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NATIONAL RESEARCH COUNCIL OF CANADA
RADIO AND ELECTRICAL ENGINEERING DIVISION

CLASSIFIED PROGRESS REPORT NO. 17

(APRIL - JUNE 1959)

Declassified by
ORIGINAL SOURCE BY
ORIGINAL SOURCE FOR

Authority: S. A. MAYMAN

Date: NOV 26 1992

OTTAWA

JULY 1959

NRC # 35423

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.

| <u>CONTENTS</u> | <u>Page</u> |
|--|-------------|
| Counter Mortar Radar (AN/MPQ-501) | 1 |
| Purpose of Equipment | |
| General Description | |
| Status of Prototype | |
| Standardization | |
| Scanner Brake | |
| Circular Polarizer | |
| Antenna Mount | |
| Receiver | |
| Slides and Demonstrations | |
| Trainer | |
| Anti-Jamming Measures Against Carcinotrons | 3 |
| Dicke-Fix Receiver | |
| Video Processing | |
| Pre-Selector Cavity for AN/MPS-504 Radar | |
| Improvements to Ground Radars | 4 |
| PRF Jitter Circuit | |
| Azimuth Time Recorder | |
| Echo Monitor "Emma" | |
| Automatic Strobe Triangulation Display (Astrid) | 5 |
| Low Angle Detection | 6 |
| Sound-Ranging Computer | 7 |
| Instantaneous Microwave Direction Finder (AN/UPD-501) | 8 |
| Prototype Antennas | |
| Spiral Antennas | |
| Crystal Matching | |
| Prototype Auxiliary Equipment | |
| Shore-Based High-Frequency Direction Finder (AN/GRD-501) | 10 |
| Shipborne High-Frequency Direction Finder | 11 |
| Shipborne Short-Signal Intercept Receiver | 12 |
| Improvement of HF DF Techniques | 13 |
| Self-Monitoring Degaussing System | 14 |

| | <u>Page</u> |
|--|-------------|
| Dynamic Characteristics of the Induced Field in Ferromagnetic Bodies | 15 |
| Airborne Homing System for MG-2 | 16 |
| Model Antenna Studies for HMCS "Bonaventure " | 17 |
| ECM Antenna System for B-52 Aircraft | 18 |
| ECM/DF Antennas for P2V7 Aircraft | 19 |
| Jamming Studies | 20 |
| Antenna for X-7769 Carcinotron Jammer L-Band Horizontally Polarized Antenna | 22 |
| Vulnerability of the Doppler Detection System to Countermeasures | 23 |
| Instantaneous Microwave Frequency Indicator | 24 |
| Classified Reports Issued | 26 |
| Declassified Reports | 27 |
| Distribution | 28 |

COUNTER MORTAR RADAR (AN/MPQ-501)

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

Period under review: April-June 1959

PURPOSE OF EQUIPMENT

The primary role of this radar is the detection and location of mortars to ranges of at least 7000 meters. 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 was 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. The design is generally suitable for mounting on the new Canadian tracked armored personnel carrier. Consideration of modifications required to take full advantage of the new vehicle is being continued in cooperation with the vehicle authorities.

STATUS OF PROTOTYPE

The equipment has been located at the National Research Council where it has been used as an aid to the modification of the antenna structure. Maintenance and investigation of items listed as deficiencies in the trial reports have been continued. Development and assessment of improvements are reported below.

STANDARDIZATION

The equipment was declared standard for Canadian Army use.

SCANNER BRAKE

Direct-current braking of the scanner motor to replace the mechanical brake is being installed for use when A-scan presentation is desired.

CIRCULAR POLARIZER

A number of test pieces were cast. The pieces were tested for accuracy of dimensions and electrical uniformity. Results appeared acceptable and a longer run was made to test the repeatability of the process. Results of this are being examined before the final die is manufactured.

ANTENNA MOUNT

A full scale model of the antenna structure was made to the revised design from the new drawings. New features incorporated include symmetrical scan, polarizer mount, sturdier construction, and elimination of the need of counter-weights.

RECEIVER

The video bandwidth of both A- and B-scan video amplifiers was increased, largely by reducing stray circuit capacitance. Bandwidths are now as follows: A-scan, 6.5 mc/s; B-scan, 6 mc/s. These bandwidths are sufficient for the 0.2 microsecond pulse employed.

