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National Research Council of Canada. Radio and Electrical Engineering Division

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NATIONAL RESEARCH COUNCIL OF CANADA  
RADIO AND ELECTRICAL ENGINEERING DIVISION

CLASSIFIED PROGRESS REPORT NO. 10  
(JULY - SEPTEMBER 1957)

Declassified to  
ORIGINAL (signed by  
ORIGINAL SIGNER FOR  
Authority: S. A. MAYNARD  
Date: NOV 26 1992

OTTAWA

OCTOBER 1957 NRC # 35413

## FOREWORD

This Classified Progress Report is intended to present a convenient quarterly summary of some of the classified aspects of the research and development program of this Division, for the information of the Services in Canada, the United Kingdom, and the United States, and of laboratories and other organizations in these countries which are engaged in work similar to ours and which have been supplying us with reciprocal information. Unclassified material, whether or not it is of Service interest, appears in our open publications and will not be covered here. The format of this report is such that the account of each project may be separated from the whole without loss of security grading. It is thought that this feature may be appreciated by some agencies, such as the Project Coordinating Centre of the Department of National Defence, where they may prefer to file the individual sheets according to their own systems. It also permits us to issue the separate sheets to persons who may have an interest in certain selected projects but who do not require the remainder of the report.

A list of classified reports issued by the Division each quarter is included. There is no automatic distribution for these reports — the circulation list for each is determined by the nature and interest of the work described. Requests for copies of these reports, to be directed to the Document Control Office of this Division, will be given every consideration, subject to security regulations. Recipients of these documents should note that Canadian approval is required for release to other persons, organizations, or governments of any classified information (including this Classified Progress Report) which may be issued by this Division.

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COUNTER MORTAR RADAR (AN/MPQ-501)

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

Period under review: July - September 1957

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.

STATUS

The prototype production unit, which was ordered from Canadian Arsenals Limited following the 1953-54 field trials, has been completed. NRC personnel have continued to work closely with the production engineers, particularly in adjustment and trouble shooting. Development on several items for later assessment is being continued at NRC. Liaison with the manufacturer and the design authority has been continued. The equipment was prepared for the DAD Acceptance Trial which was conducted at Camp Borden by DAD. No official trial report has been received, but, on the basis of recorded results, performance is high.

RANGE OSCILLATOR AND GONIOMETERS

The additional error in this system, mentioned in the previous issue of the Progress Report, was found to result from circuit differences and has been eliminated.

COMPUTER

Some assistance in setting up test and adjustment procedures was provided to CAL. A number of test problems were calculated and made available for use in

estimating the computer location error.

#### TRAINER

This equipment was re-packaged, as required for shipment and Army operation, and several lectures and demonstrations to Army personnel were given. It was used by a group of operator trainees at NRC and was taken to Camp Borden for operator practice during the radar trials. Its use has been considered to be a significant factor in the accuracy obtained from the radar during initial tests.

#### VEHICLE

Further information gathered from the vehicle designers supports our belief that the present radar design would be suitable for mounting on the new carrier with no major changes — in fact, indications are that practically all the design modifications would be to fixings rather than equipment. A discussion of this has been passed on to DAD.

#### POLARIZER

The mandrel was modified to take care of an additional design factor. It has been decided to fabricate a one-foot test section for confirmation of the design before constructing the complete polarizer. Material is expected soon for this work.

The stowing and mounting mechanism is being designed so that the completed unit will be suitable for use with the production prototype during the user's trials.

#### TRIAL OF RADAR IN THE MORTAR ROLE

During the period of preparation for the DAD Acceptance Trials the equipment as a whole was examined critically and a number of deficiencies, some of which have since been eliminated, were pointed out to the design authority and the manufacturer. While the trial was taking place a few more points requiring attention were noted. The accuracy and sensitivity of the set as indicated by the trials (conducted at Camp Borden by DAD) appear to be very satisfactory. The sensitivity appears superior to that achieved in the experimental model. Much of this improvement could be accounted for by the increase in antenna gain of from 3 to 6 db as indicated by the tests conducted during the previous quarter. The simplicity of operation and speed in, and out of action was clearly demonstrated during these trials.

