Progress report for October, November, December, 1947

National Research Council of Canada. Electrical Engineering and Radio Branch

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UNCLASSIFIED

LABORATORIES

OF

THE NATIONAL RESEARCH COUNCIL OF CANADA

ELECTRICAL ENGINEERING AND RADIO BRANCH

PROGRESS REPORT

FOR

OCTOBER, NOVEMBER, DECEMBER, 1947

OTTAWA

JANUARY, 1948

Report no. ERA - 149

Laboratories

of

The National Research Council of Canada

Electrical Engineering and Radio Branch

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Ottawa, January , 1948.

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Unclassified

I
ELECTRICAL ENGINEERING

VAN DE GRAAFF GENERATORS

Summary. Construction of these generators arose from a requirement of the Nuclear Physics Division of the Laboratories of the National Research Council for a high-voltage electrostatic generator. As extensive work on the mechanical and electrical design of electrostatic generators had been carried out at the Massachusetts Institute of Technology, it was decided to follow closely the basic design, as developed by Dr. Van de Graaff of MIT. This, the Electrical Engineering Laboratory of NRC proceeded to do, subject to the general direction of physicists of the Nuclear Physics Division, and the machine was designed to use discharge tubes which had been developed by the Machlett Corporation for wartime radiography.

A number of modifications of the MIT mechanical design were made in order to improve the accessibility of the working parts of the machine. Among these were a different type of belt-tensioning device; a modified design of equipotential plane, having a removable section to facilitate servicing of the belt and of the resistor chain; and a new type of fastening between the pressure tank and its base.

The Electrical Engineering Laboratory also undertook the design and construction of a 500-kv Van de Graaff generator for the NRC Division of Chemistry. This generator is mainly of original design and its chief features are its compact size, horizontal mounting, potential division by means of corona points and its sealed-off electron accelerator tube.

Progress.

Five-Megavolt Generator. Meetings have been held with physicists and engineers of the Atomic Energy Project at Chalk River in order to co-ordinate the work of installation of the generator. It was decided that the Electrical Engineering Laboratory would be responsible for high-voltage testing of the machine under pressure, before the installation of the accelerator tube.

The installation of hangers and hydraulic fittings for the flange of the air receiver has been completed, except for the hydraulic system. The stainless-steel domes have not yet been received.

Trouble was experienced with the permanent-magnet alternator which supplies filament and ion-source power in the top dome. Installation of a different type of oil seal corrected this difficulty.

Five-Hundred-Kilovolt Generator. Preliminary electrical tests have been made under gas pressures up to 500 pounds per square inch. A number of minor gas leaks were detected and the pressure sealing was improved. The gas-pressure system used for these tests was constructed by the Division of Chemistry and a similar system will probably be used in the final machine. The vacuum system, which will remove the moist air from the tank prior to the introduction of nitrogen, has also been constructed by the Division of Chemistry.

The physical layout of the rectifying circuit of the generating voltmeter was revised in order to improve the accessibility of components. A rough calibration of the voltmeter was carried out in order to determine the maximum voltage generated, and a maximum reading of 300 kv was obtained. During these tests, the performance of the corona potential-dividing system was found to be erratic. A number of tests have since been made on the characteristics of point-to-plane electrodes under high gas pressure in an attempt to determine the optimum electrode spacing for the total voltage required. When the proper spacing has been found and the machine conditioned, it is expected that operation will be more stable.

The focussing magnet and mounting for the electron-accelerator tube have been constructed and the ground plate of the machine has been prepared for mounting this assembly.

Difficulty has been experienced due to failure of the glass insulators used between the equipotential plates. This failure was caused by stresses in the glass introduced during the process of gluing the insulators to the dural electrodes. Tests have been carried out in co-operation with the Division of Chemistry on various commercially-available adhesives, one of which shows promise of being a solution to the problem.

HIGH-SPEED RECORDING OSCILLOGRAPH

This instrument is being designed for the recording of the voltage wave of our one-million-volt surge generator. A sealed-off tube and a fluorescent screen will be employed.

The three standard impulse waves, which this instrument must record, are 1/2-5 (1/2 microsecond rise time, 5 microseconds to half-value decay), 1-10, 1 1/2-40. This necessitates three different sweeps, the last of which must be exponential. A preliminary sweep circuit, designed to meet these requirements, has been set up and tests indicated that certain modifications would be necessary.

A phase inverter is required, which will deliver a minimum output of 300 volts, peak-to-peak, and have a frequency-response characteristic which will be flat up to 10 megacycles. Experimental work is continuing on the preliminary circuit, and some thought is now being given to modifying a circuit developed by the Philips laboratories.

The 20 kv r-f power supply was tested and found satisfactory. It has been installed in the experimental chassis. The provisional low-voltage power supplies for the deflection circuits have been completed and tested. These are stabilized supplies, continuously adjustable over a wide voltage range. It is intended to use these supplies in the development of the oscillograph circuits and to replace them with a final design when the requirements become fixed.

Progress on the project as a whole has been somewhat retarded owing to lack of staff.

ELECTRONIC SYNCHRONOUS SPEED REGULATOR

This device will make available for laboratory use an a-c sinusoidal voltage supply of about 30 kva, with a frequency stability equal to that of our standard frequency 60-cycle supply. The regulator operates in the field of the d-c motor driving our 30 kva Westinghouse sine-wave alternator.

A transient analysis of the control system has been made and the effect of various types of feed-back in improving the stability of the system investigated. It has been found that the introduction of derivative feed-back from the voltage applied to the field, and also from the output of a tachometer generator mounted on the end of the shaft, tended to increase the stability of the regulator.

An attempt was made during the latter part of December to verify this experimentally, but a short-circuit developed in the tachometer generator. Another generator was used and appeared to be satisfactory, but time did not permit further work on the subject.

Present efforts are confined to reviewing the literature in preparation of a suitable background for a publication.

BREAKDOWN TESTS OF LOW-VOLTAGE DISTRIBUTION CABLE

Samples of low-voltage power distribution cable have been received from the Northern Electric Company. These cables were required to undergo surge tests and 60-cycle tests.

Investigations have been carried out on methods of terminating for test purposes the three-conductor, 300,000 circular mils, PILC belted

cable rated at 15 kv. No satisfactory termination has been found. The best termination used up to the present time withstood only 250 kv between conductors on impulse.

Since the construction of satisfactory cable terminations for the 60-cycle tests is much more difficult than for the surge tests, it has been decided to postpone their construction until a satisfactory design has been worked out for the surge tests.

TRANSMISSION LINE FAULT LOCATOR

In response to a request by the AIEE, the original paper on the transmission line fault locator was presented to the Ottawa section of that body, accompanied by an actual demonstration, with the apparatus connected to an artificial line. This paper is now being suitably modified for submission to the Conference Internationale des Grands Reseaux Electriques a Haute Tension.

The work on cable fault location has been discontinued, owing to lack of staff.

CSA APPROVAL TEST WORK

The Canadian Standards Association has requested the National Research Council to undertake the task of examining oil burning equipment with regard to its safety in domestic applications. The National Research Council reports, dealing with the results of the tests, are presented to the Canadian Standards Association Fire-Hazard Committee and generally constitute the basis for acceptance or rejection of the apparatus.

The Mechanical Engineering Division of the National Research Council inspects the mechanical features of the oil burners, while the Electrical Engineering Laboratory examines the equipment for its compliance with the requirements of the Canadian Electrical Code.

