Classified progress report no. 7 (October-December 1956)

National Research Council of Canada. Radio and Electrical Engineering Division

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SECRET

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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.

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SECRET

COUNTER MORTAR RADAR (AN/MPQ-501)

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

Period under review: October-December 1956

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 $2\frac{1}{2}$-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 been continued at NRC. During the period under review liaison was continued with the manufacturer and design authority. Machining of the scanner was continued. The production console was built and a number of the electronic units were completed and tested.

Transmitter

Several visits were made to the manufacturer's plant to correct minor difficulties in the production model of the transmitter. Poor thyratrons, faulty relay wiring and interlocking, faulty cooling duct design and consequent pressure switch maloperation are typical. The transmitter now operates satisfactorily at 75% of rated

power; beyond this point tripping of protective relays occurs — the reason is not yet known.

Two pulse transformers, one built by NRC and one by Hammond, were repaired and returned. One failed owing to faulty oil seal, the other because of slippage of an insulation pad, probably caused by the low friction coefficient of the Teflon winding.

Receiver

A sensitivity time control circuit was tested for use with this radar receiver. The circuit is capable of reducing the receiver gain by any desired value, with a maximum attenuation of 60 db, immediately after the transmitter pulse, and has a variable recovery time constant. A 60-cycle model was built, and a 400-cycle model will be constructed shortly.

Subsequent to a visit to Electronic Associates, Limited, the production model of the receiver preamplifier was returned to Ottawa for bandwidth and noise factor measurements. Quoted noise factors for this preamplifier had been as high as 4.5 db, and there was doubt about the accuracy of the measurements. It was discovered that the entire preamplifier was badly mistuned, thus making previous noise factor measurements of little value. A new input circuit was designed to tune the capacitances presented by the mixer currently in use. This input network was installed, and the remainder of the preamplifier tuned for proper frequency response before noise factor measurements could be made. Finally, the noise factor was measured with various input tubes. The measured values lay between 2.4 and 4.4 db. Most of the tubes yielded values of 3.2 db or less. The median value was 2.7 db, which is close to the expected value for this amplifier.

Computer

Engineering assistance was provided to CAL on a number of design problems associated with the computer. This included elimination of excessive backlash in critical gearing, and setting up an adjustment procedure for the coordinate conversion system.

Antenna

Work was commenced on the development of a polarizer for assessment as an aid during periods of precipitation.

ACQUISITION RADAR MODIFICATIONS (AN/MPS-501B)

Reference: Army. No DND project number.

Period under review: October-December 1956

R.F. SWITCH FOR AZIMUTH SECTOR GATED OPERATION

The purpose of this development is to provide a fast-acting S-band waveguide switch to allow the full magnetron power to be transferred to a dissipative load.

The VSWR of the switch was reduced to less than 1.1 over the entire travel of the vanes, and over the frequency band 2700-2900 mc/s. The tendency to corona discharge was reduced. Preliminary oscilloscope measurements of switching time indicate this to be approximately 0.020 second. The change of isolation during this period has yet to be determined experimentally. The switch was tested at 500 kilowatts (peak) without adversely affecting the transmitter. Further tests are planned to evaluate the effect of the switch on overall radar performance.

RECEIVER AND VIDEO ENHANCER

Development of wide-band Dicke-type receivers and of the video enhancer was described under this program in past issues of this report. However, since these circuits are of wider application, the work will, in future, be recorded under the more general heading "Anti-Jamming Measures". Specific work for any one radar will still be reported on the project sheet.

FIELD MODIFICATIONS OF RCAF GROUND RADARS

Reference: RCAF. DND Project D48-38-03-27

Period under review: October-December 1956

AN/CPS-6B EW Receiver

Field evaluation of the unmodified receiver and a receiver modified according to NRC's suggestion was carried out using a spot jammer. It was found that both the modified and unmodified receivers produced bright strobes if the indicators were operated in the proper manner. However, no bright strobes were produced if the indicators were improperly operated, i.e., if video gain was low.

It was found that the NRC modification increased the dynamic range of the receiver over that of the unmodified receiver, but even this dynamic range was insufficient for the jamming powers likely to be encountered. Hence it is proposed that a logarithmic receiver be built for this system and evaluated.