#### TECHNICAL DESCRIPTION

Comments, descriptions, and explanations were passed on to the manufacturers as required for preparation of Technical Manuals.

ACQUISITION RADAR MODIFICATIONS (AN/MPS-501B)

Reference: Army. No DND project number

Period under review: July-September 1957

R.F. SWITCH FOR AZIMUTH SECTOR GATED OPERATION

Work on this switch has been suspended until completion of tests on the X-band model described separately on page 23.

A contract with industry to develop the S-band model is being considered.

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FIELD MODIFICATIONS OF RCAF GROUND RADARS

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

Period under review: July-September 1957

ANTENNA PATTERN RECEIVER

A receiver was designed and built for measurement of antenna patterns in the field with the maximum of accuracy consistent with the minimum of additional equipment. It consists of an i-f strip whose gain is reduced in steps at fixed intervals after a trigger pulse. The video output of the receiver is connected to a conventional PPI. A bright strobe is produced on the PPI whose extended length from center is a function of the signal strength at the antenna's terminals.

An airborne or ground-based signal source, modulated or unmodulated, is directed at the radar antenna from a distance greater than  $\frac{1}{2}$  mile. The radar antenna and PPI sweep are rotated in synchronism and the antenna pattern is traced out on the PPI where it may be photographed. An unclassified report describing this receiver in detail is now in preparation.

The receiver was used to obtain photographs of the antenna patterns of AN/FPS-3 and AN/FPS-6 radars. An airborne jammer was used as signal source. The numerous photographs obtained are being analyzed by ADC.



CONFIDENTIAL

### FLIGHT PLAN CORRELATION EQUIPMENT

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

Period under review: July-September 1957

### PURPOSE AND DESCRIPTION OF EQUIPMENT

To facilitate correlation of radar tracks with flight plans, it is proposed to use the Charactron tube to display the information contained in the flight plans synthetically and to superimpose this flight plan display on the "raw" radar display. To demonstrate the feasibility and advantages of such a system, an experimental model was built which is capable of displaying four tracks, with four characters on each track. The position of the aircraft is indicated by the position of the first character in the group, and the heading and speed by the direction and rate at which the group of characters moves across the display. The four characters are used as follows: one for displaying the track designation, two for the altitude in thousands of feet, and one for the aircraft type. The synthetic display of flight plan information is superimposed on the radar display during the dead time which is available following the radar range sweep, one track being written after each range sweep.

### TRIAL RESULTS

The experimental model of the flight plan correlation equipment was installed at RCAF Station Falconbridge and trials were commenced on July 3, 1957. The trials were completed September 27, 1957. The equipment was operated independently of normal correlation methods, and the results obtained using the two systems were compared.

Initially, the equipment was operated on a 150-mile range and the radar information written using a beam formed by passing it through the 0.005 inch diameter hole in the matrix. It was found that a considerable number of tracks were being correlated by normal methods outside the 150-mile range of the Charactron display. Also, the display of radar information was much too dim, resulting in difficult operation. Consequently, the range was increased to 200 miles and the equipment was modified so that the radar information was written using a beam focussed by normal methods. These changes resulted in a considerable improvement in the operation of the equipment.

During the period of the trials, August 22 - September 13, 95% of the flight plans put on the Charactron display were correlated, compared with 76% of the same flight plans by normal methods. Also, 90% of the flight plans put on the Charactron display were correlated prior to being correlated by normal methods.

The mean time from correlation on the Characteron display to correlation by normal methods during this period (considering only flight plans which were correlated by both methods) was 10.6 minutes. It should be pointed out that not all available flight plans were carried on the Characteron display because of the limited capacity of the demonstration equipment. Hence, more tracks were handled by normal methods than by the Flight Plan Correlation Equipment.

AREA MOVING TARGET IDENTIFICATION

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

Period under review: July-September 1957

This project has been suspended for some time. Test results of the RCA-CAL equipment of the same type are awaited.

REMOTE RADAR DISPLAY

Reference: Army, RCAF. No DND project number.

Period under review: July-September 1957

No further development was done on this full-bandwidth remote radar display system. A report is being prepared to describe the equipment.

