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NATIONAL RESEARCH COUNCIL OF CANADA
RADIO AND ELECTRICAL ENGINEERING DIVISION

CLASSIFIED PROGRESS REPORT NO. 35
(OCTOBER - DECEMBER 1963)

OTTAWA
DECEMBER 1963

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: October-December 1963

RECEIVER

An improved receiver mixer assembly has been obtained and will shortly be installed in a radar for evaluation.

TRANSMITTER

Work has been resumed on the Ferranti magnetrons. One proved gassy; the manufacturer attributed this to a faulty vacuum seal and promised to replace the tube. The cathode bombardment circuit is being modified at Ferranti's suggestion, and the modulator impedance (pulse transformation ratio) will be altered as recommended for the short pulse length.

MAGNETRON PROTECTOR CIRCUIT

The prototype magnetron protector circuit has been completed and tested at high power in the laboratory. A series of reflecting sections having VSWR's from 1.25 to 4:1 was constructed to permit controlled testing. VSWR's of 2:1 and greater are sufficient to cause the transmitter to be turned off. Waveguide arcing has been initiated by several means, and in each case, the protector circuit turned off the transmitter, and no damage resulted to the magnetron or to other components.

Drawings of the present unit have been prepared.

WAVEGUIDE WINDOW

There is general agreement that the improved Raytheon magnetron accounts for the discrepancies in test results between our laboratory test and field results. An improved window is obviously needed.

Recent field trials indicate that the teflon "H-plug" windows are unsatisfactory for low-temperature operation. Excessive gas leakage has been observed when the equipment is subjected to temperatures near 0°F for extended periods.

A number of new window designs, in which ceramic dielectric elements are to be used, have been made. For purposes of evaluation, polystyrene is being used to confirm the design procedure, while Wesgo A1-300 alumina will be used for the ceramic elements.

One window design comprises a rectangular-to-circular-to-rectangular waveguide section, with a ceramic disc in the circular waveguide section. The second design is in rectangular waveguide, and comprises a triple-element resonator consisting of two metallic irises and a thin dielectric slab. A number of different diameters of circular waveguide will be tried.

Initial results on the circular waveguide section indicate that a VSWR of less than 1.1 over the frequency range 15,600 to 16,200 mc/s is achievable. High-power testing will be started shortly.

VIDEO STORAGE UNIT

In preparation for the December field trials at Shilo, Man., the unit was fitted with an AGC video amplifier and modified high-beam identification circuit.

The AGC amplifier, gain-controlled by i.f. noise sampled during the high-beam scan, was introduced to provide the video storage unit with a video signal of constant noise component. This permits precise adjustment of the threshold level, without fear of compromise by operational adjustments of the radar i.f. gain control.

The trial demonstrated the basic value of the video storage unit and of the modifications, but at the same time pointed out certain important deficiences in the operational capabilities of its controls. Because of the wide range of signal strengths encountered when both low-velocity projectiles with good reflecting characteristics and high-velocity shells with relatively poor reflecting characteristics are to be dealt with, threshold level must be under operator control.

As threshold level approaches noise level the storage time (persistence) must be reduced to prevent noise buildup. Experience gained during the trials emphasized the desirability of providing switched persistence, with optimum threshold level selected by the same switch. Such a simplified control is being installed.

IMPROVEMENTS TO GROUND RADARS

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

Period under review: October-December 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 is 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. In a fully coherent system such as the AN/FPS-508, this is extremely easy, as the only requirement is to replace the coherent oscillator by a stable oscillator whose center frequency of 30 mc/s can be shifted by 360 c/s.

Suitable units to equip all AN/FPS-508 sites in Canada are now nearing completion at one of the RCAF Repair Depots. During the period under review, measurements of frequency drift were made on the experimental model, excluding any intentional drift. After an hour's warmup time, the maximum drift was 11 c/s for the next two hours. This was considered satisfactory.

During November, the production prototype was used in trials at a USAF base on Cape Cod, when the winds there are at their worst for chaff cancellation. The unit performed extremely well.