FLIGHT PLAN CORRELATION EQUIPMENT

Reference: RCAF. DND Project C98-39-30-02

Period under review: October-December 1956

At the present time, radar tracks and flight plans are correlated manually by leafing through copies of flight plans received by teletype. This method is laborious and time-consuming and inadequate in high traffic density. To speed up the correlation process, a unit is being built which employs the Charactron tube to display synthetic targets with flight-plan data superimposed. Each flight will be indicated by a group of four characters which moves across the tube with heading and velocity determined from the flight plan. The prototype equipment will be capable of displaying four linear tracks, with four characters on each track which will be used for displaying the track designation, altitude in thousands of feet, and aircraft type. The flight plan information will be written on the tube along with the radar information on a time-sharing basis, the radar information being written with a beam which has been formed by passing it through one of the holes in the matrix of the Charactron. The equipment has been designed to operate with the FPS-3 radar, and will be capable of displaying radar information on two ranges, 150 miles and 300 miles.

During the period under review the storage and switching units were completed and the first of the four track generators was built.

AREA MOVING TARGET IDENTIFICATION

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

Period under review: October-December 1956

No work was carried out on this project: an improved Radechon storage tube was received and suitable power supplies and data-switching equipment were built, but this work was done with a view towards using the tube as a video integrator. It is still too early to say whether or not this will be feasible.

REMOTE RADAR DISPLAY

Reference: Army, RCAF. No DND project number.

Period under review: October-December 1956

This system is being 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 accuracy or quality.

No further work was done on the remote display equipment. Arrangements are being made to obtain a commercial microwave relay system for further field trials and demonstration. It is planned to transmit PPI information from an AN/MPS-501B radar at the Metcalfe Road Field Station to the remote indicator located in Building M-50, a distance of approximately 5 miles.

LOW ANGLE DETECTION

Reference: Army, RCAF. No DND project number.

Period under review: October-December 1956

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 possibilites of high-resolution radar to enable a complete proposal to be formulated.

Operation of this unit has become routine, and expected difficulties with heavy clutter are observed. Receiver saturation and limiting are obvious causes of trouble. The extent of the clutter also makes it difficult to find targets readily even though they are clearly visible when free of the clutter area. The influence of higher resolution on this problem is being studied through the use of various pulse lengths and appropriate receiver bandwidths.

The problem of saturation is being attacked first; two different approaches will be made — a logarithmic receiver and a detector circuit which is nonlinear with amplitude will be evaluated.

During the period under review, propagation calculations were made as an aid in determining the low angle coverage of ship-based radars. "Field strength vs. height" curves were plotted from the calculations, for wavelengths of 25, 10, 3 and 1.87 cm, at ranges of 25 and 50 statute miles. Because of the difficulty of treating the problem exactly, simplifying assumptions were necessary. In this problem, a smooth, spherical, perfectly reflecting earth was assumed. Atmospheric absorption, which becomes important at the shorter wavelengths considered, was included in the path losses. Charts have been prepared showing the free-space radar range required for detection at various heights as a function of wavelength used.

SOUND-RANGING COMPUTER

Reference: Army. No DND project number.

Period under review: October-December 1956

The computations on the records obtained at Shilo last summer are almost completed. Results obtained from the division shoot have not yet been analysed. Several sets of locations of guncotton charges have been calculated. In one case, 19 bangs were set off at a range of approximately 4000 meters in front of the base. Using the small diamond-shaped base (length 4000 meters) all the locations were contained within a rectangle 101 meters by 20 meters. Using the larger base (length 8000 meters) all the locations were contained within a rectangle 45 meters by 11 meters. The error in the location of the mean point in the first case was -11 meters in eastings and -22 meters in northings; in the second case the error was -5 meters in eastings and -22 meters in northings. In both cases, the meteorological corrections were made using the wind and temperature correction graphs.

RADAR INTERFERENCE EFFECTS IN MICROWAVE RADIO RELAY

Reference: RCAF. No DND project number.

Period under review: October-December 1956

With the rapid increase in the use of microwave radio relay systems in Canada, a possibility of interference to these services by high-power radar sets has been created. The problem is most acute at one site on the Bell Telephone Company's Trans-Canada System in Northern Ontario where topographical considerations require that an AN/FPS-3 radar and a TD-2 microwave relay be placed only about 3000 feet apart. This particular relay system carries television programs as well as multi-channel telephone circuits, and Bell Laboratories measurements have shown that the tolerable interference level is considerably lower for television than for telephone service.