During the quarterly period October-December, 1947, fifteen samples of oil burners and components were examined, six of which were recommended for CSA listing. In one case, the tests were conducted at the manufacturer's plant in the United States. Four manufacturers withdrew their applications, as their apparatus was consistently found unsafe for domestic use.

II
ELECTRONICS

pH MONITOR

Summary. This instrument was developed for the Division of Applied Biology and is used to measure and control the pH of solutions

in which cultures are grown. Each unit can monitor simultaneously three such solutions of different pH. Provision is made for the connection of a recording meter to provide a permanent record of pH variation.

Two three-channel control units have been built and calibrated and one of these has been put into operation in the laboratories of the Division of Applied Biology.

Progress. A number of preliminary, controlled pH reactions have been run, and, as a result, certain improvements in equipment and technique have been made. This has led to the development of a satisfactory technique for routine operation of the instrument, and consequently, one or two controlled pH runs have been made weekly for the past three months. The staff of the Division of Applied Biology has become quite proficient in the operation and adjustment of the instrument, with the result that very little assistance has been required by personnel of this branch.

Considerable interest in the instrument and its possibilities has been shown by visitors to the laboratory. It is therefore anticipated that in addition to further requirements for these instruments within the laboratories of NRC, there may be a general market for them in research laboratories. Preparations for their manufacture are being made and several firms have already expressed interest in such a project. Before much progress can be made in this direction, however, the question of obtaining patents for the pH control system must be investigated. A patent search with respect to the metering pumps was begun some time ago.

Some laboratory work has been carried out on the electronic portion of the system in order to secure an improvement in performance and to collect technical details required for reports which are in preparation.

INFRA-RED DETECTOR

Summary. The purpose of this apparatus is to locate faulty joints in power transmission lines. These faults are located by observing the temperature difference between the joint and the conductor, this temperature difference being detected by means of thermal radiation focussed on a bolometer by a parabolic reflector.

The two schemes under consideration at present involve the use of the bolometer either with a radiation chopper or in an alternating-current bridge.

Progress. Two bolometers, a thermistor type and a platinum type, are being investigated for this application. Because of faulty operation, the thermistor bolometer was sent to the factory in August for inspection

and repair and has only recently been returned. Hence, during the past few months, work has been done with the platinum bolometer only.

This bolometer was set up for a sensitivity test, using a radiation chopper consisting of a sectored disc rotating in front of the bolometer entrance slit. The test revealed a sensitivity of the same order as that quoted by the manufacturer. The target used in this test was a flashlight bulb at 75 feet. It was found that for about a half-hour after the apparatus was turned on, the temperature of the disc increased slightly. This was due to heating by radiation from the driving motor, which caused a slow drift in the reading of the instrument. To avoid this difficulty, a chopper was built, consisting of a square tube with ports cut in opposite sides of the tube. This tube was mounted concentrically with the shaft of the driving motor and the bolometer was placed inside the tube and opposite the ports.

It was checked experimentally that a heat signal could be balanced out by directing radiation from a small incandescent bulb onto the back of the chopper, but no tests have been made as yet on the stability of this arrangement.

A battery-operated bolometer amplifier, using a parallel-T network for limiting the frequency response, has been constructed and is being tested. Microphonics are found to be troublesome in the 2E31 sub-miniature pentodes used in the present circuit, and hearing-aid, type CK512AX, sub-miniature pentodes have been substituted in an effort to eliminate this difficulty.

A miniature, battery-operated audio oscillator is being constructed for use as a voltage supply for the bolometer bridge.

AIRCRAFT ANTENNA PATTERNS USING SCALED MODELS

Summary. Radiation patterns of aircraft in flight are obtained by scaling the model, the antenna, and the wavelength down to one-fifteenth or one-twentieth, and then rotating the entire model in various planes on a plastic tower, mounted on a turntable.

Progress. Two unforeseen difficulties arose in putting the preliminary pattern-recording system for model aircraft antenna measurements into operation. Attempts to take patterns further to those reported previously, showed serious distortion due to unbalanced feed and reflections from neighbouring objects.

The first problem - that of unbalanced feed - was finally solved, after a consultation with Dr. George Sinclair of the University of Toronto, by using the split co-axial balance-to-unbalance transformer, which was admirably suited for use on antennas that are small relative to the size of the feeder.

A very promising solution to the second difficulty - reflections from neighbouring objects - has been indicated by the use of a large wire-mesh screen, placed so as to shield the reflecting objects without disturbing the flooding of the model. The exact location of the screen to accomplish this purpose is determined from diffraction theory.

MEASUREMENT OF THE PULSE CHARACTERISTICS OF RECEIVING TUBES

Summary. During the development of a small radar equipment, data on the pulse characteristics of miniature tubes was required, and, as this information was not available, a program of measurements of pulse characteristics was begun with limited personnel.

The apparatus includes a five-microsecond pulse generator with suitable attenuators and pulse-measuring circuits. For convenience in handling various types of tubes a special low-capacity drum switch is used for the interconnection of tube elements.

Progress. Operation and accuracy of the test unit have been greatly improved by the incorporation of new metering circuits. Several alternative metering circuits were built and tested and the best features have been included in the experimental equipment. Where feasible, the apparatus has been made direct-reading.

Some errors in the recorded data have been found and corrected and these curves are now being redrawn for publication.

A test panel has been constructed for the life-testing of groups of miniature tubes, but personnel has not been available to build the separate pulse generator required to feed the panel.

TECHNICAL AIDS FOR THE BLIND

(a) Reading Aid for the Blind.

Summary. This device uses a beam of light to scan printed material. The impulses received are used to control the operation of a series of embossing pins which reproduce the printed characters in a continuous line, slightly enlarged in size, on a moving tape.

Status. The pick-up system has proved satisfactory. Experimental tests of the printing system have disclosed that the thyratron circuits are fundamentally too unstable for reliable operation.

Interviews with organizations in the United States engaged in this type of work indicate that the raised-type printing system, which was to have been used with this device, does not lend itself

to sufficiently high reading speeds. It is believed, however, that this system is reasonably practical for reproduction of diagrams.

Psychological studies are being carried out at the University of Michigan on a system somewhat similar to ours, and also on an auditory system, in order to evaluate their usefulness. Further work on the NRC project has been postponed until the results of these investigations become known.

(b) Guidance Device for the Blind.

Summary. This device will provide indication of the presence, distance and direction of obstacles in the path of the operator, within a range of three to fifteen feet.

Status. A survey of the work done in the United States revealed that some of the supersonic methods of indicating distance and direction of obstacles gave a fair amount of information, but that no reliable method of relaying this information to the operator had yet been devised. Any auditory system of indication tends to interfere with the normal hearing of the operator, which is very undesirable. Further research on these problems in the United States has been greatly curtailed owing to lack of funds.

Experimental work on this device has been greatly retarded by lack of technicians.

REGULATED POWER SUPPLIES FOR LABORATORY USE

It has been found from experience with pulsed circuits, such as are commonly used in radar range-measuring systems, that a low output impedance is essential in regulated power supplies. Some commercially available supplies have output impedances in the neighbourhood of 10 to 15 ohms, which has been found very much too high. The units described here, have, in addition to excellent regulation, an output impedance of less than 0.3 ohms.

These regulated supplies are being made in two ranges. One is a 400-ma unit, operating over the range 250-325 volts, while the other is a 125-ma unit, with a range of 650-800 volts. The results of a series of tests on these supplies will be included in a report now in preparation.