LOW ANGLE DETECTION

Reference: Army, RCAF. No DND project number.

Period under review: July-September 1957

The radar is ready for trials against low-flying aircraft. An additional magnetron has been ordered as a precaution, and trials will be arranged after its arrival. A 0.5- $\mu$ sec pulse is being used, but 0.3- $\mu$ sec and 1.0- $\mu$ sec pulse lengths are available.



SOUND-RANGING COMPUTER

Reference: Army. No DND project number.

Period under review: July-September 1957

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

SECRET

INSTANTANEOUS MICROWAVE DIRECTION FINDER (AN/UPD-501)

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

Period under review: July-September 1957

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 the signal displayed on a cathode-ray tube as a radial line. The angle of the line, with respect to a reference, represents the bearing of the signal.

The development and testing of antennas for the AN/UPD-501 was continued.

SPIRAL ANTENNAS

A number of spiral antennas were constructed and measurements of the radiation patterns, VSWR, and axial ratio made. It is now felt that what has been learned from this work, together with information available in the classified literature, is sufficient to enable a start to be made on the development of a spiral antenna for the UHF band of the UPD-501.

ANALOG BEARING ERROR COMPUTER

The analog device for studying the effects of antenna pattern and number of antennas on multi-antenna amplitude-comparison direction finders has been used extensively.

The results of bearing error measurements on 6-, 7-, 8-, 9-, 12-, and 16-antenna systems were analyzed and empirical relationships established between the number of antennas in the antenna system, the radiation pattern beamwidth, and the amount of bearing error when one channel is badly degraded. These relationships, presented in graphical form, show how the characteristics of the antenna system of a multi-antenna instantaneous direction-finding system influence its accuracy. Their purpose is to assist in evaluating multi-antenna direction-finding systems and to assist in choosing characteristics of multi-antenna systems to meet specific requirements.

Cossor is continuing work on the design of three prototype antennas:

- 1) S-band, vertical polarization
- 2) L-band, vertical polarization
- 3) L-band, horizontal polarization.

Designs of antenna couplers for S-band and for X-band are complete. These units will couple r-f energy into an antenna from very close range with a minimum of reflections. Several experimental prototypes have been fabricated (and successfully tested). An X-band and an S-band coupler are on loan to DeHavilland Aircraft Corporation for production testing of the UPD-501 antennas.

A coupler to cover the band from 1.0 kmc/s to 2.35 kmc/s is being developed.

A crystal multiplier unit was designed to produce third harmonic energy from an input at a frequency of about 3.0 kmc/s. This is for use with the X-band antenna test coupler.

A portable klystron test oscillator with a well regulated supply was developed. An experimental prototype was built and is undergoing evaluations trials by the RCAF.

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

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

Period under review: July-September 1957

Active work on this project has been suspended until the receipt of the prototype recorder now being built by the contractor. The prototype receiver, now at NTS, has recently undergone an operational trial with RCN operators. Computation of the results is being undertaken by RCN.

IMPROVEMENT OF HF DF TECHNIQUES

Reference: DND Project A14-38-10-24

Period under review : July-September 1957

This project has, for the time being, been divided into two parts: (a) an investigation of the effects of site imperfections on HF DF, and (b) an investigation into some of the effects of sky wave propagation on HF DF.

In the first case our attention was directed toward measurement of change of phase front of a wave caused by crossing a sea-land boundary. Also, a report was drafted which discusses the effects of certain re-radiating structures on nearby HF DF antennas. This study compares the susceptibility of Adcock, loop, and spaced-loop antennas to secondary fields.

Study of the effects of ionospheric disturbances on direction of arrival of waves was started with the logging on GRD-501 equipment of a number of transmitters well distributed in azimuth, distance, and frequency. Some work was done on instrumentation of the display so that the analysis of bearing data is more easily accomplished.



SHIPBORNE HIGH-FREQUENCY DIRECTION FINDER

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

Period under review: July - September 1957

This equipment is being developed for the Royal Canadian Navy to intercept and give unambiguous bearings of high amplitude ground-wave signals whose durations may be as short as 100 ms.