The paper study of the feasibility of single-sideband modulating the coherent oscillator with a single audio frequency, in order to provide variable velocity notch MTI, has been completed. This would permit the use of an audio-signal generator tunable over the band of 1.44 to 2.88 kc/s. This, in turn, would allow the use of calibrated controls that could be pre-set by the ECCM officer, which cannot be done with the present model. It would also permit a single set of controls to be used for both channels when the AN/FPS-508 is used in the diplex mode. Construction of a breadboard model has been commenced.

C.W. INTERCEPT RECEIVER

Reference: Army, Navy. No project number

Period under review: October-December 1963

Work which has been in progress at Canadian Arsenals Limited for the design and manufacture of a light-weight portable c.w. intercept receiver is being transferred to us for completion, with assistance from DRB/DRTE. Orders for material have been placed and development of the circuitry has been started.

A report (ERB-643) describing a more complex system for interception of c.w. radiation has been issued.

RADAR PERFORMANCE EVALUATION

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

Period under review: October-December 1963

The pressure relief valve springs were changed to allow higher pressure settings. Mylar balloons can operate at approximately six times the pressure of balloons formerly used.

The pressure relief valve seats were modified to improve the seal when the valve is closed. Laboratory tests indicate the valves will hold pressure in a 4-foot-diameter balloon for at least 1000 hours.

Field trials of Mylar balloons were held at RCAF Station Foymount. Sixteen balloons were released; all but two were tracked to the limit of the radar coverage. One balloon, released during a heavy rainstorm, was not tracked, and one was not tracked owing to a radar fault. The 14 balloons were floating level at approximately the predicted altitudes when lost by the radar at times varying from 3.5 to 5.5 hours after release. One balloon was returned from a point over 300 miles from Foymount. The results indicate the balloons may achieve the desired 10 hours of flight. Further trials, with tracking from down-wind radars, are necessary to discover the time of level flight.

To facilitate the prediction of equilibrium altitudes for balloons of various sizes and shapes, a simple calculator has been devised. It provides a graphical solution for equilibrium altitude in terms of the standard stmospheric density profile and the balloon "density" (i.e., balloon mass per unit volume), with the balloon super-pressure as a parameter. A clear plastic model of the calculator with engraved curves is being constructed.

X-BAND GROUND SCATTER MEASUREMENTS

Reference: RCAF. No project number

Period under review: October-December 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 the 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 entering through the side lobes of the interceptor's radar antenna. A report [1] has been prepared on the measurements on the "scatter loss factor" $S(\theta)$ for flat farming land and for tree-covered hills. $S(\theta)$ is defined as the scattering cross section divided by the area in which scattering takes place, times a constant.

During November, measurements were made of the scatter loss factor over large bodies of salt water (Gulf of St. Lawrence) and fresh water (Lake Ontario). Measurements were also made over land in order to check the repeatability of results. Surface winds over the Gulf varied from 10 knots to 35 knots, while over Lake Ontario the velocity was 35 knots. The measurements are being analyzed.

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1. F.R. Hunt, "Bistatic Scattering Measurements at X-band", NRC Report ERB-651, November 1963

SOUND-RANGING COMPUTER

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

Period under review: October-December 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.

TRIALS

Tape recordings of the field trials are being processed by the experimental equipment in the laboratory.

COMPUTER

The IBM Selectric output writer has now been installed and is operating satisfactorily. Computation of the locations obtained during the September firings, using the readings from the No. 5 recorder, is being continued, as well as computation of the locations from the June trials using the readings from the display system.

PROGRAM

A program has been written for the solution of the sound-ranging problem incorporating a meteorological correction based on an approximation of the ray-tracing formula. The program tape has been prepared, but has not yet been checked out.

CIRCUITRY

The frequency-modulation system now in use has resulted in a considerable improvement in the displays, but modulation linearity, and sources of noise, such as tape-driven friction, are being investigated. A circuit to restore the carrier in case of tape or drum drop-outs has been incorporated in the demodulation system. A similar system is also being used in the timing-channel circuitry.

FILTERING

High-pass filters with sharp cutoff frequencies of 0.5, 1.5, 5.0, 15, and 50 c/s have been added, and the attenuation slopes of the low-pass filters (300, 100, 30, 10, and 3 c/s) have been increased. More accurate results are usually obtained using a relatively narrow bandwidth.