Tests on the 300-volt supply, operating at 400 ma, give output voltage variations within ±0.15 volts, for a variation of ±10 volts in line voltage input. For a change of load from zero to 400 ma, the output variation is within ±0.1 volts. The light-load performance at 250 volts has been considerably improved by the addition of an internal stabilizing load.

The 800-volt unit has not been given detailed tests as yet.

Several of each type have been ordered from the shops and some of the 300-volt units are nearing completion.

These units will replace the various non-uniform wartime supplies at present in use in the Sussex Street Laboratory.

Wide-Range Regulated Power Supplies

Design and testing of the wide-range regulated power supply has continued. Tests on the breadboard model now show a regulated output over the range 300 to 3,500 volts, at a load of 250 ma. Utilizing a plate transformer, which is available in the laboratory, a unit will be built up to cover the range 300 to 2,800 volts, for laboratory use, provision being made for a 3,200-volt maximum output by the substitution of a larger transformer.

Two methods of control have been shown to be practical:

(a) Voltage-operated control, permitting output voltage to be swept or stepped up by means of an applied signal. This sort of control may be employed in cathode-ray presentation of vacuum tube characteristics.

(b) Manually-operated control, by which more efficient operation may be had.

Miniaturized Regulated Power Supplies

As an example of miniaturizing techniques, a voltage-regulated power supply using miniature tubes throughout, has been designed. The outside dimensions are only 9 by 9 by 7 1/2 inches. It provides 100 ma at 250 to 300 volts, -150 volts, and 4 amperes at 6.3 volts. The electronic design is similar to that of the larger regulated supplies previously mentioned, and comparable regulation has been obtained. Six of these supplies are being constructed for use in the laboratory.

Vacuum Tube Load

This unit was designed to facilitate the laboratory testing of power supplies having voltage ratings in excess of 1,000 volts d.c. It will provide loading up to 125 watts, at a maximum voltage of 2,500.

Drawings have been completed and one unit has been constructed. A report is in preparation.

MASS SPECTROMETER

Almost a year ago a request was received from the NRC division of Chemistry for the construction of a mass spectrometer. This instrument was required by their Fundamental Chemistry Branch. It was not possible to begin construction at that time, but orders were placed for nearly all the required components. During the past three months laboratory staff has become available and construction is now well advanced.

The circuit design follows very closely that of a mass spectrometer employed at McMaster University, but the mechanical design is being converted from the conventional "pan" chassis construction to relay-rack construction, which, it is expected, will greatly facilitate servicing. In general, the electronic and electrical components are being carefully engineered in order to provide the instrument with the maximum of stability and reliability.

III
RADAR

SHORAN AIDS TO AERIAL SURVEY

Consideration by the Department of Mines and Resources and the Department of National Defence lead to the conclusion that the accurate survey of Canada must be accelerated to permit the country to make full use of its natural resources. Methods were considered and in March '46 the Associate Committee on Survey Research recommended the use of Shoran as an aid in the accumulation of field data. Shoran systems for measuring geodetic baselines and for topographic mapping are to be tested co-operatively by the Department of Mines and Resources, the Department of National Defence, the Department of Transport and the National Research Council.

American Shoran equipment was finally delivered to the RCAF late in August. It is the function of this organization to fly the photographic missions and to maintain the Shoran equipment during operational use. The NRC undertook to develop or to modify for Canadian conditions, certain items of equipment and to examine the problem from the viewpoint of suggesting modifications to apparatus or procedure.

Late in October, 1947, it was decided to form a section to investigate the problem, and work started early in November. Prior to October, one member of the E.E. and Radio Branch staff had visited McDill Field, Florida, where the U.S. Army Air Forces were working on the problem of measuring geodetic baselines by Shoran methods. Unfortunately, he returned to Australia after making his report, so that

the time of NRC personnel in the first instance was devoted to the study of existing knowledge on the subject.

During the months of November and December the design was completed for a computer which is intended to facilitate flying any arbitrary straight-line course from Shoran data in the aircraft.

Modifications and repairs were made to the camera and instrument used in the airborne recorder.

An instrument was designed and built which repeats Shoran readings at the navigator's position. This greatly facilitates the work of the air crew during flight and should become a standard modification to all Shoran-equipped aircraft.

PRECISION RADAR RECORDING ALTIMETER (Three-centimeter altimeter)

Summary. This instrument was designed to expedite contouring in the preparation of topographical maps. A narrow beam of three-centimeter pulses transmitted from an aircraft illuminates a small area of ground. The height of the aircraft above the ground is measured in terms of time delay and the results presented as a continuous graphic record.

Progress. About one-half of the eight-thousand square mile area, chosen to determine the suitability of the altimeter as a mapping instrument, was successfully mapped during November and December. The remainder must be left until weather conditions are more favourable. Meanwhile, further experiments are to be carried out to determine the effect of leafless, deciduous trees on the accuracy of mapping. It is known that when trees are in leaf, the upper foliage affects altimeter readings.

It has been necessary during test flights to take continuous photographic records of the pressure altimeter readings in order to compensate for fluctuations of the aircraft from level flight. Data thus obtained must be applied as a series of corrections to the graphic record. This is a long and tedious operation. It has, therefore, been considered expedient to develop an instrument which would automatically apply the corrections to the graphic record during flight.

The instrument consists basically of a variable-frequency oscillator, whose operating frequency is determined by a pressure-actuated condenser. The capacitance of this condenser is controlled by an aneroid unit, of the type used in aircraft altimetry. A frequency-discriminating system translates the frequency into a control voltage which is applied as a correction to the graphic record. Temperature compensation of the instrument, while necessary, has not yet been incorporated.

An experimental model has been constructed, and preliminary tests

indicate that more accurate correction can be obtained by this method than by the previous method. The workable range of the instrument covers 175 feet of deviation from level flight, and an accuracy of ± 5 feet was indicated by initial tests.

RADAR DISTANCE INDICATOR

Summary. The pilot of an aircraft is provided with the slant distance of his aircraft from one or more pre-selected ground points. The information is presented on a meter in the cockpit, the scale of which is graduated from 0 - 100 miles. The accuracy of indication is ±0.5 miles, or ±2% of indicated distance, whichever is the greater. Both airborne and ground equipments are used.

Progress. The chain of six ground beacons and monitors installed on commercial airlanes between Montreal and Windsor was in continuous operation until December 31, 1947.

As a result of PICAO conferences, the 1,000-megacycle region was allocated to civil airways distance-measuring equipment. In view of the above decision, and because the 200-megacycle region was employed for television operation and for Army-Navy communications in the United States, the Department of Transport agreed to close the 200-megacycle region for distance-measuring operation in Canada. The ground beacon stations of the RDI system were accordingly shut down on December 31, 1947.

The RCAF is now proposing to use the RDI system, in a modified version, for Service requirements, and is putting the airborne equipment into production at Montreal.

In order to provide the left-right indication required by the RCAF, further developmental work was done on the ADF antenna and associated circuits. Considerable difficulty was experienced with the antenna, both electrically and mechanically. Associated circuits are awaiting trial when the antenna is completed.