Construction of the experimental triple-channel receiver which it is hoped to use for ship trials in 1958 was continued. This receiver is to consist of non-tunable r-f amplifiers at the inputs feeding, through mixers, folded i-f amplifiers with bandwidths of 490 kc/s (from 10 to 500 kc/s), giving a total final bandwidth of 980 kc/s. The signal bearings will be displayed on a "Memotron" display storage tube and the detected output of the sense channel will be fed to a raster display on another "Memotron" tube.

The i-f amplifiers for this receiver were built and work satisfactorily. I-F filters to provide the final selectivity are being built; one model has been completed satisfactorily and the components for two more have been received. A high pass filter cutting off at 1.5 mc/s has been designed to provide i-f rejection.

The "Memotron" tubes were received and power supplies for these tubes have been designed and built.

Time base circuits for the raster scan needed for the signal-channel detected-output display have been designed and the bench model works satisfactorily.

MAGNETIC SIGNATURES OF ALUMINUM MINESWEEPERS

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

Period under review: July - September 1957

Investigation of various problems associated with magnetic minesweepers is being continued.

In 1955, trials were carried out to determine the effectiveness of two types of compensating devices installed in HMCS "Comox". Various components of the compensating systems were tested in the laboratory during 1956. Results were then reported to the RCN in preliminary form. This work has since been re-examined and a final report is in preparation.

In June 1957, stray field measurements were made on an impulse generator with a yoke cross section which was 50% larger than that of the original design. Although these tests were made under unfavourable conditions they showed that the yoke modification had reduced the stray pulse field at high currents by 56%. One of the conditions obscuring the determination of the generator pulse field was the presence of the large stray field of the nearby special pulsing controller. A further investigation of stray fields of generator and controller is to be made over a magnetic range in a future series of ship trials.

Temporary instrumentation for this work has been developed and consideration has also been given to the equipment required in permanent RCN magnetic ranges. A suitable commercially made magnetometer has been evaluated and recommended. This magnetometer, which was designed by Dr. P. Serson, was found to have the required sensitivity and frequency characteristics. The salient features of the instrument are a tuned magnetic detector and a feedback system of the electronic type rather than the servo type used in the Rose and Bloom magnetometer. A report (ERB-442, Limited) on the evaluation of this instrument has been completed.

FIELD CONTOURS OF MAGNETIC SWEEPS

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

Period under review: July - September 1957

In order to determine the safe depth of a minesweeper the magnetic field under the ship must be known. This field consists of the ship's own field and the fields contributed by the minesweeping equipment. The report on the magnetic sweeps ML. Mk. 4 Mod. 2 and ML Diverted, issued earlier, contains the results of scale model measurements of the fields of the loop portion of these sweeps. The minesweeping loops are in each case connected to the equipment on the minesweeper by a 270-yard length of married buoyant cable. The field of this cable must be determined since it will contribute to the total field near the minesweeper. It was found that in this case scale model measurements of the cable field would be impracticable, whereas computation of the field would be relatively simple. Sample calculations of the horizontal magnetic field in the region near the end of the married cable were carried out for a depth of 10 fathoms. The results were conveyed to the RCN in letter form.

EXPERIMENTAL ANTENNA FOR S-BAND SURVEILLANCE RADAR

Reference: RCAF. No DND project number.

Period under review: July - September 1957

Flight tests of this 36'  $\times$  6' variable-beam-shape antenna were completed some months ago but the antenna and its associated AN/MPS-501B radar continue to be used in evaluation of anti-jamming measures.

A report on the flight tests is being prepared.

TELEMETRY ANTENNA FOR CARDE TEST VEHICLE

Period under review: July - September 1957

A request was received from CARDE, Valcartier, to assist in the design and development of a telemetry antenna for use on a test vehicle for rocket research. Since the telemetry equipment is located in the forward part of the vehicle, it was requested that the antenna also be located near the nose. The antenna system proposed consists of three radial stubs, spaced  $120^\circ$  around the vehicle, and inclined at  $45^\circ$  to the line of flight. These are to be fed in such a way as to be equivalent to a single balanced dipole, the choice of three unipoles arising from consideration of launching and aerodynamic problems.