SLIDES AND DEMONSTRATIONS

A set of explanatory slides was made, including exterior and interior views and functional diagrams. These were used in conjunction with brief demonstrations of the equipment when it was shown to groups of United Kingdom, United States, and Canadian army officers.

TRAINER

The equipment is being modified to display operator error directly on suitably calibrated meters.

ANTI-JAMMING MEASURES AGAINST CARCINOTRONS

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

Period under review: April-June 1959

DICKE-FIX RECEIVER

Design of a receiver using the so-called "Bessel Filter" response* has been planned. Some components, notably the special type-D3A tubes, have been ordered, and some sheet-metal work has been completed.

Work on the preamplifier using type-VX3519 tubes was postponed.

VIDEO PROCESSING

Experiments are being conducted with a regenerative pulse-width discriminator which rejects pulses shorter than the anticipated radar return and regenerates those which are longer. The device works well with a conventional video integrator, and a second unit is being built to permit the use of the discriminators both before and after the integrator.

The device would be expected to be of some value under low jamming conditions; i.e., while the jamming can still be described adequately in terms of isolated pulses. It will clearly cease to be of assistance when these impulses begin to merge, which is the point at which Dicke-Fix and guard-channel systems fail.

PRE-SELECTOR CAVITY FOR AN/MPS-504 RADAR

The servo for tuning the cavity was developed; a loaded potentiometer was employed instead of a cam to generate the tuning law. Information was passed both to the Army and CAL.

* "The Transient Response of Common Filters", K.W. Henderson and W.H. Kautz, Trans. IRE CT5, December 1958

IMPROVEMENTS TO GROUND RADARS

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

Period under review: April-June 1959

PRF JITTER CIRCUIT

A simple circuit that will produce jitter of the pulse recurrence frequency of the AN/MPS-504 radar was supplied to the Army. The circuit involves a simple modification of the radar's synchronizing chassis and allows on/off control of jittering from a remote point. The circuit was tested on the radar at the Metcalfe Road Field Station and was found to operate satisfactorily. It provides a jitter of at least 150 μ sec and requires no adjustment after installation.

AZIMUTH TIME RECORDER

When it was decided to use the Stepped Gain Receiver with Astrid, it became apparent that this receiver could also be adapted to the Azimuth Time Recorder. This would allow the same receiver to be used for three purposes at the same time — with Astrid, with the Azimuth Time Recorder, and as an instantaneous jamming power level monitor. A printing circuit was designed which was much simpler than those used previously. It also permitted the use of pulses of unequal amplitude to produce four gray scales without increased circuit complexity.

Tests of the revised circuit were carried out at an RCAF Station with ground-based and airborne jammers. Results were the best obtained up to that time. The RCAF is now satisfied with the Azimuth Time Recorder and is procuring more units for operational use.

ECHO MONITOR "EMMA"

The first field trials of EMMA were carried out at an RCAF Station. The RCAF's Central Experimental wished to compare the performance of their standard chaff and a cheaper type of chaff cut for L and S bands only. EMMA was connected to an AN/FPS-3 (C) radar. The aircraft dropped alternate bundles of standard and experimental chaff. A scan-to-scan photographic record was made of the EMMA display. Later analysis showed that echoes from the experimental chaff were about 2 db stronger than those from the standard chaff and that the two had equal blossoming and lay times.

These early field trials pointed out the desirability of several minor modifications to EMMA, such as provision of camera control from the EMMA display. These modifications are being incorporated in the display.

A report of these trials is being prepared for the RCAF.

AUTOMATIC STROBE TRIANGULATION DISPLAY (ASTRID)

Reference: RCAF and Project "Napkin". No project number

Period under review: April-June 1959

Two preliminary field trials were conducted. To test the azimuth transmission system, antenna positional information was transmitted in the form of a tachometer signal and north marker from a radar site, for a distance of 80 miles over a voice channel. Satisfactory following was obtained from a synchronous motor at the receiving end, and as a result, construction of two additional azimuth coders and decoders was undertaken. The second trial involved an aircraft carrying a spot jammer. The encoded jamming signal and antenna azimuth information was recorded on magnetic tape at a radar site. When played back into the decoding equipment and onto the triangulation display, a single, well defined strobe was obtained. Preparations are being made for a three-station field trial.