Two of the three installations made in TCA aircraft were completed and left in service until the closing of the ground beacon stations. The third aircraft installation, in which the antenna was located on top of the fuselage, caused interference to communication equipment. Consequently, a rejection filter was developed, but its installation was not carried out before the shutdown of the system. A number of reports have been received on the operation of the two remaining installations. The accuracy of indication was found to be very good, the actual error being within the 2% accuracy of the meters. Three aircraft antennas were broken off but it was impossible to ascertain

whether this occured during flight or in aircraft servicing. Difficulties were encountered in the ground beacons with faulty coding wheel operation, supply voltage fluctuations and antenna pattern gaps. On the whole, the information provided by the RDI equipment was found to be a useful addition to the information provided by present radio and flight navigational instruments.

The RDI installation made for icing experiments in the RCAF aircraft at the Rockliffe Airport operated satisfactorily until the antenna was broken off by heavy icing during flight. It has not yet been decided whether replacement of the antenna is warranted in view of the closing of the ground beacon stations.

The portable test gear was completed and operated satisfactorily when in the immediate vicinity of the aircraft. A prototype model was not furnished to TCA because of the impending shutdown of stations. For the same reason, development of the approach beacon was discontinued.

A report summarizing the experience gained from the operation of the chain of stations is being prepared.

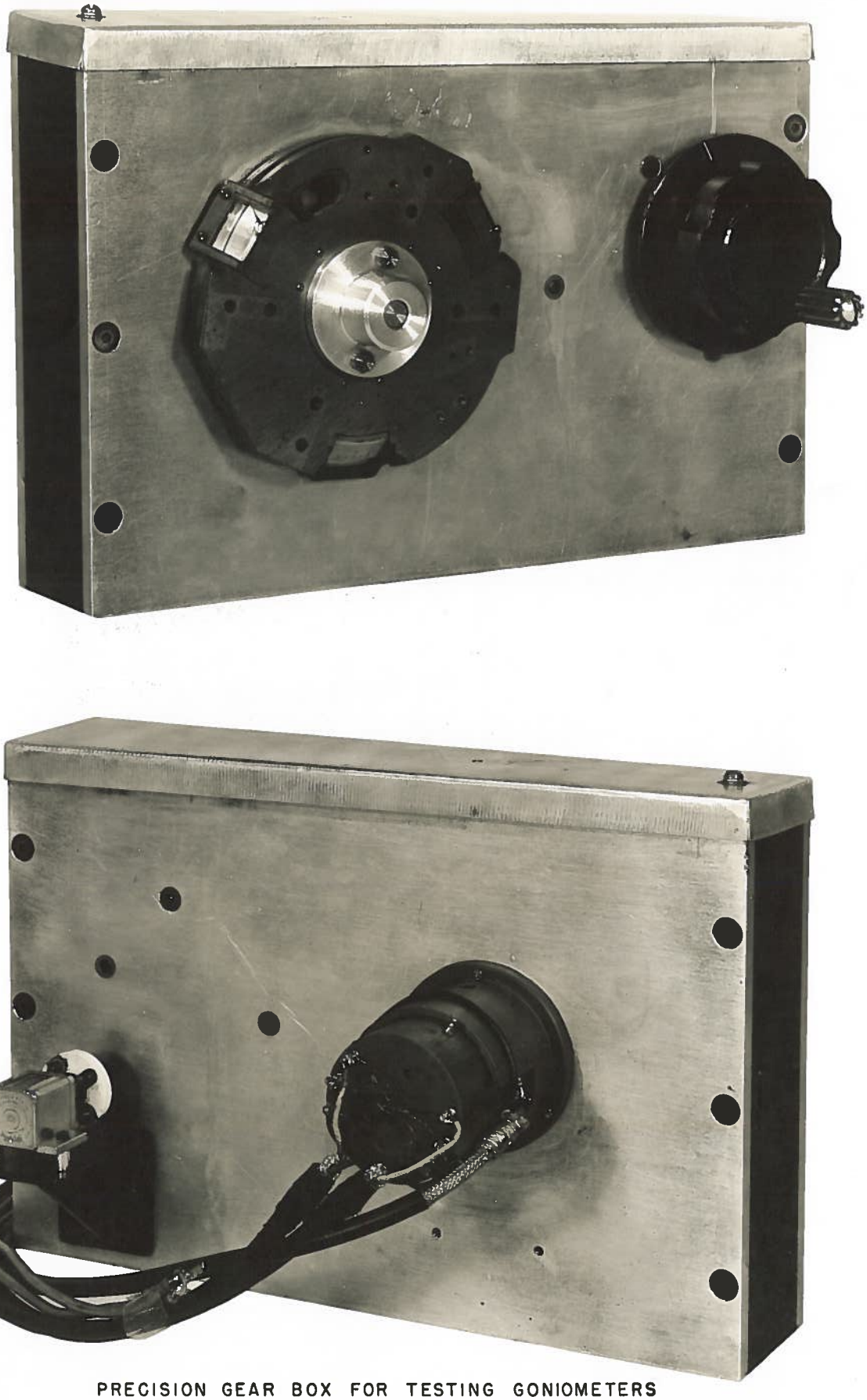
PRECISION RANGING GONIOMETER

Summary. A small goniometer, accurate to within ±0.3°, was required for range-measuring applications. Goniometer test apparatus, which included an oscillator, amplifier, precision gear box and an accurately calibrated low-resistance potential divider was built. A small goniometer, using a three-section cylindrical search coil with a polyiron core, and two-section rectanglar field coils, was designed and constructed. After tests and adjustments, the error in the goniometer was reduced to ±0.4°.

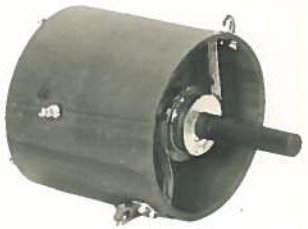
Using the same search coil, a new field coil assembly with three-section cylindrical field coils, was constructed. The first tests on this unit showed an error of ±0.25°.

Progress. From the records of previous results on air-core goniometers, it was thought that modification of the search coil might improve the accuracy. Therefore, a new search coil was built, retaining the polyiron core. This search coil differed from the first model, in that the side sections were smaller and spaced closer to the center section. This design was not very successful, the test showing a fourth harmonic coupling error of ±.75°.

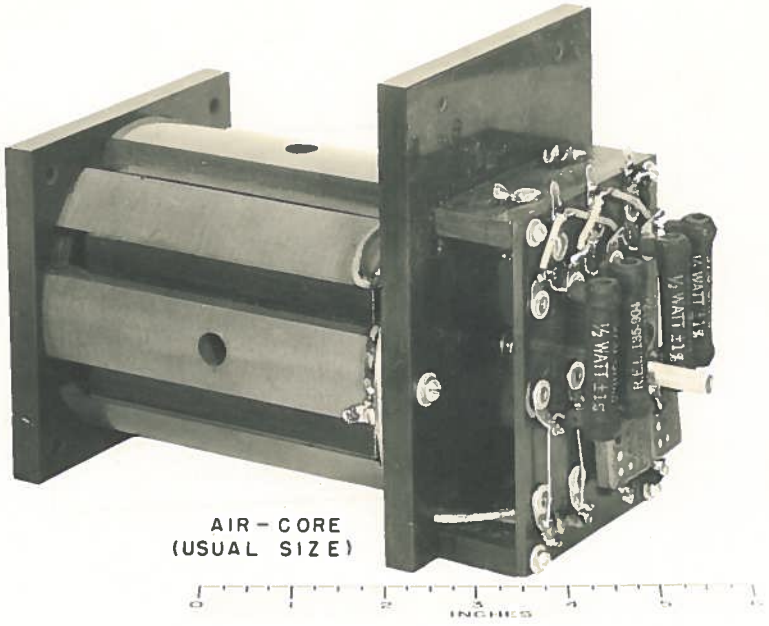
It was decided to return to the original search coil design. This coil as well as the field coils, were rewound very carefully. The tests on this unit showed a maximum error of ±0.2°, the main reduction

