in the solution of the sound-ranging problem, a digital computer suitable for solving this problem should be capable of performing floating-point arithmetic operations. A method of performing the necessary operations in floating-point arithmetic suitable for a serial binary computer is described in a report now in preparation.

Trial data from a base laid out as described in report ERB-365 was obtained from the Army in order to determine the operational accuracy of sound-ranging. Locations obtained by calculation (corresponding to digital-computer solutions) will be compared with locations obtained by using the plotting boards which are now in use.



INSTANTANEOUS MICROWAVE DIRECTION FINDER (AN/UPD-501)

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

Period under review: October-December, 1955

The purpose of this equipment is to detect a pulsed radar transmission instantaneously and indicate the bearing in an unambiguous manner. It consists of a four-channel crystal video receiver, with signals displayed on a cathode-ray tube as a radial line from which bearings may be read.

As the indicator and power supplies are now in production, most of the effort during the period under review has been put into development of satisfactory antennas and detector crystal mounts.

A production prototype of an antenna with horizontal polarization in the 2.3-5.5 kmc, and 7.0-10.5 kmc bands will be delivered by the contractor in January for testing. Drawings of an interim antenna with vertical polarization in these bands have been completed. Design of both vertically and horizontally polarized antennas in the 5.5-10.5 kmc band is complete. Development of an improved antenna with vertical polarization covering 2.3 to 5.5 kmc is being continued.

The vertically polarized antenna, which operates from 1.0 to 2.3 kmc, requires a crystal mount of low standing-wave ratio in order to maintain a balance of the four channels over the full frequency range. This unbalance is made worse by the coaxial switches which are necessary to prevent crystal burnout. However, using Transco Corporation coaxial switches and the broad-band crystal mount developed by NRC with an integral 50-ohm resistor, the performance is satisfactory. A horizontally polarized antenna covering the 1.0 to 2.3 kmc band is being developed. Considerable difficulty has been encountered in reducing the mutual coupling between channels.

A buzzer-type test signal generator has been designed. The buzzer is mounted in the antenna in such a manner as to present equal signals to two adjacent channels. Two buzzers will check a complete antenna of four channels, and indicate a deterioration of the gain of any one channel.

An improved method of mounting the antennas has been developed, which allows any combination of two frequency bands or polarizations to be covered in one installation. The components of the antenna will be more accessible, which will make them more easily maintained in service.

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

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

Period under review: October-December, 1955

This equipment is a narrow bandwidth direction finder which is intended to provide all the facilities required for direction finding on conventional types of communication signals in the HF band. In addition it is intended that it shall provide bearing information on messages of duration as short as 0.1 second.

The D/F receiver which was shipped to ASRE has been set up, tested, and demonstrated. Its performance is quite similar to that of the Canadian model.

Liaison is continuing with the contractor who is now engaged in producing a final prototype for production. Development of the recorder has reached the point where information is being prepared to enable the contractor to begin design of his first model.

Antenna design is complete and final details have been passed to the contractor. Two arrays are being made, one for each of the receivers so far delivered.

Details of the specifications for other items such as remote cables, ground mat for the antenna, remote hut, and antenna array base are being drawn up for the RCN to facilitate plans for future installation of the equipment.

SHIPBORNE HIGH-FREQUENCY DIRECTION FINDER

Reference: Navy. DND Project A12-38-20-19

Period under review: October-December, 1955

This equipment, when made, will be required to intercept and provide unambiguous bearings of ground-wave short signals occurring on frequencies anywhere within a wide bandwidth at random time intervals.

All the chassis of a wide-band twin-channel receiver, whose main purpose is to determine the dimensions of the problem outlined in the first paragraph, have been completed. Two of these chassis remain to be put in satisfactory working order before the receiver can be made operative. An aerial consisting of a pair of crossed loops (RN type-S25B) has been erected for use in this experiment.

The receiver now being built will be used as the framework for testing the feasibility of schemes intended to ease the operator's task and increase the probability of intercepting the wanted signal. It is very unlikely that the final shipborne high-frequency direction finder will bear much resemblance to this present receiver.

