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RADIO AND ELECTRICAL ENGINEERING DIVISION

CLASSIFIED PROGRESS REPORT NO. 33

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OTTAWA

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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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COUNTER MORTAR RADAR (AN/MPQ-501)

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

Period under review: April-June 1963

ANTENNA

Scattering Measurements

A method of supporting targets, using a Styrofoam column and string, has been developed in which the background scattering is less than -40 db, referred to a square meter. This is considered satisfactory for the targets at hand and a number of patterns have been obtained. A decibel pattern recorder and Scientific Atlanta receiver have been incorporated into the measurement apparatus.

RANGE OSCILLATOR AND TRIGGER UNIT

Improved circuitry has been built into these units, but a complete assessment has to await a new transmitter. Provision for gating-off the transmitter trigger during the inter-beam period has been included.

TRANSMITTER

This unit is now ready for test with the new magnetrons which were received very recently.

TARGET SIMULATOR

The second model has been made available to the RCEME School for use in conjunction with the Counter Mortar Radar there, and a third model has been built for use here in testing the Video Storage Unit.

VIDEO STORAGE UNIT

The special power supply was completed, and although it did not completely eliminate range jitter, it improved the performance of the video storage unit to the point where it was within tolerance on the short range sweep (12 kilometers), and showed some promise of attaining acceptable performance on the long range sweep (20 kilometers).

WAVEGUIDE WINDOWS

The main factors causing window breakdown in the radar appear to have been moisture (condensation) on the low-pressure face and excessive mismatch due to faulty operation of waveguide switches. These problems are being resolved. A new design of window capable of handling much greater power has been developed.

IMPROVEMENTS TO GROUND RADARS

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

Period under review: April-June 1963

VARIABLE VELOCITY NOTCH MTI

It can be shown theoretically that by shifting the frequency of the coherent oscillator in a coherent MTI system, the blind speeds of the radar's MTI can be shifted. If the radar is the AN/FPS-508 with a PRF of 360 c/s and operating at L-band, the first blind speed can be altered from zero nautical miles/hour to 80 nautical miles/hour by shifting the frequency of the coherent oscillator by 360 c/s. This shifting in blind speed is difficult in a normal radar using a magnetron as the radar's master oscillator because of the complexity of the frequency shifting circuitry. However, in a fully coherent system, such as the AN/FPS-508, it is extremely easy, as all that is required is a reasonably stable 30 mc/s oscillator which can have its frequency altered by 360 c/s.

The Northern Electric Company built a pre-production model of the single oscillator unit described in a recently issued report (F.R.Hunt, "Variable Velocity Notch Moving Target Indication", NRC Report ERB-628, April 1963, Confidential). Difficulty was encountered initially with the stability of the video cancellation circuitry. However, back-biasing of the diodes used in the bi-polar detector improved the long-term stability. They are now completing the drawings necessary for producing units for all AN/FPS-508 sites. The United States Air Force have requested a demonstration of the pre-production unit at one of their sites in mid-July. The RCAF have agreed to make the unit available.

Trials of a more sophisticated model were also held during the period under review. The unit was designed to permit cancellation over much wider areas and to provide for the choice of either MTI or Dicke receivers in various sectors. The unit performed as expected. Against a solid sheet of chaff, excellent cancellation was obtained. However, during the trial on the second evening, the chaff was dropped over a more extensive area. There was a large amount of wind shear, and consequently only part of the chaff in any area could be cancelled. It was decided to have Canadian Arsenals Limited build an experimental model of the multi-sector unit for more extensive testing.

RADAR PERFORMANCE EVALUATION

Reference: RCAF. DND Project 098-38-02-09

Period under review: April-June 1963

Seven half-mil Mylar balloons have been received from the manufacturer and are undergoing static tests together with twenty 1 mil Mylar balloons.

X-BAND GROUND SCATTER MEASUREMENTS

Reference: RCAF. No project number.

Period under review: April-June 1963

The RCAF has made a proposal for an electronic airborne jammer which would combine the masking properties of a conventional jammer with the main advantage of a decoy; i.e., the possibility of diverting the interceptor from the target to a decoy. Briefly, the airborne jammer feeds a directional antenna with very low side lobes directed at the ground below the jamming aircraft. To an interceptor, the jamming appears to come from the ground rather than from the aircraft. At the same time, the jamming is strong enough to mask active radar returns from the jamming aircraft, even though the jamming is coming in the side lobes of the interceptor's radar antenna. In order to evaluate the feasibility of such a jammer, measurements must be made of the scattering properties at X-band of various types of terrain.