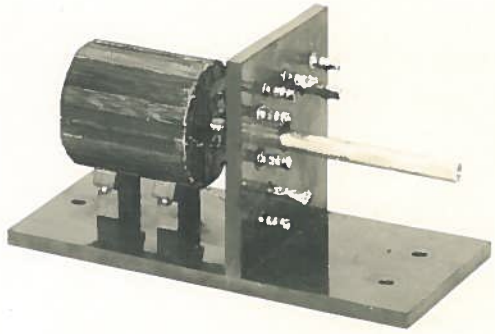


PRECISION GEAR BOX FOR TESTING GONIOMETERS



MINIATURE, IRON-CORE, TYPE II





MINIATURE, IRON-CORE, TYPE I-A

PRECISION GONIOMETERS

from the previous results being in the second harmonic errors (from 0.10 to 0.04 degrees). This reduction was due to the improved winding on the field coils.

This unit was designated as the "Type I-A Goniometer" and is shown in the photograph, along with its mounting bracket. Considerable difficulty was experienced with this method of mounting in the later tests, and it was decided that a different mounting system would be used for future tests. The gear box shaft was shortened considerably, and a cylindrical housing, into which the goniometer could be tightly fitted, was mounted on the face of the gear box. This system was found to work very well and eliminated the slippage formerly experienced. It is shown in the photograph of the gear box, together with the Type II Goniometer described below.

A new principle was applied in the design of the Type II Goniometer. This incorporated two identical polyiron cores, 7/16" thick and 1 3/16" diameter, with perpendicular slots cut in one face. The slots were 1/4" deep and 1/8" wide, producing a "clover leaf". The search coil was wound on one of the iron cores, with the field coils on the other, a "figure 8" winding being used in both cases. The two coils were then mounted face to face in a bakelite housing. The first test of the new unit showed an error of ±5°.

At the same time, an improved design of the Type I-A Goniometer was completed and the construction started. This design resulted in a further reduction in size of the whole unit, as well as several other minor refinements in construction.

The photographs show the precision gear box, with the transit head employed for calibration, and the drive shaft, on one side, and the counter and goniometer on the other side. This gear box is accurate to within ±0.01°.

The second photograph illustrates the reduction in size achieved by the use of polyiron, for the same search coil and field coil inductances. (The error in the large air-core goniometer is ±0.7°.)

A report is being prepared on the test apparatus used with the goniometer and will be published shortly.

MERCHANT MARINE RADAR - (MMR-B)

Summary. The aim of this project is to develop a simplified, low-cost radar equipment, particularly for the use of vessels in such services as inland and coastal shipping, fishing fleet service, and in

general, for all vessels which do not require the more complex equipment designed for larger vessels in ocean-going service. Special attention is being given to the navigational problems of such vessels in restricted or inland waters.

The emphasis in the design is placed on a high-definition display, and a very short minimum detection range. An effort is being made to keep cost at a minimum by dispensing with secondary facilities or requirements, such as azimuth stabilization of display and multiple displays; and by paying careful attention to such structural details as size, weight, power consumption and ease of fitting.

Progress. A great deal of time was spent on circuit development for the display unit, in order to get a simplified, continuously variable range control and automatic sweep centering. The latter proved very difficult to achieve with a simple circuit and a comprise was finally made whereby sweep centering was established by pre-set controls.

A simplified r-f system was developed, such that the only adjustments required, other than those for the T-R cell and local oscillator, were two screw adjustments for setting the AFC and receiver crystal currents.

The receiver and AFC units received special attention. The receiver has a band width of 8 megacycles and operates on a mean frequency of 30 megacycles. At low gain settings, this band width is essentially maintained by means of a special type of gain control. This is particularly important in obtaining high definition in the display.

A modulator was designed, using a hydrogen thyratron, a pulse-forming line and pulse transformer. Since the Type 2J42 megnetron is used, there are no very high voltages encountered in this unit. It is hoped that this will add greatly to the reliability of the equipment in service.

As an antenna gear box patterned after the Canadian Type 268 Radar unit was considered much too costly to manufacture, a new unit was designed, incorporating a standard gear reduction unit. In order to meet the more or less universal requirement of two-degree bearing discrimination, (i.e. to discriminate between two targets at the same range which subtend, at the radar antenna, an angle not greater than 2°), it was felt that the horizontal beam width of the antenna at half voltage should not be much greater than 2°. Work was therefore started

on the design of a four-foot open paraboloidal slice (cut from a parabola of revolution) antenna with horn feed. The horizontal beam width of this antenna was about 2.1° (at half voltage), but had two, relatively small side lobes at about 80°, each side of the main beam. Since side lobes at these angles are very annoying, the horn feed was modified and the lobes essentially eliminated with a slight increase in antenna beam width. The vertical beam width of this antenna turned out to be only about 11°, which is insufficient to allow for the roll of the ship. Therefore, further work is being done on a similar parabolic slice, (cut from a parabolic cylinder) antenna, which, it is hoped, will not only give the required beam width of more than 15° (to half-voltage) in the vertical plane, but will be even simpler and cheaper to manufacture than the original design.

The first experimental chassis were assembled to form a transmitter-receiver-power supply unit and a display unit, and the equipment was given extensive trials on the M.V. "Radel". The minimum range performance was exceptionally good. Reasonably small targets (small buoys, etc.) could be detected at less than 25 yards and, on actual minimum range trials, with a proper target and under optimum conditions, it was found that the trailing edge of the target echo could be observed outside the ground pulse for ranges considerably less than 25 yards. As the original objective was a minimum range of 50 yards, the results of the trials were very gratifying.

Three types of antennas were available during the trials, namely the Canadian Type 268 antenna with a beam width of approximately 3°, a four-foot paraboloidal slice antenna with a 2.1° beam width, and a 60" vertically-polarized pillbox antenna with a 1.6° beam width. It was discovered that 2° discrimination was possible, even with the Type 268 (3°) antenna, by proper adjustment of the gain control.

For two targets (radar target buoys) separated 100 yards and on the same bearing, two distinct echoes were observed out to at least 6,000 yards, which far exceeded any requirements as laid down by current specifications for Class A radar. (See photo).

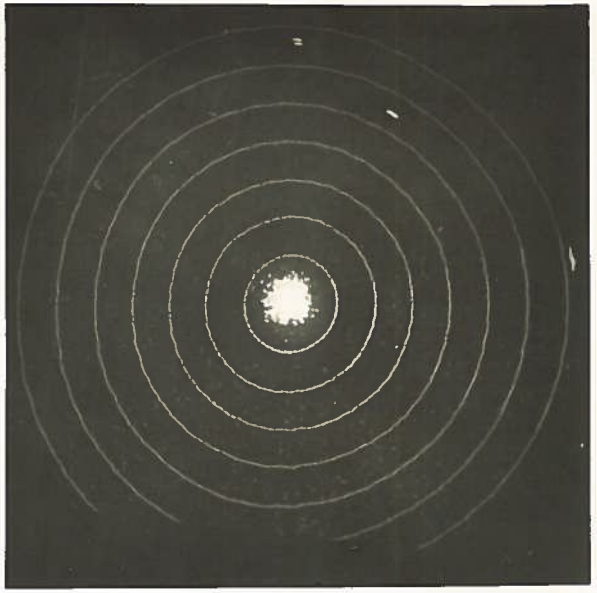
Photographic as well as written records were obtained for results of both bearing and range discrimination trials.