MAGNETIC SIGNATURES OF ALUMINUM MINESWEEPERS

Reference: Navy. DND Projects A20-05-60-02 and A12-05-60-04

Period under review: October-December, 1955

This project was undertaken in co-operation with the Royal Canadian Navy to determine the magnetic fields of rolling ships and to evaluate methods of reducing the magnitude of these fields. The period under review was spent entirely in analysis of the results obtained during trials conducted at Esquimalt, B.C., in September, 1955. In order to separate the effect of ferromagnetic materials and the effect of eddy currents in the aluminum frame members, two ships were investigated in these trials: a wooden minesweeper HMCS "Cordova" and an aluminum framed minesweeper HMCS "Comox".

The analysis of test results on the wooden minesweeper HMCS "Cordova" has been completed and a report written. Both the magnitude and phasing (with respect to the ship's motion) of the magnetic field variations under the rolling ship have been determined. For the degaussed ship, the maximum half-amplitude of this field variation is 2.5 milligauss at 22 feet depth for a  $\pm 15^\circ$  roll. Field variations lag the ship's motion by angles of the order of  $10^\circ$  (at 7.2 sec/cycle). For the undegaussed ship the maximum half-amplitude is 5.5 milligauss (22 feet depth,  $15^\circ$  roll) and a more complicated phasing exists. At the forward measuring units under the keel the field variation lags the motion by  $12^\circ$ , at the midship units the field is very closely in phase, and at the aft units under the keel the field leads the motion by  $20^\circ$ .

Data from tests on the aluminum framed minesweeper HMCS "Comox" is being studied. Determination of the pure eddy-current field is nearing completion. The amplitude of this field is very nearly the same as that determined from tests on the bare hull of HMCS "Cowichan" (1952).



C-119 AIRCRAFT ANTENNA STUDY

Reference: RCAF. DND Project C37-55-40-09

Period under review: October-December, 1955

Radiation patterns of all the HF, VHF, and UHF antennas on the C-119 aircraft are being investigated to determine whether or not improved antenna performance may be achieved by minor modifications of antenna configuration or location.

In the period under review pattern measurements have been completed on a proposed installation for two AN-104-B VHF antennas for use with AN/ARC-502 ECM equipment on the aircraft. Indications are that unsatisfactory coverage would be obtained with the antennas in the proposed location, and the problem is being reviewed by the RCAF.

VHF ANTENNA FOR THE CF-100, MARK IV

Reference: RCAF. Avro Aircraft Order No. RL-7793

Period under review: October-December, 1955

An order has been accepted from Avro Aircraft to study means of improving air-to-ground communication on the CF-100 Mark IV aircraft. Pattern studies have shown that excellent coverage can be expected from an external antenna mounted on the underside of the fuselage near the trailing edge of the wings.

In the period under review an antenna for use in this location has been constructed by Avro, and a prototype matching unit has been designed and tested by the Division. The antenna has been returned to Avro Aircraft who will complete the mechanical design and manufacture of the matching network.

HIGH RESOLUTION IFF ANTENNA FOR AN/FPS-3

Reference: RCAF-S1950-100-IFF DRW

Period under review: October-December, 1955

It was reported previously that this antenna was installed at an RCAF station in order to determine the performance of the antenna under operational conditions. A report issued by AFHQ concerning the results of these trials indicated that the general performance of the antenna was equal to that of the present AS-295/UP IFF antenna, and it was superior to that of the AS-295/UP antenna insofar as resolution was concerned. However, in view of the divergent opinions of the controllers regarding the value of the higher resolution characteristics when balance against the logistic problem involved, it was recommended by the RCAF that a program to instal the high resolution antenna not be implemented at the present time.

A technical report describing the design of the high resolution IFF antenna will be issued.

ANTENNA PATTERN AND GAIN MEASUREMENTS FOR AN/FPS-503

Reference: DRB, RCAF. No project number.