At the request of the RCAF, NRC agreed to examine this problem by using the AN/TPS-1D radar, on loan to NRC from the RCAF, in an attempt to produce interference with a TD-2 link. This radar and the AN/FPS-3 use the same magnetron type, and operate in such a frequency band that third-harmonic radiations would fall in the TD-2 frequency band. Preliminary measurements of third-harmonic output and a literature search revealed extreme variability and large dependence on radio-frequency plumbing. Values of third harmonic ranging as high as -40 db and as low as -70 db relative to the fundamental were noted or measured. Since the two radars use completely different antennas and feed systems — the FPS-3, waveguide and the TPS-1D, coaxial line — it was decided that an instrument for field measurement of harmonic radiations should be constructed and used as a transfer standard between specific radars and the signal generators used to check the interference susceptibility of microwave links. Such an instrument was built, calibrated, and tested until it was felt that measurements could be reported within about 2db.

Measurements were then made at a typical RCAF FPS-3 site in those accessible positions most closely corresponding to the relative positions expected at the incompleted Northern Ontario site. A preliminary study of the tolerable interference level was started. The Bell Telephone Company installed a TE-2 relay link (a simplified portable TD-2 system) between their downtown Ottawa TD-2 terminal and NRC building M-50. A television program was transmitted over this link and pulse interference added at NRC. An unofficial viewing panel, consisting of representatives of the Department of Transport, the RCAF, and the Bell Telephone Company, then established

tolerable levels to serve for the present time.

Unfortunately many unknowns still remain in the dual system since the radar is not yet installed and the normal range of TD-2 signal levels at the particular site has not yet been well established. Additionally, variations might occur between the TD-2 and the TE-2. However, measurements to date indicate that 10 to 15 db protection will be available even during moderate fades on the TD-2 link. Should this degree of protection not be achieved, actions such as radar frequency shifting, third-harmonic reject filters, or antenna screens could be employed.

Measurements are being continued as time and equipment availability permit.

INSTANTANEOUS MICROWAVE DIRECTION FINDER (AN/UPD-501)

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

Period under review: October-December 1956

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 signals displayed on a cathode-ray tube as a radial line from which bearings may be read.

Development of antennas for AN/UPD-501 was continued during the period under review.

Experimental four-channel antennas operating from 1.0 Kmc/s to 11.0 Kmc/s with vertical and horizontal polarization were designed. Six antenna systems are required to cover the band, three of which are horizontally polarized and three vertically polarized. Each system includes two cylinders and each cylinder is 10 inches in diameter and about 8 inches long. The three frequency bands covered are 1.0 to 2.35 Kmc/s, 2.35 to 5.5 Kmc/s and 5.5 to 11.0 Kmc/s. It is intended that a normal installation will consist of two antenna systems covering two frequency bands or two polarizations of the same band.

Design of the vertically polarized S-band antenna (2.35 to 5.5 Kmc/s) was completed. Bearing errors less than ± 15° were obtained by means of beam-shaping elements at the aperture which complicate the antenna considerably.

An experimental antenna for Ku band, 11.0 to 20.0 Kmc/s, is nearing completion. This antenna consists of eight channels mounted in a 10-inch-diameter cylinder. The horns may be assembled for reception with either vertical or horizontal polarization, or with both polarizations with a 3-db loss. The flexibility is possible mainly because eight horns are used instead of the usual four. This considerably reduces bearing errors caused by: (a) crystal sensitivity unbalance, and (b) departure of antenna patterns from an error-free shape.

The eight-channel antenna is connected to the four-channel UPD-501 indicator through a resistive resolving network. Several types of networks were built and tested in order to obtain the optimum design.

Experimental eight-channel, dual-polarization antennas were built and tested at X-band and at S-band. A single antenna system will operate with both polarizations over the same frequency range as a four-channel antenna. In both eight-channel antennas, errors caused by unbalance of the antennas, and by patterns

were much less than in the four-channel case.

A report is being prepared on the operation of an eight-antenna system, in which the advantages over a four-antenna system are discussed.

A quick-disconnect device for mounting cylindrical antennas was designed at Cossor Canada, Limited, through an Industrial Assistance Contract. The mechanism appeared to be satisfactory. Since the completed antenna was slightly too heavy for the CS2F aircraft wing-tip mounting, the contractor was requested to modify the design to lighten it as much as possible.