The experimental equipment on the M.V. "Radel" was also used to obtain pictures of harbours and harbour entrances on Lake Ontario and

ONE OF THE MULTI-TRIHEDRON TARGETS USED IN THE TRIALS.

ECHOES FROM TARGETS AT 2900 YARDS INDICATE THAT TWO-DEGREE BEARING DISCRIMINATION IS EASILY ACHIEVED.

GOOD RANGE DISCRIMINATION IS OBTAINED AT 6600 YARDS.



BEARING AND RANGE DISCRIMINATION TRIALS WITH MERCHANT MARINE RADAR (MMR-B) EQUIPMENT

TARGETS ARE SHOWN AT THE "TWELVE O'CLOCK" POSITION IN BOTH CASES.

TARGET SEPARATION — 100 YARDS

of shorelines and narrow passages in the St. Lawrence and Ottawa rivers, between Ottawa and Lake Ontario. From this sequence of pictures it was possible to form radar composites or mosaics corresponding to the marine chart for the particular areas. These pictures show the high degree of discrimination obtainable in the MMR-B display.

At the close of navigation in November, the experimental set was taken off the "Radel" and set up at the Metcalfe Road Field Station, where it is being used to check modifications and prototype units for the final design.

From the commencement of the project, the government of New Zealand has been interested in the development of the equipment and has provided some scientific assistance. Arrangements have been made to furnish New Zealand with a complete prototype equipment when it is finished.

The preliminary trials carried out on the M.V. "Radel" demonstrated that the original objective - the development of a small, simple, high-definition radar set - had been satisfactorily achieved. Since it was known that a real need existed, in Canadian shipping at least, for such an equipment, arrangements were made with a Canadian manufacturer to undertake the production of this equipment for sale to Canadian shipping and also for export. To this end, every effort is being made to make complete prototype drawings available as soon as possible.

RADAR AID AT HARBOUR ENTRANCES

Summary. The aim of this project is to determine the usefulness of shore-based radar equipment as an aid to navigation at harbour entrances. The work is carried on jointly by the Department of Transport and the National Research Council.

Present tests are being made at Camperdown Wireless Station, at the entrance to Halifax Harbour. The equipment in use is a modified Canadian Type 268 Radar which has been in operation experimentally since December, 1946.

Progress. During October and November, two 12-inch PPI tubes were installed at the test site. These equipments somewhat facilitate the use of the display, and have the additional advantage that the cursor

for azimuth readings is displayed directly on the tube face, eliminating parallax errors, and also some of the system errors.

Tests were also made on the identification of ships by radio direction-finding and the bearing information so obtained was compared with the radar bearing information. When these bearings are in coincidence, it is assumed that the radar echo on that bearing is the ship with the same radio d-f bearing. Some preliminary tests were made using an automatic radio compass, or self-aligning radio d-f system. In this case the loop bearing is displayed as a cursor on a PPI tube, reducing manipulation of the equipment to a minimum. These tests gave satisfactory results, except for the bearings on the marine radiophone bands, (from 2 megacycles to 3 megacycles), which were in error as much as 20°. It is believed that these errors were due to the large number of antennas located at the test site.

At present, the radar and radiophone equipment is housed in a building about 100 yards distant from the wireless station. The incorporation of complete remote control of the radar and radiophone equipment from the wireless station has facilitated operation of the equipment.

The radar equipment has been in operation 1400 hours, to the end of December. Failures have been infrequent and were chiefly due to tube failures. A breakdown occurred as a result of an arc in the modulator, at about 1400 hours.

Preliminary planning is underway for the equipment of a truck with radar gear, to allow proper choice of suitable sites for other harbour radar aids, without the necessity of making permanent installations. It is excepted that this truck will facilitate the investigation of ducts, and other anomalous propagation problems.

X/S TRIALS

Summary. The attenuation due to rain, snow, hail, fog, sand etc. has been measured at different times by others working in this field, but so far there has been little or no work done on the absolute measurement of snow and rain clutter signals on both X-band and S-band, and the correlation of this data with precipitation rate, drop size and drop distribution measurements, taken simultaneously. From this data

it should be possible to predict, for a given precipitation rate, at what maximum range a particular target can be detected on an X-band or S-band radar of known characteristics. A direct comparison could then also be made of the results to be expected from an X-band and an S-band radar operating under the same storm conditions.

Progress. A great deal of work has been done on the setting up and calibrating of testing and monitoring equipment. The gain calibration of both the X-band and S-band radar receivers is being periodically checked and the transmitter power is also monitored.

Three special rain gauges have been constructed. These gauges employ Nipher screens to eliminate errors due to the effect of wind, and are sufficiently sensitive so that readings taken at one-minute intervals lead to a fairly accurate determination of precipitation rate.

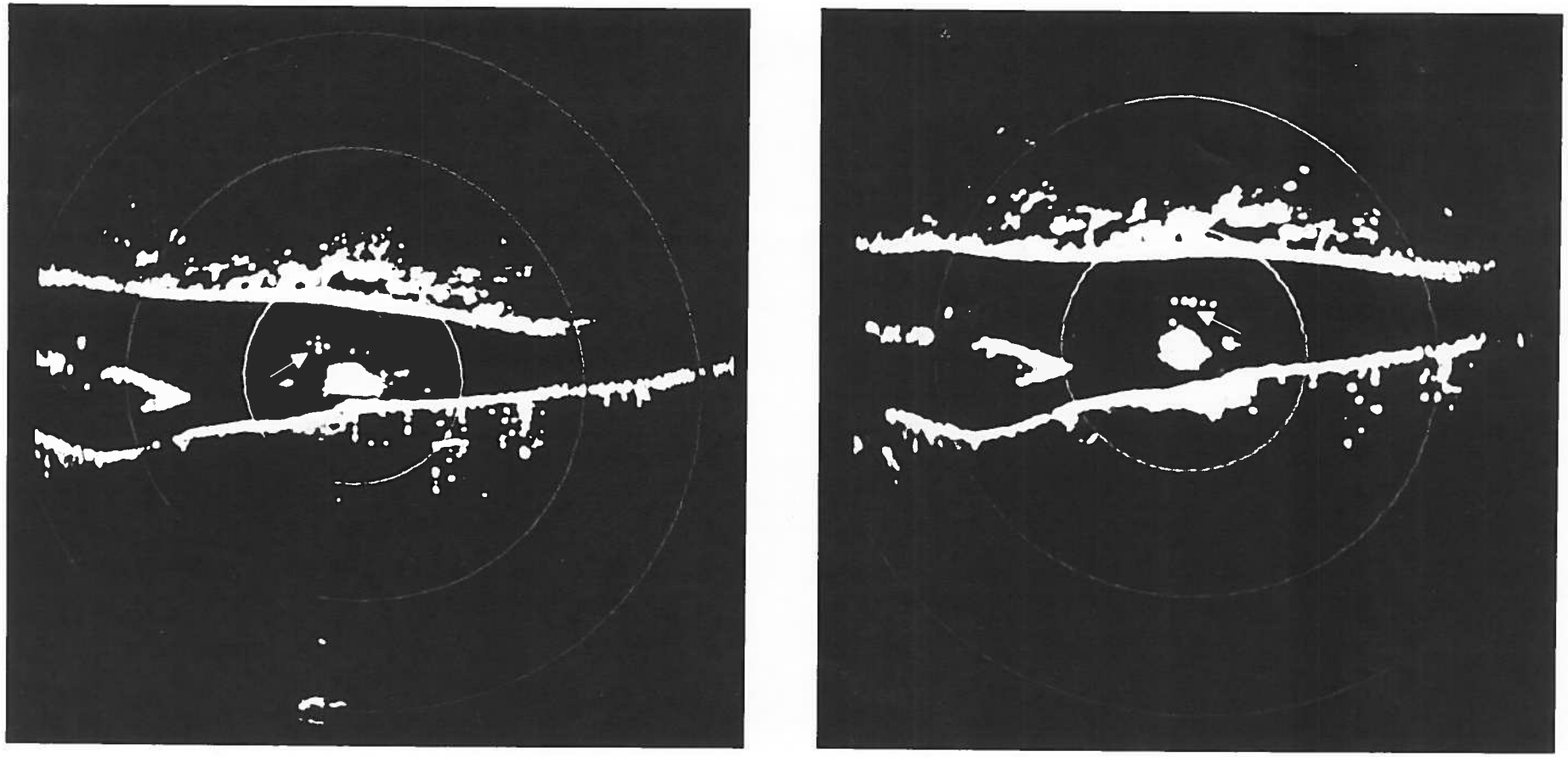
A snow gauge, similar to the rain gauge, has been constructed but insufficient experience has been obtained with it to determine its accuracy. A device was also constructed for automatically photographing samples of snowfall obtained by collecting flakes on black velvet. The samples obtained represent a definite interval of exposure to the storm and are obtained by the use of a special gauge.

