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National Research Council Canada. Radio and Electrical Engineering Division

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NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

CLASSIFIED PROGRESS REPORT NO. 48
JANUARY - MARCH 1967

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

Period under review: January-March 1967

MILITARY RADAR RESEARCH AND DEVELOPMENT AT THE NATIONAL RESEARCH COUNCIL

This final issue of the Classified Quarterly Bulletin of the Radio and Electrical Engineering Division signifies the completion of 28 years of radar design activity in support of the Canadian Armed Forces. It seems fitting that a short résumé of the highlights and accomplishments of that period be included in this report.

Our involvement with radar began in March 1939 with the invitation by Britain to an Empire Radar Conference. About twenty radar stations were then operational in Britain, but, after the Munich Conference and the invasion of Albania, it was foreseen that design and production assistance would be needed from Canada and the Commonwealth. Canada was asked to design and produce radars, particularly those operating in the microwave band. To launch this work, Britain supplied her most highly classified and revolutionary developments, including the cavity magnetron. Starting in September 1939 with a staff of five scientists and seven technicians, the Radio Section (as it was then called) grew quickly to a staff of 300 and was re-established as the Radio Branch. In July 1940, NRC was instrumental in establishing the crown company Research Enterprises Ltd. (REL), to cope with radar production. This company had a staff of many thousands and produced over $300,000,000 worth of radar equipment for ground, sea, and air services.

Through the close collaboration of NRC and REL, Canada was the first nation in the world to achieve mass production of microwave fire control radar — the NRC-designed AA No.3 MK1/AA No.4 MK1, otherwise known as the GL III C radar. The cavity magnetron which was a critical factor in the success of this radar was produced in Canada also. The original British 10-cm magnetron developed at Birmingham University was brought to Canada in August 1940 by the mission headed by Sir Henry Tizzard. (The size of the REL operation can be judged from the fact that the cathode-ray tube plant at REL, which was planned by NRC engineers, had a monthly output exceeding the annual capacity of all United States plants combined.) There were many other notable accomplishments, only a few of which will be mentioned here. The first Canadian radar, known as the Night Watchman, was designed, built, and installed in four months in early 1940, its role being the protection of Halifax harbour. A duplicate for the United States Signal Corps was completed in six weeks. Coast defence radars, types CD and CDX gave additional support in 1942-43. To counter the submarine threat in the St. Lawrence, the AJ radar was built and installed in less than two weeks in 1943 as an interim measure. The MEW/AS radar, designed specifically for the antisubmarine role, followed in 1943, and in it a new invention was used for the first time — the slotted waveguide radiator developed at McGill University and covered by NRC patents.

Characteristic of the speed with which development proceeded under the pressures of war was the ASV radar program. The RCAF requested an air-to-surface-vessel radar on Sept.2 1939; echoes were received in November 1939 on an experimental unit based on a modified Western Electric radio altimeter. Thousands were later produced by REL to be interchangeable with the U.K. model.

A series of shipborne radars were also produced. The first, known as SW1C, was requested by the Canadian Navy in February 1941, and was completed and tested in March 1941. By 1942 a 10-cm microwave model, the SW2C, had been completed and many of these served the navy until the end of the war. Following a request from the British Admiralty in May 1942, a 3-cm radar known as the 268 was designed, built, and demonstrated in 11 months. Sixteen hundred 268 radars were produced and served on convoy runs until 1945. As a marine radar in peacetime, there were more of these radars afloat than of any other type for several years after the war. Late in the war NRC designed and built a naval gunnery control radar with exceptionally high resolution and data rate. A small number of these equipments (type 931) were constructed in the laboratory because of the urgent need expressed by the British Navy for such a radar.

Besides the GL III C radar, which was developed and demonstrated in only seven months, antiaircraft radars designed by NRC included the Long-Range Early-Warning (LREW) equipment with a 200-mile range on aircraft (1943), the Variable-Elevation Beam radar, using phase control of a 150-foot vertical antenna to achieve accurate height finding, and the Microwave Early-Warning (10 cm) radar (1943). In the course of these programs, NRC developed the first PPI radar display using fixed deflection coils. In 1943 also, the AA No. 4 MKVI (MZPI) acquisition radar reached prototype production within 12 months from its request date. Over 400 were produced by REL and they served in virtually every war zone.

Altogether, more than 8800 radars were produced by the NRC-REL team. The equipment saw service in all major theatres of war: some warned of the Japanese attack on Pearl Harbour; others protected London and other key industrial cities in Britain against planes and V-1 missiles; some were installed to protect Canada's coasts and the Panama Canal, while others served on the Russian and European fronts. At sea, nearly 2000 Canadian radars protected convoys or directed naval guns. In the air, more than 4500 radars were used in the war against submarines and surface craft. Complementary IFF equipment for many of these radars was designed and mass-produced also.