The design of a method of balancing the UPD-501 four-channel antenna by means of small monopoles normal to the cylinder and equispaced between the horn apertures was completed for both the X-band and S-band antennas. An adjustable stripline-type of power splitter was used, and appears to be satisfactory.

An antenna operating in the band 480-620 mc/s is being developed. It consists of eight folded dipoles mounted symmetrically around a 10-inch-diameter cylinder, connected through a resolving network to the UPD-501 indicator. By mounting the dipoles at 45° to the vertical, and in a plane parallel to a plane tangential to the cylinder, dual polarization can be achieved. Some further design work is required on this antenna to obtain satisfactory performance. A coaxial crystal mount was designed to operate in this band with a VSWR of about 4:1. A band pass filter, using stripline techniques, was fabricated for this antenna.

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

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

Period under review: October-December 1956

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.

Design of the input coupling transformers and associated circuits was completed, with the exception of some final tests of their overall performance in the system.

Four change lists were submitted to the RCN, proposing a number of corrections to the existing drawings. The fifth and final list will be submitted shortly. During the period under review the last unit of model#3 prototype receiver to be supplied by the contractor was received and tested for performance.

The polarization error test equipment was completed and is ready for trial on the new Fiberglas tower.

Final corrected drawings of the recorder mechanism were turned over to the contractor.

SHIPBORNE HIGH-FREQUENCY DIRECTION FINDER

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

Period under review: October-December 1956

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.

The three-channel receiver is operating satisfactorily on outside signals fed to it from the S25B crossed-loop aerial outfit.

Modification of the CFT-52300 target transmitter was discontinued in favour of a more convenient system for providing an external test signal. The test signal frequency is now obtained from a signal generator, and passed through a wide band amplifier which feeds the transmitting aerial through a length of cable. This arrangement allows the test signal to be controlled at the same time as the three-channel receiver, and provides much better control of test signal field strength, but the test signal aerial is not conveniently portable. This latter disadvantage is not considered to be serious.

Calibration of the test-signal field strength was carried out using a Stoddart Radio Interference and Field Intensity Meter model W.M. 20A. The three-channel receiver is being calibrated.

MAGNETIC SIGNATURES OF ALUMINUM MINESWEEPERS

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

Period under review: October-December 1956

Investigation of magnetic fields associated with Canadian minesweepers of aluminum and wood construction was continued. Laboratory tests were made on some of the equipment used in the current shunt method of degaussing. These tests disclosed a phasing condition in the control system which will assist in explaining the large phase lag which was found necessary for satisfactory degaussing by this system. The results of these tests will be included in the second "Comox" report.

FIELD CONTOURS OF MAGNETIC SWEEP

Reference: Navy. DND Project A17-05-60-05

Period under review: October-December 1956

This project was undertaken at the request of the RCN. Its objective is to produce a map of the magnetic field of a new type of current loop used in magnetic minesweeping. A method of carrying out the investigation by the use of a model technique has been established.

All equipment necessary for the investigation was constructed.

A model measuring range was built using a scale factor of 180. The model sweep is supplied by 5 kc/s alternating current and the field explored with a small 1000-turn air core search coil. The movement of a recording d-c milliameter is utilized to move the search coil continuously along a wooden track positioned below the model sweep. The magnetic field of the sweep is thus traversed at the desired depth. The output from the search coil is amplified and converted to direct current by a phase-sensitive rectifier, and then fed into the recording milliameter. A continuous record of the field along the traverse is obtained in this manner. All three components of the magnetic field of the sweep may be obtained. The records are used to plot contour maps of the field.

Contour maps of the field of the sweep at a depth of $6\frac{1}{4}$ fathoms are nearly completed. Further measurements will be made at 10, 20, and 30 fathoms.

STRAY FIELD MEASUREMENTS OF IMPULSE GENERATORS

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

Period under review: October-December 1956

This project was undertaken in cooperation with the Royal Canadian Navy to investigate the magnitude and origin of stray fields of impulse generators used for minesweeping. The project has been completed and a report is in preparation.

Two 3000-ampere 540-kw generators were tested. Both exhibited a non-linear relationship between magnitude of stray field and pulsing current. The maximum vertical component of stray field at the ten-foot level above the generator shaft, for example, increased from 4 milligauss to 15 milligauss as the pulsing current was increased from 2000 amperes to 3000 amperes.