The jammer used in the measurements was an AN/ALT-4 with an output of approximately 120 watts. This was directly coupled to the downward-looking antenna mounted on the under side of a North Star aircraft. By means of a 30 db directional coupler and an 0 to 20 db attenuator, a portion of the output of the transmitter was also fed to a standard horn antenna mounted on the side of the aircraft.

A small airborne radar, the AN/APS-3, was mounted in a Dakota aircraft. Its antenna was mounted in the open door, an arrangement that allowed it to scan vertically. One of the radar's indicators was used by the observer while the second had a camera fitted to it.

The two aircraft flew side by side with the distance of separation being varied from one-half to four nautical miles. When a measurement was to be made, the observer in the Dakota aircraft equalized the noise levels of the direct and reflected jamming strobes by having the jammer operator vary the attenuation in the horn antenna feed. One db difference was readily apparent on the radar indicator when the gain of the radar receiver was reduced until both strobes were just barely visible. At each measurement, a photograph was made as a check on the observer. Subsequent comparisons have shown that about five percent of the readings required alteration. The latter readings coincided with the roughest parts of the flights.

The measurements included flights over flat farming country, hilly wooded areas, and calm water. Horizontal and vertical polarizations of the radar antenna and parallel and cross polarizations of the jammer's tunnel antenna with reference to the radar antenna were used. Analysis of the results has just been commenced. No further flying trials will be held until next winter, when the flights will be repeated over snow-covered terrain.

SOUND-RANGING COMPUTER

Reference: Army. DND Project B105-38-50-08

Period under review: April-June 1963

PURPOSE

The purpose of this equipment is to provide a sound-ranging system which will reduce errors in film reading, in application of meteorological corrections, and in calculation of locations. It will provide equipment for magnetic storage of sound data, and facilities for computation of sound source locations by means of a special digital computer.

COMPUTER

Most of the faults in the computer have now been corrected, and a considerable number of locations have been computed, using data obtained during the fall of 1958, which had been processed earlier on the IBM 650 computer. Results obtained using our computer were compatible with those obtained on the IBM 650 computer. Approximately 200 locations were calculated on the computer during the trials held at Camp Shilo, Man., in June. As is to be expected, the computer-calculated locations were more consistent than those obtained by plotting.

Several minor changes are required in the store circuits to eliminate overheating. The digit inhibit drivers draw too much current and operate at a temperature 30 to 40 degrees F above ambient. These circuits will be modified to permit operation at lower current levels.

PROGRAM

The present sound-ranging program results in significant errors for locations close to the base, owing to the asymptote approximation and method of correction. This error can be as high as 30 meters at very close range. A new program is being written which applies the asymptote correction differently to eliminate this error.

CIRCUITS

The modulation system, which is a suppressed carrier type, is not satisfactory since it requires regeneration of the carrier (for demodulation) after data speed-up. It was expected that the timing channel would provide the required frequency, but it is now apparent that phase variations in this channel in the tape playback introduce excessive distortion. Other modulation methods are being considered.

The digital delays and the display circuitry operate satisfactorily.

MAGNETIC DRUM

No major damage to the equipment was apparent as a result of the road trip to Camp Shilo. However, some apparent changes in the head-to-drum spacing of the magnetic drum heads are under investigation. The variation in response between heads seems to have increased by several decibels over that tabulated previously in the laboratory. In addition, spurious end-of-track pulses were in evidence on the display tubes, causing confusion with the desired signals.

TRIALS

During June, the equipment was transported by road (1500 miles) to Camp Shilo, for engineering trials. A microphone base approximately 7,500 meters long was used, and locations were made at ranges up to 10,000 meters. Detailed meteorological information was gathered during the period of firing. Radiosonde flights were made hourly up to 10,000 feet, and wind balloon flights, using a double theodolite base on the half-hour, between the radiosonde flights. All firings were recorded using a multi-channel FM tape recorder so that they may be played back through the equipment, as desired. Direct comparison with conventional sound-ranging results will be possible, as all sounds were recorded by a duplicate microphone base and a No. 5 Recorder. A trained sound-ranging team read these records and plotted the locations on a plotting board.

MODEL ANTENNA STUDIES FOR RCN

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

Period under review: April-June 1963

HF ANTENNAS

In an attempt to reduce the coupling between the receiving whips and the transmitting antennas on the General Purpose Frigate model, the whips were replaced with a fan-type antenna installed on the side of the main deck. Isolation figures of the order of 50 db were obtained, compared with 35 db for the whips. Input impedance characteristics of the fans appear to be satisfactory.