Full-scale antennas for use in impedance measurements have been designed and are being built by CARDE. A scale model of the vehicle, for use in measuring radiation patterns, has been constructed by this Division. This latter measurement program will start shortly, using a circularly polarized antenna to simulate the helical antennas used on the rocket range.



MODEL ANTENNA STUDIES FOR HMCS "BONAVENTURE"

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

Period under review: July - September 1957

During the period under review, radiation pattern measurements of the HF system for HMCS "Bonaventure" were completed.

In order to assess the performance of each of the antennas, the radiation patterns are being analyzed by a method which was indicated in the previous issue of this report.

MODEL ANTENNA STUDIES FOR HMCS "ST. LAURENT"

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

Period under review: July - September 1957

A basic investigation is being continued on broad-band HF antenna systems for HMCS "St. Laurent". Impedance measurements were carried out on a scale model of a conical monopole antenna, and results indicate that satisfactory operation can be achieved over a band of frequencies from 4 to 30 mc/s with a VSWR of about 3.5. Further investigations of this antenna are being carried out with the objective of increasing its bandwidth.

Construction of the 1/48-scale model of the "St. Laurent" was completed and radiation patterns were measured on the existing HF antenna system. The antennas are being relocated on the model in an attempt to obtain more uniform azimuthal coverage. This phase of the program is being continued.

MODEL ANTENNA STUDIES FOR HMCS "LABRADOR"

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

Period under review: July - September 1957

It was mentioned in Classified Progress Report No. 8 that a preliminary report of the VHF/UHF antenna model studies on HMCS "Labrador" had been forwarded to Naval Technical Services, NDHQ, Ottawa.

A technical report on this study has now been prepared, and will be issued as ERB-428.

X-BAND WAVEGUIDE SWITCH FOR THE ROYAL CANADIAN NAVY

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

Period under review: July - September 1957

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

The first experimental model of this switch was fitted to an SU Radar in HMCS "Carleton", which was operated at an estimated peak power of 60 kw. No power breakdown was observed, and magnetron operation was not impaired by the switching operation. Photographs of the PPI display indicate that the width of the sector illuminated can be varied between a minimum of approximately  $5^{\circ}$  and a maximum of approximately  $170^{\circ}$ . The bearing of the center of the illuminated sector is continuously variable over  $360^{\circ}$ .

A double-acting solenoid was fitted to the second experimental model of the switch, which has an improved shutter. This model is being tested at low power, and will be fitted to a radar for high power tests when low power tests are complete.

JAMMING STUDIES

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

Period under review: July - September 1957

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

The study is concerned both with the properties, capabilities, and limitations of the more promising generators of jamming signals, and the manner in which jamming signals affect jammed systems, so that the effectiveness of jamming can be predicted. Knowledge of what may be expected in the way of jamming by a hostile force and the susceptibility of our defences to such jamming is necessary in defence system planning.

Investigation of the effects of FM-by-noise jamming of radar receivers was continued. The study of the jamming of "Dicke Fix" type receivers was completed. A report has been prepared [1] and is ready for publication. In the report, laboratory test results showing the effect of varying jammer and receiver parameters on the ratio of jamming to signal power required to mask radar signals on both A-scan and PPI are presented. Performance in the presence of multiple jammers is examined, and an attempt is made to assess both the usefulness and the limitations of the "Dicke Fix" technique as an anti-jamming measure.

Methods and techniques useful in generation and amplification of wideband video noise are being investigated. An experimental 0.1 - 50 mc/s noise source employing a photomultiplier tube and distributed amplifiers to bring the level up to that required for the modulation of laboratory jammers is being designed. Printed circuit techniques have been employed to advantage in the distributed amplifiers. Following a suggestion from the Naval Research Laboratory, the properties of the magnetron beam switching tubes, used in computers and counters as a noise source, were investigated. A video noise generator, having a spectrum uniform within  $\pm 2$  db to 10 mc/s was designed, and a report [2] was issued so that Canadian establishments may be aware of its advantages and have a useful circuit configuration.