The strength of the stray field was found to vary as the inverse 3.4 power of depth.

The two exciters which are mounted on top of the main generator were found to have no measurable effect on the stray field.

The measurements indicated two main sources of stray field — current loops in the machine and leakage of flux from the yoke. At high pulsing currents the yoke leakage effect is predominant and from a distance appears similar to the field of a vertical dipole. Measurements of yoke thickness show that the yokes of the two machines are oval-shaped, with the thickest sections near top and bottom. This nonuniformity of yoke thickness may be one cause of high stray fields, since it tends to direct the leakage flux in the vertical direction.

Reduction of the stray field by means of a horizontal compensating coil connected across the generator output terminals was attempted. For 3000 amperes pulsing current the maximum vertical stray field measured at the 10-foot level was reduced from 15 milligauss to 3.5 milligauss.

The field of the iron of the unexcited generator was measured in a vertical earth's field of 490 milligauss. The maximum vertical component was 7.1 milligauss at the 10-foot level above the machine. During a current pulse the change in permeability of the generator iron caused the field of the iron to decrease, thus producing an upward pulse of field above the machine. For 3000-ampere pulsing the field of the iron at the 10-foot level was found to decrease by 15 percent during a pulse.

Measurements of stray field were also made on the generator auxiliary equipment.

CRASH POSITION INDICATOR

Reference: RCAF. No DND project number.

Period under review: October-December 1956

In the period under review further experimental work, as well as field tests, were continued.

The SARAH unit was found the most acceptable receiving system for the CPI under present circumstances. As a result, modifications of the CPI design were found necessary in order to permit the triggering action of the SARAH sweep display system to respond to the signal transmitted by the CPI. Among a number of possible solutions to this problem, which were investigated, suitable reshaping of the transistorized B+ power supply output waveforms and elimination of the squegging circuit of the transmitter were found to yield most satisfactory results.

Field tests with a new CPI model incorporating the described changes, and a SARAH receiver unit revealed a reception range of 25 miles, under favourable conditions.

EXPERIMENTAL ANTENNA FOR S-BAND SURVEILLANCE RADAR

Reference: RCAF. No DND project number

Period under review: October-December 1956

For several years a program of modifications was carried out to improve the performance and extend the application of the basic AA No. 4 Mk. 6 S-band acquisition radar. Because of service interest in greater coverage and a higher data rate at all aircraft altitudes, a larger antenna with special characteristics has been designed for this, or other S-band radars. It is a semi-parabolic cylinder having an aperture of 36' × 6', and fed by a single slotted-waveguide radiator. It is designed to make either a cosecant-squared pattern or a pencil beam available to the operator by remote control, thus avoiding the physical size and complications inherent in a back-to-back configuration of two antennas. The beam shape is controlled by deformation of a portion of the reflector surface, the pencil beam being formed by pulling the surface back against parabolic-shaped ribs. The horizontal beamwidth is approximately 0.7 degrees.

Flight trials were run, in conjunction with an AN/MPS-501B radar (500 kw, 2 μsec, 440 pps, 10.5 db N.F.), the antenna being rotated at 5 rpm on a 40-foot tower. Using the cosecant-squared pattern, tests with a small T33 jet aircraft confirmed the predicted coverage. The maximum range (for 75% blip-scan ratio) on this target was 95 nautical miles outbound and 85 nautical miles inbound, at 20,000 feet. Estimated coverage on a B-29 aircraft for this antenna-radar combination is 200 nautical miles.

Trials using the pencil-beam pattern are in progress. Preliminary results confirm the expected coverage patterns with ranges on a T33 of approximately 120 nautical miles with the beam set at 3° above horizontal. Ranges of approximately 175 nautical miles have been noted consistently on random aircraft believed to be of the CF-100 type.

MODEL ANTENNA STUDIES FOR HMCS "BONAVENTURE"

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

Period under review: October-December 1956

During the period under review radiation pattern measurements were started on the HF antenna system for HMCS "Bonaventure". The measurements are being carried out on the newly constructed 200' x 70'HF shipborne-antenna pattern range.

MODEL ANTENNA STUDIES FOR HMCS "LABRADOR"

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

Period under review: October-December 1956

A request was received from Naval Technical Services, NDHQ, Ottawa, to study the VHF/UHF antenna system for HMCS "Labrador". It was reported that the existing antenna system did not provide reliable ship-to-air communications, especially on forward bearings of the ship. Model studies on three UHF and two VHF antennas were carried out in order to determine the best antenna arrangement for most effective all-round coverage.