Period under review: October-December, 1955

Radiation pattern and gain measurements were carried out on a production model of the McGill Fence (AN/FPS-503) antenna, for the Bell Telephone Co. of Canada, Special Contracts Division. The antenna employed in the McGill Fence doppler detection system is of the horn-reflector type. The reflector consists of a doubly-curved surface 120 inches long and 96 inches wide, designed to produce a cosecant-squared type of pattern in the vertical plane, and a pencil-type beam in the horizontal plane. Radiation patterns in both the principal planes and in an elevated plane containing the maximum radiation were measured for a band of frequencies from 470 to 500 Mc/s. An average of 12 degrees was obtained for the beamwidth in the horizontal plane. Gain measurements yielded a power gain relative to an isotropic radiator of 16.8 db at 470 Mc/s, and 17.2 db at 495 Mc/s.

A report entitled, "Pattern and Gain Measurements on the AN/FPS-503 Antenna" has been issued as ERB-366.



MODEL ANTENNA STUDIES FOR HMCS "BONAVENTURE"

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

Period under review: October-December, 1955

VHF/UHF model antenna studies for the DE-205 destroyer escort have been completed and copies of the various patterns forwarded to Naval Technical Services, NDHQ, Ottawa. A request was received to carry out a similar antenna study for HMCS "Crescent", and suitable working drawings of a 1/6-scale model of the mast are being prepared.

Construction of the 200-foot by 70-foot pattern range for the HF studies is about 90% complete. The remainder of the work including installation of the copper-mesh ground screen, will not be done until spring, since the range can not be used conveniently under winter conditions. Construction of a 1/48-scale model of the "Bonaventure" is currently underway in our Model Shop.

WAVEGUIDE SWITCHES FOR THE ROYAL CANADIAN NAVY

Reference: Navy. DND Project A12-55-10-02

Period under review: October-December, 1955

The purpose of the project is to develop suitable fast-acting waveguide switches to allow switching of the full magnetron power of X-band radars from the antenna to a dissipative load.

During the period under review, no further replies have been received from Airtron Company and Cascade Research on their ferrite switches.

Work has started on a new type of switch using two short-slot hybrids. Preliminary tests have shown the switch to have excellent electrical performance. The input voltage standing-wave ratio is close to unity during switching, and it appears that isolations of approximately 70 db might be feasible. A prototype will be built to check the speed of operation and to confirm the preliminary electrical results.

CARCINOTRON STUDIES

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

Period under review: October-December, 1955

The aim of the project is to study the use of carcinotrons as devices for jamming, and to develop experimental jamming equipments.

Carcinotrons are microwave backward-wave oscillators having a very wide electronic tuning range, and output powers up to hundreds of watts. Because the tuning is accomplished electronically, the frequency can be varied at a very rapid rate. The device can be modulated in both frequency and amplitude by frequencies up to at least a few megacycles per second. Efficiencies of up to 30 percent are obtained in current tubes. The presence in a single tube of all these desirable properties permits the development of more effective microwave jammers than have been available previously.

Development of self-contained power supplies for backward-wave oscillators to be used in the low-power test bench is nearing completion. Tests indicate that the short-time stability of oscillation of the CO127 S-band carcinotron is about  $\pm 100$  kilocycles per second when powered by the prototype supply. Some spurious modulation of the output frequency has been noted when a modulation choke is inserted between the tube and the power supply. This is believed to be due to stray pick-up voltages, and an effort is being made to eliminate it. Measurement of the long-term stability of the current-stabilized power supply for the solenoid of the X-band oscillator indicate that a stability of 0.02% is obtained after an initial warm-up period. It is anticipated that construction of the low-power test bench should be sufficiently advanced during the next period to allow a start to be made on investigation of a number of problems connected with the jamming of radars by carcinotrons.

Investigation of the operating characteristics of the type-CM710 carcinotron and circuit problems encountered in the process has continued. From the standpoint of performance, shunt modulation is preferred to series modulation. The carcinotron appears to the modulator as a resistance shunted by a capacitance. A series modulator can charge the capacitance rapidly, but the discharge is governed by the RC time constant. This limitation does not exist for the shunt modulator. However, the shunt modulator requires more power and a separate power supply. An experimental shunt modulator and power supply have been constructed, and components for isolating the modulated electrode for the band of modulating frequencies are being prepared.