LOW ANGLE DETECTION

Reference: Army, RCAF. No DND project number

Period under review: April-June 1959

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

SOUND-RANGING COMPUTER

Reference: Army. No DND project number

Period under review: April-June 1959

Study of the data presentation requirements indicated that a specially designed, data speed-up, tape loop is required to satisfy the read and write requirements and to provide sufficient storage for several recordings, and that a multi-track magnetic drum can be utilized to display selected parts of the recordings. The repetition rate of the display will be directly proportional to the product of the speed-up ratio of the tape and the number of tracks on the magnetic drum. This is also limited by the maximum permissible counting rate of the computer circuitry. Commercially available magnetic recording equipment which may be adapted is being investigated.

The logical design of the arithmetic unit for MINIAC using the transistor NOR circuit was completed. The arithmetic unit operates in the parallel mode and is capable of performing fixed point addition, subtraction, and multiplication. The "Booth" method is used for multiplication.

Three-dimensional wiring configurations of the individual NOR circuits are being examined to obtain high component density and to simplify wiring of the computer. A 32 word (8×4) program storage unit was wired and tested. The word length is seven binary digits. The unit is driven by two magnetic decoder switches using a coincident current method.

INSTANTANEOUS MICROWAVE DIRECTION FINDER (AN/UPD-501)

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

Period under review: April-June 1959

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.

PROTOTYPE ANTENNAS

The L-band antennas of both polarizations were rechecked electrically after environmental testing by DND Inspection Services. Their performance remained within satisfactory limits.

SPIRAL ANTENNAS

A 16-antenna direction-finding system was fabricated and is being measured for bearing error and sensitivity. It consists of 16 flat double-spiral antennas, each two inches in diameter. To improve the axial ratio, a radio-frequency absorbing ring is placed at the outer periphery. This reduces the axial ratio to about 1.2 to 1.4. The 16 antennas are coupled to the four-channel indicator through a resistive resolving network.

For test purposes two configurations were made: one consisted of a single row in a 12-inch diameter cylinder, and the other of two rows in a 5½-inch-diameter cylinder.

The operating range is 2.0 to 10.5 kmc/s, with circular polarization. The bearing error maxima are mostly less than 10°, using vertical or horizontal polarization, but a few peak errors reach 15°. The gain of a single spiral is 2 to 4 db above isotropic from 10.5 to 3.2 kmc/s; then it drops uniformly to about 8 db below isotropic at 2.0 kmc/s.

CRYSTAL MATCHING

A system for selecting matched crystals for the UPD-501 was developed and the method given to a contractor who is now able to select crystals to ±0.5 db.

Two methods of monitoring the sensitivity of crystals in service use were compared: a d-c method and a pulsed 50 mc/s method. The latter appeared to give

more reliable results. Laboratory measurements indicate that a change of as little as 1 db can be detected with the pulsed 50 mc/s equipment.

PROTOTYPE AUXILIARY EQUIPMENT

Measurements were made on a 28-volt d-c power supply and an antenna control unit, both before and after shock and vibration tests. Several minor defects were noted, and will be corrected in future models.

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

Reference: Navy. DND Project A14-38-10-01

Period under review : April-June 1959

Difficulties which had been encountered by the production contractor in making the production model perform according to specification were found to be due chiefly to misalignment and measurement techniques. The final performance proved to be satisfactory in every important respect.

Tests of the prototype recorder unit now installed on model No. 3 set are almost complete and drafting of the performance specification has been commenced.

A report entitled "Proposed Modifications for Improved Performance of AN/GRD-501" (ERB-516) is in preparation.

SHIPBORNE HIGH-FREQUENCY DIRECTION FINDER

Reference: Navy. DND Project A17-38-20-19

Period under review: April-June 1959

The major effort during the period under review was development of the 8-16 mc/s radio-frequency amplifier. The design appears to be satisfactory from the point of view of frequency response, gain, and stability, and three models have been built for the final equipment. High-pass filters must be installed before alignment of these models.

Five broad-band balance-to-unbalance transformers were purchased. These have been tested for frequency response, insertion loss, and balance ratio, and appear to be satisfactory for use with this equipment.

The AGC system which will operate on the common local oscillator signal is being constructed.