The complete equipment, with sufficient operating personnel, has been ready since about the middle of November, but no storms of sufficient intensity have yet occurred to produce any usable data. The equipment is being operated periodically to secure fair-weather reference data and to determine the stability of calibration of the measuring equipment.

Close co-operation is being maintained with the Dominion Meteorological Bureau in Toronto and a Defence Research group doing similar work.

MOTOR VESSEL "RADEL"

During the month of October discrimination trials of the Merchant Marine Radar equipment continued on Lake Ontario and photographic records of the radar echoes from interesting portions of the shoreline of the lake were made.



PRELIMINARY BUOY PATTERN TRIALS
CONDUCTED WITH MERCHANT MARINE RADAR (MMR–B) EQUIPMENT IN THE OTTAWA RIVER

8–INCH BUOY REFLECTORS, ONLY 2 FEET ABOVE WATER, WITH 50-YARD SEPARATION.

ARROWS INDICATE 5 – POINT CROSS AND STRAIGHT–LINE PATTERNS USED TO IDENTIFY SHOAL.

(1)

(2)

(3)

(4)

(5)

(6)

VERY HEAVY RAINSTORM PASSING OVER M.V. "RADEL"
EN ROUTE THROUGH TELEGRAPH NARROWS, BAY OF QUINTE

DISPLAY OF CANADIAN TYPE 268 RADAR, INSTALLED ON THE VESSEL, INDICATES THAT PENETRATION OF THE STORM IS SUCH AS TO PROVIDE SUFFICIENT ECHOES FOR A CONTINUOUS NAVIGATIONAL FIX (COMPLETE SHORELINES COULD BE DISPLAYED IN (3) AND (4), IF DESIRED, BY REDUCTION OF RECEIVER SENSITIVITY)

A four-foot paraboloidal slice antenna was installed on the MMR-B equipment for operational trials. It was found that this antenna suffered from slight side lobes, due to flooding beyond its edges. This fault was subsequently eliminated by re-design of the antenna feed system. (see page 16)

Late in October, the boat was returned to Ottawa, where radar mapping and buoy-pattern trials were conducted until the close of navigation. The buoy-pattern trials were undertaken upon receipt of a request from the Department of Transport only two days before the close of navigation, and were carried out very roughly. The object was to obtain some indication of the feasibility of using buoy patterns for the positive identification of the location of buoys over shoal water or dangerous coast lines, where the radar features of the coast line are not readily identifiable. (See photo) More precise trials will be carried out next season, with more suitable buoys, in a less restricted body of water.

The "Radel" was docked for the winter in the Rideau Canal and the MMR-B equipment was removed to the field station for modifications. The vessel will be repainted during the winter, and minor adjustments will be made to the main engine.

IV

RADIOPHYSICS

PANORAMIC IONOSPHERIC RECORDER

Summary. A pulsed, vertical-incidence, fully-automatic ionospheric recording equipment is being designed and constructed at the request of the Canadian Radio Wave Propagation Committee. It is to be used for the study of quick-change phenomena in the ionosphere.

Progress. A new crystal-controlled timing unit, whose main features were described in the last progress report, has been constructed and given a rough check against a General Radio 1,000-cycle source. The stability appeared to be satisfactory. It will be necessary to use a synchronous clock, checked against standard time, for an accurate determination of the stability of the timing circuits. This will be done after all circuits associated with the timing unit are completed.

A second control unit has been built, which includes (a) a motor-driven gear box providing six frequency sweep intervals in the range 7.5 seconds to 8 minutes (b) a variable-frequency oscillator, covering the range 31-50 megacycles, driven from the above-mentioned gear box (c) a horizontal sweep voltage for the panoramic display, synchronized with the 20-megacycle variation of the variable-frequency oscillator (d) a synchronous drive for the 35-mm recording camera, and the trigger for advancing the film in a 16-mm, single-frame camera.

The chassis for this second control unit has been constructed but the variable-frequency oscillator has not been calibrated. Complete testing of this unit cannot be accomplished until the entire system is in operation.

The 16-mm, cinema-presentation unit has been completed and mounted and the 35-mm unit, to be used for routine measurement and analysis, is under construction.

SOLAR NOISE OBSERVATIONS

Continuous daily recordings of 10.7-centimeter energy arriving from the sun and from the zenith were made and it is planned to continue the solar observations for a long period. The 27-day variations of 10.7-centimeter solar noise are being observed with reduced amplitude in comparison to the amplitudes reported for the period from February to July.

Interference from local 10-centimeter operation at the field station has made the observation of impulsive variations (bursts) very difficult. It has accordingly been decided to remove the equipment to a new site at Goth Hill, five miles south of the Metcalfe Road Field Station. A building 20 by 20 feet, has been erected and the power transmission line has been completed to the building.

Two new 10.7-centimeter radiometers have been constructed, but have not yet been checked for faults. In addition, a variable-frequency radiometer, covering the range 7 1/2-15 centimeters is being constructed. All three of these radiometers will eventually be installed at the new site and will be employed for sky-noise measurements.

The present equipment, consisting of two 10.7-centimeter radiometers, one used for solar measurements, the other for sky-noise measurements, will remain at the Metcalfe Road Field Station and serve

as stand-by equipment for the apparatus at Goth Hill. It will also be used for other experimental work.

Work continues on the improved model of the 200-megacycle radiometer which is intended for the measurement of day-time solar noise and night-time sky radiations.

SHOOTING-STAR RADAR

The correlation of the data of the August Perseid shower continues. Because the interested members of the staffs of the Dominion Observatory and NRC are not able to put full time on this job, the final paper will be delayed. A short letter was written to "Nature" in December, covering the preliminary results, and a presentation was made at the Christmas meeting of the American Astronomical Scoiety in Columbus, Ohio.