At the request of the RCAF, monitoring of jamming signals emitted during

1. ERA-326. The Jamming of "Dicke Fix" Radar Receivers. S.G. Jones and T.H. Shepertycki (Secret)
2. ERB-443. A Wideband Video Noise Generator. S.G. Jones (Confidential)



tests of the engineering model of the carcinotron jammer was attempted. Records of the jammer output spectrum and estimates of output power were obtained, but the determination of the jammer antenna pattern with the aircraft in flight was hindered by lack of adequate communications. This has now been rectified, and the work can be resumed.

The AN/SPG-48 naval fire control radar was installed in the laboratory. Noise jamming tests of the range tracking circuits are being planned initially, with methods of reducing angular accuracy to follow.

The investigation into the advantages of turning off the radar receiver local oscillator when jamming is encountered is being resumed, since the necessary travelling-wave tube amplifiers are now available.

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ANTI-JAMMING MEASURES AGAINST CARCINOTRONS

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

Period under review: July - September 1957

It is probable that a Dicke-type receiver in which the i-f amplifier tubes are coupled by double-tuned transformers will have a slight advantage over the simpler type employing single-tuned interstages, particularly under conditions of severe jamming by "FM by noise". All the receivers tested to date were of the latter type. A double-tuned i-f strip was designed, and a group of three stages was tested. The measured response of the group was very close to the predicted curve. "Degenerate  $\pi$ " analog couplings are employed throughout, except in the input stage. A special transformer has been designed to enable a type-6922 double-triode tube to be used in the input stage, replacing the two type-417A triodes currently employed.

A high-frequency tetrode transistor (type-3N25) was operated as a hard limiter, but gave a performance comparable only with that of a pentode vacuum tube.

It is proposed that a video integrator should be added to the AN/MPS-504 for the duration of the RAF jamming trials to be held in Canada in 1958. A 2500-microsecond quartz delay line has been received from the manufacturer and some parts of the equipment, including the carrier-balanced modulator and repeater amplifier have been tested.

A short report on the two-channel noise subtraction scheme was prepared and submitted to pertinent Service groups; the report was based on material disclosed by Mr. Heaton-Jones (R.A.E. Farnborough) in discussions held at NRC.

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ANTENNA FOR X-7769 CARCINOTRON JAMMER

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

Period under review: July - September 1957

During the period under review the first dielectric slab antenna was delivered to the RCAF. Preliminary reports from them indicate quite satisfactory performance. Two more of these antennas are required, one of which is now completed.

Impedance tests on the scimitar antenna were carried out, and a matching unit was constructed.

AUTOMATIC STROBE TRIANGULATION DISPLAY (ASTRID)

Period under review: July - September 1957

This project is concerned with the problem of rapidly determining the position of a number of jammer-equipped aircraft when only bearing information is obtainable from the strobes generated by radars in the presence of jamming. Conventional triangulation techniques involve plotting simultaneous bearings from at least two sites to determine the intersections of the bearing lines. However, with only two reporting sites and more than one jammer, the resulting plot is ambiguous since "n" bearing lines from each of two sites will in general result in  $n^2$  intersections. Bearings from a third site can help sort out the "n" true intersections from the  $n(n-1)$  false or ghost intersections, since in general, only the true intersections will then be formed by the intersections of three bearing lines. To present such a plot automatically, a 12-inch long-persistence cathode-ray tube is used with circuitry such that the strobe pictures from three radar sites can be presented essentially simultaneously on the one display, with the centers of the three rotating scans disposed on the tube to represent the three radar sites. This is accomplished with a fixed coil display by switching the azimuth and signal strength information electronically from the three sites at a switching rate of 400 cps.

To assess the systems without resorting to field trials, a jammer simulator was built, which can simulate the jamming strobes which would result from three ground radars in the presence of a number of ECM-equipped aircraft. The jammers are simulated by moving spots of light projected from below onto a frosted glass screen by small projectors, each separately motor-driven to turn slowly about a horizontal axis. Six such projectors were built, capable of simulating aircraft speeds from 450 to 2000 mph. The three radar simulators sit on a clear glass shelf above the frosted glass, and consist of a photomultiplier tube behind a narrow slit cut in a disk. A lens in front of the disk focuses images of the slowly moving spots of light onto the disk, and, by rotating the slit and photomultiplier combination at the radar scan rate of 4 rpm, the output signal simulates that of a jammed radar with a somewhat idealized antenna with no side lobes. However, it is believed that such a "cleaned-up" picture could be obtained in practice with improved antennas and time-azimuth plotters to permit azimuth integration.