Radiation patterns measured on the three UHF antennas (AT-150/SRC) in their present location demonstrate conclusively that the shadowing effects are caused primarily by the AN/SPS-10 radar reflector. It appears that in order to achieve the most effective all-round coverage, the antennas must be located above the AN/SPS-10 reflector. It was found that the metal-pole mast on which the antenna spurs were mounted also contributes to the pattern distortion. A small but definite improvement in the circularity of the patterns was achieved by employing a dielectric pole.

Pattern measurements are being continued on the two VHF antennas.

X-BAND WAVEGUIDE SWITCH FOR THE ROYAL CANADIAN NAVY

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

Period under review: October-December 1956

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

As a result of the performance of the S-band waveguide switch (see p.3) it is proposed to move the vane in this X-band switch in the H-plane rather than in the E-plane. An experimental model using a vertical vane actuated by a rotary solenoid is being constructed. Alternative mechanical designs are being considered.

CARCINOTRON STUDIES

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

Period under review: October-December 1956

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

Investigation of the effects of frequency modulation by noise barrage jamming of radar receivers, using the low power test bench, was continued. Detailed measurements of camouflage factor (the maximum value of the ratio of jamming power to signal power in the receiver bandwidth for which the signal is detectable) were made, using both A-scan and PPI displays. Two receivers, one having a linear and the other a non-linear input-output characteristic, and each with bandwidths of about 1 mc/s, were tested. The effects of changing jamming level, modulation bandwidth, barrage width, and the position of the receiver frequency relative to the frequency range of the barrage were determined.

Comparison of the frequency-modulation-by-noise type of barrage jamming with that generated by combined frequency-modulation-by-sine-wave and random-amplitude-modulation-by-superregeneration was made. Under the proper conditions there appears to be little to choose between the two signals in ability to mask radar signals, but use of the latter method should effect a saving in modulator weight and power requirements.

A receiver of the wideband-input plus limiter (or "Dickefix") type was constructed, and is undergoing tests similar to those described above for the narrow-band receivers. Two additional low power test bench equipments are nearing completion and will be used to study the effect of multiple jammers, and to increase the rate at which measurements can be made. Tubes and auxiliary equipment are now on hand for operation of the low power test bench in the frequency ranges 1-2 Kmc/s, 2-4 Kmc/s, and 7.5-15 Kmc/s.

ANTI-JAMMING MEASURES

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

Period under review: October-December 1956

BROADBAND IF AMPLIFIERS

The two recently introduced Phillips high figure-of-merit tubes have both been used satisfactorily in broadband multi-stage amplifiers. These tubes are the type-E88CC, a double triode suitable for "all-cascode" strip, and the type-E180F or 6688, a pentode. Considerable difficulty was experienced at first in trying to use either tube; more than two or three stages would invariably oscillate. Very careful attention to layout has virtually eliminated all traces of instability, and important experience in building stable, predictable amplifiers has been gained.

Input stage design, with Western Electric type 417-A/5842 tubes and transitional-coupled double-tuned input matching (using either equivalent T or π networks) appears to have reached theoretical performance; bandwidth exceeding 20 mc/s while maintaining an IF noise figure similar to that of the normal receiver will pose a problem. However, the noise figure is important only in the center of the band, because in normal, or unjammed operation a narrow-band filter precedes any substantially non-linear circuit action. It is a little academic to worry unduly over input stage thermal noise when one is subjected to heavy jamming, and this is the only situation which would normally allow noise contributions from the full IF bandwidth to appear in the output, because of the limiting action preceding the narrow-band filter.

IMAGE REJECTION

Several waveguide cavities were built to reject image frequency. These were tested against a carcinotron frequency-modulated noise jammer. A cavity with a Q_L of 40 gave an improvement in MDS of 2.6 db. With a Q_L of 70 the improvement was 3.1 db, and with a Q_L of 90 the improvement was 4.1 db. These figures were obtained using an "A"-type display and three observers.

A cavity with a Q_L of 1450 at 2900 mc/s showed no improvement, and considering the loss in the cavity, would give an overall loss. The bandwidth of the cavity was 2 mc/s and the receiver bandwidth was 1.2 mc/s. This would indicate that a wideband receiver following a narrow-band TR tube would not give the results expected.