Another combined radar, visual and photographic program was carried out during the Geminid shower of December 11th-14th. The same techniques were employed, in general, except that the parameters of the radar system (still operating on 32.5 megacycles) were considerably improved, with the result that the radar echo rates exceeded 1,200 per hour at the height of the shower. A preliminary glance at the radar data alone indicates that the hourly average range of all the echoes was a maximum shortly after midnight, which is consistent with the hypothesis that reflection from meteor trails is most favourable in the vicinity of $\alpha = 90°$, since the radiant was directly overhead about midnight.

Strong echoes from bright meteors display the same general characteristics as found in the Perseid shower, namely, a type-dependence on α, the angle of elongation of the meteor trail. Many more examples of velocities were obtained in December. Fewer multi-layered trails were seen, though, which is consistent with the layer theory, when taking into account the slower velocity of the Geminids.

Equipment

Main Stationary Transmitter. The antenna was moved out into the clear, some 200 feet from the large tower, and improvement in the performance and power output of the main stationary transmitter was realized. By means of standing-wave ratio measurements made with a stub voltmeter,

the load, as seen at the transmitter, was made essentially resistive. This increased the frequency stability of the transmitter and permitted heavier transmitter loading, with the net result that it was possible to achieve approximately one-half megawatt of peak power.

There was no convenient method of checking the pulse shape of the main transmitter until the complete equipment was put into operation for the Geminid shower. It was then discovered that there was a residual after-pulse. This pulse was reduced by raising the impedance of the Blumlein circuit, so that the resistor load, plus the oscillator load, presented a better match to the modulator. This modification of the Blumlein circuit, which was made in a temporary manner, will be incorporated permanently into the system.

Package Equipment. As a consequence of the encouraging results obtained during the Perseid shower, a construction program was commenced, with the aim of producing two complete transportable radars, and with the idea in mind of simultaneous operation and the locating of the stronger meteor echoes by triangulation. To this end, package equipment was designed. The receiver and display portions were to be mounted in three stretchers, 18 inches square by 6 feet long. The receiver and display stretchers were to consist of; (1) power supplies (2) receivers for radar and time signals; sweep, calibrator and timer chassis; (3) display and camera chassis. The transmitter was to consist of three stretchers: (1) power supply (2) modulator (3) power oscillator.

The method of recording in the package equipment was different from that in the stationary equipment, in that the range trace was stationary on a five-inch tube, and a moving-film camera, using 35-mm film, was focussed on both the trace and time-registering unit. The time signals, as received from Radio Station CHU of the Dominion Observatory, were made to appear as bright dots near the beginning and near the end of the range trace, so that highly accurate "second" markers were photographed simultaneously with the radar echoes. For minute and hour identification, the time-registering unit consisted of transparent discs bearing numbers, driven by a small electric motor through suitable gears, such that once a minute, when the appropriate minute number was centered in the window, the window was illuminated from behind for a fraction of a second and the number photographed. Once an hour, the hour number was automatically changed during the non-photographing period of the 59th minute. In order to reduce the effect of inevitable line voltage change on picture brilliance, a regulated five-kilovolt supply was developed for the cathode-ray tube.

One complete receiver-display unit was finished and put into good operating order by December 11th. However, the package transmitter was not completed by that date so that the operation of a second station at a remote point was not possible. On the other hand, good use was made of the package receiver-display equipment in conjunction with the main stationary transmitter, and the new method of recording proved so much superior that it will be used for the main equipment, in preference to the T-scope and single frame camera set-up. The T-scope will probably be retained for visual observations.

ELECTRON ACCELERATOR

An experimental set-up was constructed to investigate the posibility of accelerating electrons by successively passing them through a cavity resonant at ten centimeters and situated in a magnetic field. Orbits were observed immediately out to the edge of the magnet. There were eight, and the energy in the outside orbit was about four million volts.

During the past three months work has been confined to the problem of increasing the voltage on the cavity. The use of a cavity with higher shunt resonance led to difficulties in getting the power into the cavity, and prolonged investigations of the coupling from the waveguide to the cavity were required before this was accomplished. The other major problem encountered with the higher voltages was the failure of the polystyrene phase shifter, which became overheated when operated in vacuum. It has been replaced by quartz which is satisfactory. To date no notable increase in voltage or current has been achieved, except for short periods of time.

REFLECTION COEFFICIENTS OVER SNOW AT THREE CENTIMETERS

A study of the possibility of radar camouflage of obstacles to marine navigation by loose snow has been commenced. Progress to date has been limited to the construction of equipment and the erection of towers on the site.

TUBE LABORATORY

The design and construction of apparatus for the processing of

tube parts has occupied the greater part of the available time. A completely new vacuum system has been designed and partially installed, using high-pumping-speed oil pumps. A hydrogen furnace has been constructed.

Work on the four-millimeter magnetron is being delayed for want of special materials.

The orbital-beam tube, designed to oscillate in the K-band, has been constructed and tests will be made shortly.

Development of the resonant-sphere spark oscillator will proceed when suitable bearings become available.

The commencement of work on the electron-beam tube for the 500-kv Van de Graaff generator awaits the receipt of nickel bar stock.

The damaged German mercury-vapour rectifier tube has been assembled and is now ready for pumping.

A counter-tube has been built and tested. This first tube is a scale-of-five tube, this number being chosen for ease of construction of the prototype tube. It is hoped that later tubes will count up to ten or more. No external circuits are necessary, other than the input pulse amplifier. This single tube, if successful, should replace a scale-of-ten counter circuit using at least ten tubes.

V

STANDARD FREQUENCY SERVICES

Routine maintenance was continued. Owing to remodelling operations in the Standard Frequency Laboratory, not much further work was done on the electro-mechanical counting-down systems.

The Standard Frequency transmitter, VE9FL, was maintained on two megacycles on a 24-hour basis. The carrier has a precision of one part in ten million and is modulated by a one-kilocycle tone of the same accuracy.

VI

PAPERS AND PUBLICATIONS

"Some Problems in the High Fidelity Reproduction of Music", J.E. Breeze, Ottawa Section, IRE, October 9th, 1947.

"Solar Noise Bursts, 10.7 cm", A.E. Covington, Joint Meeting URSI-IRE, Washington, D.C., October 20th, 1947.

"Combined Visual and Radar Observation of the Perseid Meteor Shower, 1947", P.M. Millman* and D.W.R. McKinley, Ottawa Section, IRE, November 27th, 1947.

"Combined Radar, Photographic and Visual Observations of the Perseid Meteor Shower", P.M. Millman,*D.W.R. McKinley and M.S. Burland,* presented at the meeting of the American Astronomical Society, Columbus, Ohio, December 29th, 1947.

"Efficiency of Inductive Coupling", A.C. Hudson, Electronics, December, 1947.

The following publications have been issued by the Electrical Engineering and Radio Branch:

"A Narrow-Beam, Recording Radar Altimeter for Topographical Survey", B.F. Cooper, (ERA-138/1).

"An Omni-Directional, Vertically-Polarized Antenna Array for Very Short Waves", R.S. Rettie, (ERA-142).

"Reduction Procedures in Shoran Geodetic Measurements", B.F. Cooper, (ERA-143).

"The 'Durac' Nickel-Cadmium Alkaline Battery", G.D. Chu, (ERB-172).

"Supplement to Report PRA-135, 'Transmission Line Fault Locator'", W.G. Hoyle, (ERB-176).

*Dominion Observatory, Ottawa.

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