TECHNICAL SPECIFICATION

Assistance has been provided to the Department of National Defence in drafting a technical specification to be used as a basis for an industrial contract.

MODEL ANTENNA STUDIES FOR RCN

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

Period under review: October-December 1963

HF ANTENNAS

Radiation pattern measurements were completed on the HF antenna system for the General Purpose Frigate and the patterns were evaluated in accordance with our proposed evaluation method. In order to reduce the coupling between the transmitting antennas and the 28-foot receiving whips, the latter were replaced with a fan-type antenna located on the side of the superstructure bridge. Two fans, one port and one starboard, were connected together and satisfactory omnidirectional patterns were obtained from 2 mc/s to about 12 mc/s. The government's decision to cancel construction of the General Purpose Frigate has terminated further work on the program. However, a final report is being prepared for DGFE/RCN.

During the period under review, a visit (with a DGFE staff member) was made to the U.S. Naval Electronics Laboratory, and HMCS Grilse, Esquimalt, for the purpose of obtaining antenna information on surface ships and submarines.

Development of an HF antenna system for the St. Laurent DE-205 conversion class is in progress. In addition to the folded tetrahedron method of exciting the foremast as a broadband 2 to 6 mc/s antenna, a different technique is under investigation. The configuration consists of a pair of wires which extend from a yardarm to a point on the ship's deck. The yard is located high up on the ship's foremast. The feed-point is located between the foremast and the extended wires. Impedance results on a 1/20 scale mock-up of the St. Laurent look very encouraging.

UHF ANTENNAS

The UHF antenna system on the destroyer escort HMCS Assiniboine consists of an AS-1018/URC antenna located inside the top section of the ship's foremast [1]. The AS-1018/URC antenna is a two-element colinear dipole array designed to operate from

225 to 400 mc/s. Operational reports received from DGFE have indicated that for certain bearings from the ship, communication was unsatisfactory and in certain cases impossible. In order to rectify this problem impedance and radiation pattern measurements were carried out on a full-scale mock-up of the antenna arrangement. The impedance characteristic appeared to be satisfactory,providing a VSWR of less than 3.5 : 1 across the band. On the other hand, the patterns exhibited a rather large null on the starboard side which was caused by the presence of a number of coaxial cables running alongside the foremast. Removal of the cables resulted in a signal improvement by as much as 13 db at the band edges. The results of our investigation have been forwarded to DGFE/RCN.

Reference:

1. J.Y. Wong, "Vertical dipole inside lattice tower provides omnidirectional pattern", Canadian Electronics Engineering, May 1962

CLASSIFIED REPORTS ISSUED

Hunt, F.R. Bistatic Ground-scatter Measurements at X-band (ERB-651, Secret)

A proposal was made 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 the decoy. The technique involved bistatic scattering from the ground, and little was known about the losses involved in X-band operation. This report describes the experimental technique employed in measuring the "scatter loss factor", $S(\theta)$, which is defined as the scattering cross section, divided by the area in which scattering takes place, times a constant. This factor was found to be given by

$$S(\theta) = 0.02 (\sin\theta)^{\frac{1}{2}}$$

for flat farming country and tree-covered hills. This result is in agreement with monostatic scattering for vegetation-covered terrain at X-band.

Stedman B.D. Experimental Video Storage Unit for the AN/MPQ-501 Radar (ERB-646, Confidential)

A radar video storage device designed specifically to complement and improve the AN/MPQ-501 (two-beam) Counter Mortar Radar system, is described.

In the prime radar role, the device, by simulating spatial storage of radar data signals, makes possible surveillance of the entire operational range interval on the regular type-B display with coordinate data extraction to the accuracy of the expanded range sweep. It permits also a more leisurely approach to coordinate measurement, where hitherto the transient nature of the

data signals demanded extended concentration by, and immediate attention from, the operator.

In addition, by virtue of the characteristic tail with which moving signals are endowed, difficulties associated with the detection of troop and vehicular movement are very considerably reduced.

An area MTI facility will very soon be added to the device and, should it be deemed desirable, semi-automatic location.