Three staff officers from Air Defence Command Headquarters conducted tests using the display and simulator. It was found that the six jammers could be tracked if tracking with a grease pencil on the face of the tube was begun as soon as the first of the jammers came within detection range. Otherwise, if a complex situation was allowed to develop without a record, the time taken to distinguish between false and true tracks was unacceptable or the effort abortive.

Work is progressing on a data system for transmitting azimuth and signal strength

VULNERABILITY OF DOPPLER DETECTION SYSTEM TO COUNTERMEASURES

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

Period under review: July - September 1957

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.

The experimental airborne superregenerative repeater-jammer constructed earlier this year was given a brief flight trial. It was found to operate satisfactorily, but was affected by reflections from the ground. A further investigation of the effect of ground echoes was made by transporting the repeater-jammer in a truck over various types of terrain. It was found that reflections were more serious for vertically-polarized radiation than for horizontal, and that reflections from the ground, at ground level, do not allow operation with weak incoming signals. However, in an aircraft flying above 1500 feet, it is believed that there will be little trouble.

As a preliminary to flight trials of the repeater-jammer, it was thought advisable to measure field strength of signals from a DDS site, to determine in advance where, in relation to such a site, it could be expected to function successfully. These measurements were made by an aircraft and crew from Air Defence Command. It was found that the AN/APR-4 receiver installed in the aircraft had not sufficient resolution to be used as a monitor for the repeater-jammer. An APR-4 receiver is to be modified for this purpose.

Work on microwave superregenerative receivers was continued. The Varian double-ended backward-wave oscillator type VAD-161-2 was repaired by Varian Associates and put to use in experimental superregenerative receivers. Further improvements in sensitivity resulted and a better understanding of the principles affecting sensitivity was gained. It was found that optimum operating parameters and quench waveforms exist for various bandwidths and types of signals. More detailed information can be found in a report on microwave superregenerative receivers which is in preparation.

A Huggins type BA-2 cascade backward-wave amplifier was received and tested. Experimental work looking into countermeasures applications of single and double circuit backward-wave amplifiers is being continued.

GROUND-TO-AIR COMMUNICATIONS USING IFF

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

Period under review: July - September 1957

For the proposed operational trials of this emergency ground-to-air communications system, six airborne decoder units were built, together with trays for mounting them in CF-100 aircraft. These units each weigh  $2\frac{1}{4}$  lbs, and occupy a space  $3" \times 5" \times 7"$ . The servo amplifier rack for orienting the antenna was wired, and work is being continued on the control panel for the operator.

ANTENNA FOR AIRBORNE EARLY WARNING

Reference: USAF. No DND project number.

Period under review: July - September 1957

In cooperation with Division IV, Lincoln Laboratory, a combination radar-IFF antenna is being developed for use with an airborne early-warning system. The antenna consists of two  $52\frac{1}{4}$ ' focal length pillboxes stacked one above the other, having a horizontal aperture of some 16 feet. The radar pillbox is 23" high, and in the frequency range 650-700 mc/s, operates with horizontal polarization in the  $TE_{10}$  mode. The IFF pillbox is 4" high, and in the frequency range 990-1130 mc/s, operates with vertical polarization in the TEM mode. The horizontal surfaces of the pillboxes flare in the vertical plane to form small aperture horns, which give moderate directivity in the vertical plane. In the case of the common boundary between the pillboxes, a horn structure, transparent at the lower frequency and effective at the higher frequency, is used.

Scale-model pattern tests of the radar portion of the antenna have been completed, and scale-model pattern tests of the IFF portion are still in progress. Matching and high-power testing of the radar feed have been completed, and a prototype antenna is under construction.



CLASSIFIED REPORTS ISSUED

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

Hudson, A.C.            Comparison of NRC Prototype and CAL Model of AFC  
                            and                              Chassis for AN/MPS-501B (ERB-436, Confidential)  
Westby, R.L.