DUAL RECEIVER

A two-channel receiver is being built to study any correlation present in the noise from a carcinotron jammer.

VIDEO ENHANCER

The new 3" cathode-ray tubes with P24 phosphor screens have not arrived yet, therefore no work has been done on the video enhancer during the period under review.

ANTENNA FOR X-7769 CARCINOTRON JAMMER

Reference: DRB. DND Project D-48-44-20-01

Period under review: October-December 1956

The requirement is for an antenna which will radiate a vertically polarized signal, omnidirectional in the horizontal plane. The pattern is to be 28° wide at the half-power points, which are at 2° and 30° measured downward from the horizontal plane. A gain of at least 3 with respect to an isotropic radiator is desired. Power to be handled is 1 kilowatt; bandwidth is from 2500 to 3500 mc/s at a standing-wave ratio of not more than 2. Flush-mounting on the under surface of the aircraft is desirable.

During the period under review attention has been confined to the circular dielectric-clad surface wave antenna (see previous Quarterly Progress Report). An X-band model has been constructed, and patterns taken. The side lobes were found to be reasonably low, and the patterns were quite frequency-insensitive.

Various modifications to the diameter and thickness of the dielectric slab are at present being carried out, with a view to obtaining the optimum beamwidth and beamtilt.

VULNERABILITY OF DOPPLER DETECTION SYSTEM TO COUNTERMEASURES

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

Period under review: October-December 1956

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.

No work directly connected with the Doppler Detection System was done in the period under review. While awaiting further advice the investigation of superregenerative devices was continued.

Study of the application of a combination of quenching and sweeping voltages to a backward-wave oscillator, to generate wideband barrage jamming noise is being continued. Measurements indicate that for many applications this jammer is as effective as FM barrage jamming, and is simpler and lighter in construction. Studies of limiting factors are being continued.

GROUND-TO-AIR COMMUNICATIONS USING IFF

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

Period under review: October-December 1956

Work was resumed on this project following a decision by the RCAF to proceed with operational trials. At least three high-speed aircraft will be fitted with airborne demodulators to be built by an outside contractor. Measurements were made on the experimental demodulator and from these results, specifications were prepared. For the ground equipment, which will be installed at one of the Pine-Tree radar sites, the antenna pedestal and turning gear from an ISG-98 radar, and an AS-295B IFF antenna have been obtained on loan from the RCAF. These two units will be used together with a co-axial rotating coupler. The hand-positioning control and the desirability of rate-aiding the antenna are now under consideration.

FLUTTAR WAVEFORMS

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

Period under review: October-December 1956

There was nothing to report on this project during the period under review.

PRESENTED PAPERS

The following papers were presented by members of the staff:

Jones, S.G. — Some New Developments in Electronic Countermeasures. Paper presented at Royal Canadian School of Artillery, Picton, Ont., December 6, 1956

Morris, W.M. — The Eddy Current Problem in Aluminum Minesweepers. Paper presented at Eighth Symposium of the Defence Research Board, held at Ottawa, Ont., December 14, 1956

CLASSIFIED REPORTS ISSUED

The following classified reports were issued by the Radio and Electrical Engineering Division during the period under review:

Wong, J.Y. — Design of a Gap-filler Antenna for AN/FPS-503 (ERA-307, Secret)

This report presents the design and results of a gap-filler antenna for use in conjunction with the AN/FPS-503 McGill Fence doppler detection antenna. The antenna is basically a sectoral electromagnetic horn capable of producing a rectangular-type pattern in the elevation plane and a semi-circular pattern in the azimuthal plane. The respective patterns are achieved by means of a metallic post located in the mouth of the horn and a set of metal flanges attached to the long sides of the antenna aperture. The maximum gain of the antenna relative to an isotropic radiator is about 8.4 db.

Wong, J.Y. — VHF/UHF Antenna Patterns for HMCS "Crescent" (ERB-395, Confidential)

Results of pattern measurements on five different

VHF/UHF antennas for HMCS "Crescent" are presented. Measurements were carried out on a 1/6-scale model of the destroyer's foremast. Reliability calculations by personnel at Naval Technical Services, National Defence Headquarters, Ottawa, for the AT-150/SRC antennas reveal that on the average the performance is somewhat inferior to that of the DE-205 antenna arrangement.

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