A breadboard model of the S-band sweeping receiver was assembled and some

preliminary tests were made. The overall frequency range is 2000-4000 megacycles per second. This full range, or any 400, 200, 100, or 50 megacycles per second portion thereof, can be swept at a rate of about 1000 megacycles per second per second. The bandwidth is approximately 20 megacycles per second, and the sensitivity about -35 dbm. The technique shows promise of being useful as a monitor of frequency for use in conjunction with barrage jammers, and a number of other applications.

A report outlining the progress to date on the project in more detail is in preparation.



TRIALS OF ANTI-JAMMING MEASURES AGAINST CARCINOTRONS

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

Period under review: October-December, 1956

Through the cooperation of the Canadian Army, the RCAF, and DRB, advantage was taken of the flight program for Operation "Bracket" to conduct a test of the AN/MPS-501B when subjected to carcinotron noise jamming. The jammer was flown in an RAF Hastings aircraft.

Two radars were used during the test; one was unmodified, the other was equipped with a new receiver of wide dynamic range and extended bandwidth and with an experimental form of video processing. These modifications considerably increased the usefulness of the radar in the presence of carcinotron noise jamming. A classified report will be issued giving details of this test. Distribution of this report will be made only to technical agencies concerned with countermeasures.

GROUND-TO-AIR COMMUNICATIONS USING IFF

Reference: RCAF. DND Project C37-28-01-05

Period under review: October-December, 1955

This system is proposed to provide an auxiliary ground-to-air communications link for Mark X IFF-equipped aircraft. Laboratory tests were completed on a system using pulse-frequency modulation, with a carrier consisting of double pulses spaced 10 microseconds at a mean PRF of 6000 pulse-pairs per second.

An airborne transponder was modified for flight trials to operate with a suitable trigger generator as the ground-based voice transmitter. At the 6000-PRF of the FM pulsed carrier the transmitter plate voltage was reduced to keep the average dissipation of the tubes within their ratings. Even so, peak pulse powers of 300 watts could be obtained. Initial trials will be performed in conjunction with a TPS-1D radar set, and indications are that the range of the system will exceed 100 miles.

CONFIDENTIAL

FLUTTAR WAVEFORMS

Reference: DRB, RCAF. DND Project D48-38-01-09

Period under review: October-December, 1955

The subject of probability distributions of the output waveforms from radio receivers has been re-examined in considerable detail. This work has much broader application than to the Fluttar Waveforms that inspired it. For example, we have now a simple but accurate explanation of the "break in the baseline". This is in reference to the well known but poorly explained ability of human observers to do a better job of detecting weak targets on a radar scope than they can on a PPI, for instance. There is some hope for improved "detection" devices operating on the same principle as the human observer.

VULNERABILITY OF DOPPLER DETECTION SYSTEM TO COUNTERMEASURES

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

Period under review: October-December, 1955

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 can be done to counter them.

An experimental super-regenerative oscillator was made by modifying an AN-APT/5 noise jammer. Field trials were carried out on an experimental Doppler Detection System Link. The results indicate that this oscillator is capable of jamming the Doppler Detection System either in a confusing manner, or at a level which will deny information from a link of the system. A progress report on the study of the vulnerability of the Doppler Detection System to countermeasures has been prepared and will be issued shortly.

REPORT ISSUED

The following report was issued by the Radio and Electrical Engineering Division during the period under review:

Clemence, C.R.      An Experimental Trainer for Counter-mortar Operators  
(ERB-367) (CONFIDENTIAL)

This report presents an outline of the operating procedure and a brief technical description of a counter-mortar trainer currently under development. As yet, the equipment is more or less in breadboard form, but it appears that a final model, because of its simple circuitry, should occupy only about three cubic feet of space and weigh less than 100 pounds, exclusive of service packaging. Simulation of any mortar velocity or mortar trajectory is possible.