SHIPBORNE SHORT-SIGNAL INTERCEPT RECEIVER

Reference: Navy. DND Project A17-38-20-24

Period under review: April-June 1959

A sweep generator was designed which will produce a three-line non-linear display with a single-gun Memotron. Each line contains two decades of an essentially logarithmic sweep. The generator has been constructed but not yet tested.

IMPROVEMENT OF HF DF TECHNIQUES

Reference: Navy. DND Project A14-38-10-24

Period under review: April-June 1959

Enough data has been taken to estimate the reduction of bearing variance by time-averaging. In 75% of the data the variance was reduced by 16:1 with a 30-second average. During the other 25% of the time the reduction for a 30-second average is much less (4:1). It is believed that this small reduction is due to long term variations, and the data will be re-examined in an attempt to correlate variance reduction with other parameters.

The Hewlett-Packard printer has been received and is functioning properly.

Since scatter diagrams of bearing and signal strength were obtained several years ago, no thorough study of their structure has been made. Equipment for such a study is nearing completion. A method of examining the general shape of scatter diagrams was tried using a Memoscope to hold the display until the scatter diagram can be studied or photographed.

SELF-MONITORING DEGAUSSING SYSTEM

Reference: Navy. DND Project A17-44-35-01

Period under review: April-June 1959

A closed-loop system for automatic degaussing of a ship's magnetic field is under development. It is being designed to null the difference between the field of the ship and the field of the ship's degaussing coils.

Preparations are being made for trials of this system on the minesweeper HMCS "Cowichan" at Esquimalt, B.C., in August. Two gradiometer detectors are being built for this purpose. One of these will be mounted in a position where it is under the influence of the ship's "M" field and will control the "M" coils; the other will operate similarly in the "A" system.

In these gradiometers, the error signal due to misalignment, magnetic unbalance, and long term drift should be less than 50 gammas. Presence of second harmonics in the exciting oscillator output caused difficulty in obtaining a magnetic balance between the two gradiometer elements. A twin T filter, used with the oscillator circuit, reduced second harmonic content from 5% to 0.1%. Accurate balance is now possible. Long term drifts due to temperature gradient in the detector system have also been a serious problem. Work is now directed towards reducing these temperature effects.

For the ship trials the gradiometers will be mounted in long lengths of thin-wall 8-inch-diameter aluminum tubing. The mechanical design and construction of this system is progressing.

DYNAMIC CHARACTERISTICS OF THE INDUCED FIELD
IN FERROMAGNETIC BODIES

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

Period under review: April-June 1959

No work was done on this project during the period under review.

AIRBORNE HOMING SYSTEM FOR MG-2

Reference : RCAF. No project number

Period under review : April-June 1959

The second model of the S-band feed was completed. Bench measurements were made, gain was determined, and patterns in azimuth were taken. The switching action is good, and patterns in azimuth are acceptable. Gain was 16.5 db from 2860 mc/s to 3020 mc/s, but fell to 10 db at 2700 mc/s. The VSWR rose from 1.2 at center frequency to 5.0 at 2700 mc/s. Further work is being done to improve the efficiency and matching.

MODEL ANTENNA STUDIES FOR HMCS "BONAVENTURE"

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

Period under review : April-June 1959

An LF (500 kc/s) "notch" antenna was designed and the calculations forwarded to EEC/Royal Canadian Navy for consideration.

Development of a broadband HF antenna system for HMCS "Bonaventure" has been started, using an approach similar to that adopted for the DE-257. Measurements are being continued on a sleeve-funnel broadband antenna.

ECM ANTENNA SYSTEM FOR B-52 AIRCRAFT

Reference: USAF. No DND project number

Period under review: April-June 1959

No further measurements of the dual slot antenna system were carried out during the period under review.

ECM/DF ANTENNAS FOR P2V7 AIRCRAFT

Reference: RCAF. No DND project number

Period under review: April-June 1959

The cavity configuration which has given the most satisfactory performance consists of an inverted cone with the base of the cone at the input terminals of the spiral antenna. A parabolic cylindrical reflector has been constructed and measurements of the radiation pattern and VSWR are being continued on the combined spiral-feed/reflector system. All the measured patterns from 1 to 10 kmc/s exhibit a squint and the nature of the squint is currently under investigation.