Some difficulties have arisen with the AFC chassis for the AN/MPS-501B radar, and the present report compares in detail the chassis as manufactured by Canadian Arsenals Limited, and the prototype designed by the Radio and Electrical Engineering Division of the National Research Council in 1954. The prototype design is described in Report ERA-264.

McCormick, G.C.    Testing of the CAL Prototype of the CB Antenna for Patterns, Gain, and Beam Position (ERB-433, Confidential)

Tests have been made on the antenna of the production prototype of the AN/MPQ-501 Counter Mortar Radar manufactured by Canadian Arsenals Limited. The tests were with respect to patterns, beam position over the scan cycle, and gain. Mean beamwidths were  $0.87^\circ$  in azimuth and  $0.85^\circ$  in elevation at the 3-db points, with side lobes varying from 5% at center of scan to 9% at the extreme scan positions. A wide angle lobe due to internal reflections within the scanner was noted, but its amplitude is less than 10%. The gain of the antenna is  $45.9 \text{ db} \pm 0.3 \text{ db}$  with respect to isotropic, indicating that the antenna efficiency is highly satisfactory. A small difference in rate of scan between high and low beam was noted. A comparison with the McGill University experimental model is made.

Moore, W.J.M.        High Voltage Surge Tests on a CF-100 Aircraft Wing Tip Rocket Pod (ERB-426, Confidential)

High voltage surge tests carried out on a CF-100 aircraft wing tip rocket pod are described. The purpose of the tests was to determine, within the limits of the test equipment, modifications which

could be made to the pod to provide protection for the rocket firing circuits from a lightning stroke.

It was found that this could best be achieved by ensuring that the entire outer surface of the pod was electrically conducting. In the laboratory a conducting surface was obtained by spraying the Fiberglas nose and tail cones of the pod with molten aluminum.

Morse, A.R.      A study of Failures in Some 400-Cycle 45-KW Alternators (ERB-423, Restricted)

Pedersen, B.O.      Field Contours of Magnetic Sweeps ML MK.4 MOD. 2 and ML Diverted (ERA-316, Secret)

Measurements of the magnetic field of the ML Mk.4 Mod. 2 Sweep and the ML Diverted Sweep were carried out on a model scale. Field maps of three components, vertical, longitudinal, and transverse, of the field are presented for several depths.

Pulfer, J.K.      A Study of Superregenerative Repeaters (ERB-424, Secret)

Qualitative results of a number of experiments with periodically quenched oscillators are given. Representative tubes operating in each portion of the frequency spectrum from a few megacycles to 15 kilomegacycles were used. Characteristics relating to operation as superregenerative repeaters, such as ease of quenching, receiving sensitivity, and output power are given for each type of oscillator.

Pulfer, J.K.      Progress Report on ECDC Project T34 (ERB-427, Confidential)

Development of the first models of the VAD-161 double-ended backward-wave oscillator by Varian Associates of Canada Ltd., is described. Data obtained from measurements made on the first

model delivered to this laboratory are included, along with recommendations for further improvements.

Pulfer, J.K.      Communications Jamming with a Periodically Quenched Oscillator (ERB-429, Secret)

The possible application of a periodically quenched oscillator as a communications jammer is investigated. Results of measurements made with a typical repeater jammer are compared with those obtained by direct noise jamming. The jammers are tried against AM, single sideband, and FM communications, to determine the relative merits of the two types in each case.

Westby, R.L.      Effectiveness of a Pre-Selection Cavity as an Anti-Jamming Measure (Preliminary Report) (ERB-425, Secret)

A study was made of the improvement to be obtained by suppression of the image frequency of a radar equipment subjected to sweep jamming. Single waveguide cavities tuned to the operating frequency, and of different bandwidths, were employed to suppress the image frequency. The jammer used was a carcinotron, frequency-modulated by noise, and the receiver was of the "Dicke-fix" type. The improvement in minimum detectable signal was found to be greater than 3 db for jamming power more than 15 db above receiver noise. This improvement is a function of jamming level and may reach 10 db at high jamming powers.

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