In addition to determining the coupling between receiving and transmitting antennas, the problem of coupling between a pair of transmitting whips has been investigated. For this case, about 15 db of isolation was obtained at the off-resonant frequencies and about 3 db at resonance.

Construction of the 1/48-scale model of the General Purpose Frigate has been finished, and radiation pattern studies of the HF antennas will be started after completion of the shipborne pattern range. The problem of determining a suitable criterion for assessing the performance of an HF shipborne antenna based on pattern measurements is being investigated. To date, the analysis proposed by NRL has been used; however, it is felt that their approach is somewhat inadequate and needs to be refined in the light of RCN operational requirements.

A number of structural changes in the superstructure of the DE-205 "St. Laurent" destroyer escort has been planned by DGFE/RCN. These modifications have necessitated further impedance and coupling measurement on our impedance model. At the same time a new type of HF antenna is being considered which utilizes the ship's foremast as a support for a normal-beam helix antenna.

ECM ANTENNAS

Drawings and radiation patterns of the 300-1000 mc/s spiral D/F antenna were forwarded to DGFE/RCN for evaluation, and found to be acceptable. As a result, tenders are being called by DDP for the manufacture of about 60 units of the antenna.

The development of an X-band conical spiral antenna for providing coverage suitable for ECM is under way. Three antennas have been built; their construction differs only in the manner of supporting the windings. Radiation patterns are being carried out to determine the optimum configuration.

TRACKING ANTENNAS FOR CL-89 DRONE

Reference: Army. No Project number

Period under review: April-June 1963

K_u-BAND ANTENNA

Tests of both K_u-band units have been completed. Radiation patterns were satisfactory, with beamwidths slightly less than 1° in elevation and side lobes of -28 db at the center of the band, rising to -24 db at the limits of the frequency band. Measurements of VSWR, squint angle, and power left over were made. The antennas have been shipped to Canadair Limited.

X-BAND ANTENNA

A second all-metal antenna was fabricated and tested on the pattern range. In this antenna, space was left below the feed horn to accommodate absorbing material which was needed to reduce spurious reflections. A second piece of absorbing material was placed in the bottom part of the aperture to absorb reflections from the feed horn. In this manner, quite acceptable elevation radiation patterns were obtained.

Initial azimuth radiation patterns were quite poor and changed rapidly with frequency. This behaviour was caused by a higher order mode which was able to propagate between the parallel plates of the antenna. The feed horn was next modified to reduce the amplitude of the unwanted mode. This modification --- addition of a flare in the H-plane of the horn --- improved the performance of the antenna considerably.

CLASSIFIED REPORTS ISSUED

Evans, G. — Final Report on the Development of the NR-2 Shipborne Direction Finder (AN/SRD-501) (ERB-631, Secret)

A breadboard model of the NR-2 (AN/SRD-501) shipborne high-frequency direction finder has been built. In this report the design philosophy is described and the lines along which further development might proceed are indicated. Some very preliminary results obtained with the equipment are discussed briefly.

Evans, G. — Operating and Maintenance Instructions for the NR-2 Shipborne High-frequency Direction Finder (ERB-632, Secret)

Hunt, F.R. — Variable Velocity Notch Moving Target Indication (ERB-628, Confidential)

The RCAF considers chaff to be one of the main threats in an air attack because of the presentation of a large number of false alarms to a PPI operator or to the automatic data transmission equipment (the AN/FST-2). Normally, MTI is not effective because the radial velocity of the chaff lies outside the blind speeds (velocity notches). In a fully coherent radar, such as the AN/FPS-508, it is a simple matter to fit a variable-frequency oscillator to shift the velocity notches to cover the chaff's velocity. The design and evaluation of a Variable Velocity Notch Moving Target Indication (VVNMTI) system is described. A more sophisticated design is proposed which will reduce the number of true targets lost owing to the velocity notches.

Hunt, F.R. — A CFAR Logarithmic Receiver (ERB-629, Confidential)

The RCAF requested the National Research Council to design a receiver with fast recovery time after large-amplitude signals of long duration due either to clutter or electronic jamming. A CFAR output was also required, to avoid over-loading the AN/FST-2 data transmission equipment in the presence of the common types of electronic jamming. The logarithmic receiver formed the basis of the design because of its large dynamic range.

A video automatic gain control circuit was used to maintain the CFAR output. The receiver and its evaluation are described in this report.