JAMMING STUDIES

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

Period under review: April-June 1959

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

The study is concerned with both the properties, capabilities and limitations of the more promising generators of jamming signals and the manner in which such signals affect various systems, so that the feasibility of jamming can be predicted. The 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.

Jamming tests on the AN/SPG-48 radar were concerned with denial of the ability to set and maintain the range gate on a target by use of FM-by-noise jamming. Variability in certain of the radar circuits, especially the video gating circuits, caused considerable difficulty in obtaining repeatable results. For this reason, completion of some sections of the report was delayed. White noise jamming tests were made, using TWT noise, and the results were compared with those of the FM-by-noise tests. A repeat performance of the jamming demonstration was recorded on motion picture film by RCN personnel. It is understood the material is to be incorporated into a training film.

A number of reasons exist for seeking an alternative modulation signal to wideband video noise which is usually employed in FM-barrage jamming. The Sum Of Sinusoid And wideband video Noise (SOSAN) as a modulation signal appeared to have several advantages, and further study was undertaken, with emphasis on experimental verification of the preliminary deductions. A briefing on the subject was given to the Project Napkin working group, and a report is in preparation. Use of the proposed modulation should: (1) give more uniform power spectrum and jamming effectiveness over the barrage, (2) allow lower modulator size, weight, and power requirements, and (3) reduce subjamming visibility obtained with "Dicke Fix" receivers.

The AN/APG-33 radar was set up in the laboratory and the necessary adjustments were made. Locking onto fixed target returns in the vicinity was obtained. Construction of a laboratory-type repeater jammer for tests with AN/APG-33 is underway. A 1-watt TWT amplifier tube was purchased, and its characteristics were measured using laboratory power supplies. A power supply specifically designed for the tube was constructed and is being tested. A crystal video receiver is being assembled, which, it is hoped, will gate on

the TWT amplifier with a delay of less than 0.1 microseconds after the arrival of the radar pulse.

Control and protective circuits for the 400-cps M carcinotron test bench were constructed. Characteristics of the 3W5000A series-regulator tube for the 5000 volt 0.5 ampere delay line supply were measured so that design of the regulator can be continued.

ANTENNA FOR X-7769 CARCINOTRON JAMMER

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

Period under review: April-June 1959

L-BAND HORIZONTALLY POLARIZED ANTENNA

This project has been discontinued, at least temporarily, while the RCAF investigate a promising commercially available antenna.

VULNERABILITY OF THE DOPPLER DETECTION SYSTEM TO COUNTERMEASURES

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

Period under review: April-June 1959

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.

Measurements were made on the third and final model of the Varian backward-wave amplifier. Results provided information on the performance of backward-wave tubes in superregenerative and autodyne receivers. The development work has been completed, and a final progress report prepared. A report is also being written giving the results of a study of velocity-sorting detection in autodyne receivers using the Varian tube.

Studies of the susceptibility to jamming of the radio relay communications system of the Mid-Canada Line were completed.

The study of the susceptibility of the Mid-Canada Line to portable ground-based jammers was also completed, and a report is being prepared.

An AN/FPS-501 receiver was obtained on loan from the RCAF and measurements are being made to determine some of the characteristics governing its desensitization by jamming signals.

A laboratory model superregenerative repeater with spare cavities was loaned to CAL of Toronto in connection with the development of countermeasures set AN/ALQ-501.

INSTANTANEOUS MICROWAVE FREQUENCY INDICATOR

Reference: DRB. No DND project number

Period under review: April-June 1959

The purpose of this project is the development of an instantaneous microwave frequency indicating device based on the principle of amplitude comparison of the detected and video amplified outputs of a set of bandpass filters with overlapping pass bands. This type of frequency indicator is closely related to the microwave instantaneous direction finder. However, because there are losses in power division and padding not present in the direction finder, and because antenna gain is expected to be lower, radio-frequency amplification is required to maintain sensitivity equal to that of the crystal video receiver of the direction finder. The radio-frequency amplification is provided by a broad-band permanent-magnet-focussed travelling-wave tube.

At the end of March a maximum error of ± 30 mc/s had been found in a 12-filter S-band frequency indicator with a new configuration of filters and power dividers. The loss involved was about 12 db. As this configuration results in a compact device, it was thought that a 16-filter frequency indicator using the same approach would be useful. Components have been constructed and tested, but no measurements have been made on the system.