In the post-war years, NRC contributed to the radars of the Pine Tree Line in Canada and conducted research and development on countermeasures for many years. About $70,000,000 worth of radar and countermeasures equipment was produced in collaboration with Canadian Arsenals Ltd. (successor to REL) and the cognizant military committee (Napkin). Additionally, this Division has contributed for more than 20 years to the counter mortar radar field, culminating in the present service model AN/MPQ-501. The AN/MPQ-501 is a highly-automated radar, completely self-contained on a tracked armoured carrier. Since no external cabling is required and antenna leveling is automatic, the equipment is exceptionally mobile — it can be put into operation in two minutes and can move off in less than one minute. Its analogue computer automatically extrapolates trajectory intercept data to provide mortar locations in both rectangular grid coordinates and polar coordinates together with elevation contour data. A unique feature is the provision for automatic correction of friendly-fire data from observation of the shell. One man can set up and operate the radar without leaving the vehicle, which is equipped with air-conditioning and filters to protect the crew from the effects of nuclear, biological, and chemical warfare. Prototype trials in 1957 and subsequent tests of production models from 1962 on have demonstrated that accuracy and range of this radar exceed service specifications. Improvement of its gun-locating ability at low angles was demonstrated in 1962 with storage tube displays designed by NRC.

Recently, the Division has conducted research on the propagation of sound in the lower atmosphere and has designed a new sound-ranging system employing modern digital techniques. This is currently in prototype production for the ABCA countries.

Other military contributions of recent years include a system for passive location of jammers, airborne passive direction-finding equipment, large-aperture ground-based direction-finding systems, and specialized antenna designs for radar and communication uses on aircraft, ships, and ground-based equipment.

Throughout the past 28 years the Division has enjoyed whole-hearted cooperation and support from all three services. This is gratefully acknowledged. International cooperation has been no less important. We are indebted to many countries, particularly to Britain and the United States of America, for the free interchange of technical information and continued collaboration throughout the years.

SOUND RANGING

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

Period under review: January-March 1967

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.

SPECTRUM ANALYSIS

In addition to the standard spectral plot of frequency as described previously, it has been found possible to produce a display of frequency versus time of each signal. Since the signals often exhibit some frequency-time correlation in their standard form as they appear on the analysis display, this facility would appear to have more promise than the simple frequency plots.

METEOROLOGICAL CORRECTION PROGRAM

Processing of the data from the September 1965 trials has now been completed, with the exception of the wind and temperature data measured at heights of 10 and 20 metres. A preliminary report has been prepared. The results indicate that the Goodwin method of applying the meteorological correction results in more accurate locations than those obtained using the weighted-wind technique.

Examination of the September trial results indicated that the time constant of the temperature-sensing element in the radiosonde package may be a significant source of error in determining the temperature structure. A program was written to correct the radiosonde temperature readings for the response time of the element. The corrected temperature readings have been used to compute meteorological corrections for three of the series fired during the September trials. No significant improvement in location accuracy was obtained.

When the tower data are processed, more accurate temperature data will be available at heights of 10 and 20 metres. This will permit a better assessment of the temperature-correction program.

Processing of the data from the December trials is nearing completion. All arrival-time measurements have been made and locations have been computed using the Goodwin meteorological correction method and the weighted-wind technique for most of the series. A final report will be prepared upon completion of the analysis of the December trial data and the tower wind and temperature data.

MODEL ANTENNA STUDIES FOR RCN

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

Period under review: January-March 1967

DDH 280

Structural changes to the superstructure of the new destroyer escort DDH280 have been finalized by CFHQ. The changes involve the hangar and funnel areas, and will seriously affect the performance of the HF antenna system already proposed for the 280. Construction of a 1/48 scale model for pattern studies and a 1/20 scale mock-up for impedance and coupling measurements is under way in our Model Shops.

SHIPBOARD ELECTRONIC SYSTEMS EVALUATION FACILITY

CFHQ/RCN is planning to establish a facility somewhere on the east coast for the purpose of evaluating the performance of the electronic (electromagnetic) systems on all RCN ships. We are assisting the RCN project officer in drawing up the specifications and requirements for the evaluation facility.

VHF/UHF MAST ANTENNA

A prototype of the VHF/UHF mast antenna being built by RCA Co. Ltd. was returned to our laboratories for further pattern measurements. Over the frequency band from about 230 MHz to 280 MHz, the patterns exhibit serious lobing which suggests that undesirable currents are being coupled to the central supporting mast. Quarter-wave chokes are being fitted on the mast in an attempt to suppress these coupled currents.

CLASSIFIED REPORTS ISSUED

Brahan, J.W. and Humphries, J.

Sound-ranging meteorological requirements (Preliminary Report) Phase A trial results (ERB-753, Confidential)

During September and December, 1965, trials were held at Camp Shilo, Manitoba, to study the effects of meteorological conditions on sound transmission paths, to determine the meteorological requirements for sound ranging, and to study methods of applying meteorological corrections to locations made by sound ranging. Results from the Phase A trials (September) indicate that the Goodwin correction method results in a significant improvement in location accuracy over that obtained using the weighted wind correction technique. The results also indicate that meteorological data is required to a height of 2500 metres for source-to-microphone distances of 40 kilometres.

Wong, J.Y. and Evangelatos, T.V.

Evaluation of 35-foot transmitting whip antennas for Restigouche DDE257 destroyer escort conversion class (supplement to ERB-734) (ERB-754, Confidential)

A change in the armament of the Restigouche DDE257 destroyer escort conversion class (ASROC model) made necessary a rearrangement of the transmitting whip locations. This report gives the electrical characteristics of the antennas in their new positions.