The possibility of using the S-band filter system to indicate frequency at other frequency bands by converting to S-band with a stable local oscillator was investigated. At X-band (8.5 to 10.5 kmc/s) it was found that this was feasible provided frequencies below 8.5 mc/s and above 10.5 were rejected by a filter. Frequencies close to, but outside the design bandwidth produce spurious responses. A mixer for converting X-band frequencies (8.5 to 10.5 kmc/s) to S-band frequencies (2 to 4 kmc/s) was constructed. The conversion loss varied from 6 to 10 db across the frequency band. It is possible that the loss can be reduced, but this problem was not pursued. It has been inferred that other frequency bands 2 kmc/s wide above S-band can be covered in the same way.

The entire frequency band from 0 to 2 kmc/s can, in principle, be covered by using a local oscillator at 2000 mc/s; however, the accuracy that could be obtained would be of little interest below about 1000 mc/s. It was found that the band from 1000 to 2000 mc/s can be covered rather easily with the local oscillator at 4500 mc/s. No spurious responses were detected after the obvious one had been filtered out. However, the percentage error doubles in this frequency band, and the design of a suitable mixer becomes more difficult because of the larger percentage bandwidth covered.

To obtain low errors, when frequency is converted to S-band from other frequency bands, a local oscillator which is stable compared with the error in the frequency indicator is required. Assuming that errors in the frequency indicator can be reduced to ± 10 mc/s, the frequency variation of the local oscillator should not be much more than ± 1 mc/s.

Stabilization of a klystron by a feedback loop from a discriminator consisting of a length of waveguide terminated with a crystal mount is being investigated. The crystal is modulated at a low frequency and this phase-modulates the reflected wave from the crystal. Discriminator action is obtained by coupling to the waveguide with a probe at the voltage minimum.

CLASSIFIED REPORTS ISSUED

- Cumming, W.A.
and
McCaskill, D.R.
- A Proposed Two-dimensional Array for Reception in the
2-6 mc Band (ERB-510, Limited)
- The choice of a suitable receiving antenna for use in the lower portion of the HF band is a difficult one, and is of great interest to those in the communications field.
- This report summarizes briefly the basic philosophy behind the design of such an antenna, and describes a proposed two-dimensional array of novel design. It consists of 24 inverted-V antennas arranged in a two-dimensional array, and through the use of multicouplers provides six independent overlapping antenna beams. The individual elements have a side length of only $\frac{1}{20} \lambda$ at the lowest frequency, and as a result are much less frequency dependent than conventional inverted-V antennas.
- A considerable amount of experimental work has been carried out in preparation for the construction of a complete array, and to date the results are most encouraging.
- Hunt, F.R.
- An Anti-jamming Logarithmic Receiver (ERB-508, Secret)
- Radar receivers presently employed by the Canadian Armed Services are of little use against chaff drops, or spot and slow-sweep electronic jammers, which almost invariably cause the receivers to saturate. A logarithmic receiver is a useful ECCM device in an air-defence radar set subjected to this jamming. It also provides a measure of relief against weather, sea, and land clutter. The circuit of the experimental logarithmic receiver and a summary of the field tests are given in this report.
- Steele, K.A.
- Buzzer Microwave Source for Testing the UPD-501 Receiver (ERB-511, Confidential)

This device is a portable source of microwave energy, which may be used for qualitative tests of UPD-501 system performance. Limitations on its use are discussed and a description of the design is given.

DECLASSIFIED REPORTS

The following reports have been declassified:

| | |
|---------------|--|
| Burtnyk, N. | I.F. Amplifiers and Gain Control for a Matched Twin-channel Receiver (ERB-431) |
| Burtnyk, N. | Design of Circuits for Coupling a Direction Finder to a 4-element and 8-element Adcock Antenna (ERB-475) |
| Cox, L.G. | Dot-lock and Blanking Unit for Twin-channel HF DF Equipment AN/GRD-501 (ERB-333) |
| Craven, J.H. | Design of a Diplexing Filter for the High Resolution IFF Antenna of the AN/FPS-3 Radar (ERB-476) |
| McLeish, C.W. | The Derivation of HF DF Corrections from Local Calibrations (ERB-496) |