Progress report for April, May, June, 1948

National Research Council of Canada. Radio and Electrical Engineering Division

REPORT NO. ERA - 159

UNCLASSIFIED

LABORATORIES

OF

THE NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

PROGRESS REPORT

FOR

APRIL, MAY, JUNE, 1948

OTTAWA

JULY, 1948

Report no. ERA - 159

Laboratories

of

The National Research Council of Canada

Radio and Electrical Engineering Division

PROGRESS REPORT

FOR APRIL, MAY, JUNE, 1948

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PROGRESS REPORT

FOR APRIL, MAY, JUNE, 1948

I
ELECTRONICS

pH MONITOR

Summary. This instrument was developed for the Division of Applied Biology and is used for precise measurement and control of the pH of solutions in the study of biological reactions. Three such reactions can be monitored simultaneously by each unit. One three-channel unit has been installed in the laboratories of the Division of Applied Biology, where it has been in continuous use for the past nine months.

Progress. During the past three months supervision of the operation of the three-channel pH monitor, previously installed for the Division of Applied Biology, continued. No faults developed in the instrument during this period, although some difficulty was experienced with the electrodes.

Most of the available time was devoted to the construction and testing of the second complete three-channel pH-monitor equipment for installation in the Prairie Regional Laboratories of the Division of Applied Biology. The entire equipment included the pH monitor instrument, the agitator table and temperature-control cabinet and the instrument rack. The construction and testing was completed late in May and the whole equipment was then shipped to the Prairie Regional Laboratories, at Saskatoon, Sask., where it was placed on display at the official opening of the laboratory on June 8th. Later in the month the equipment was set up and three experimental fermentations were run successfully.

Six reports on the instrument and its operation were prepared. These are listed as follows:

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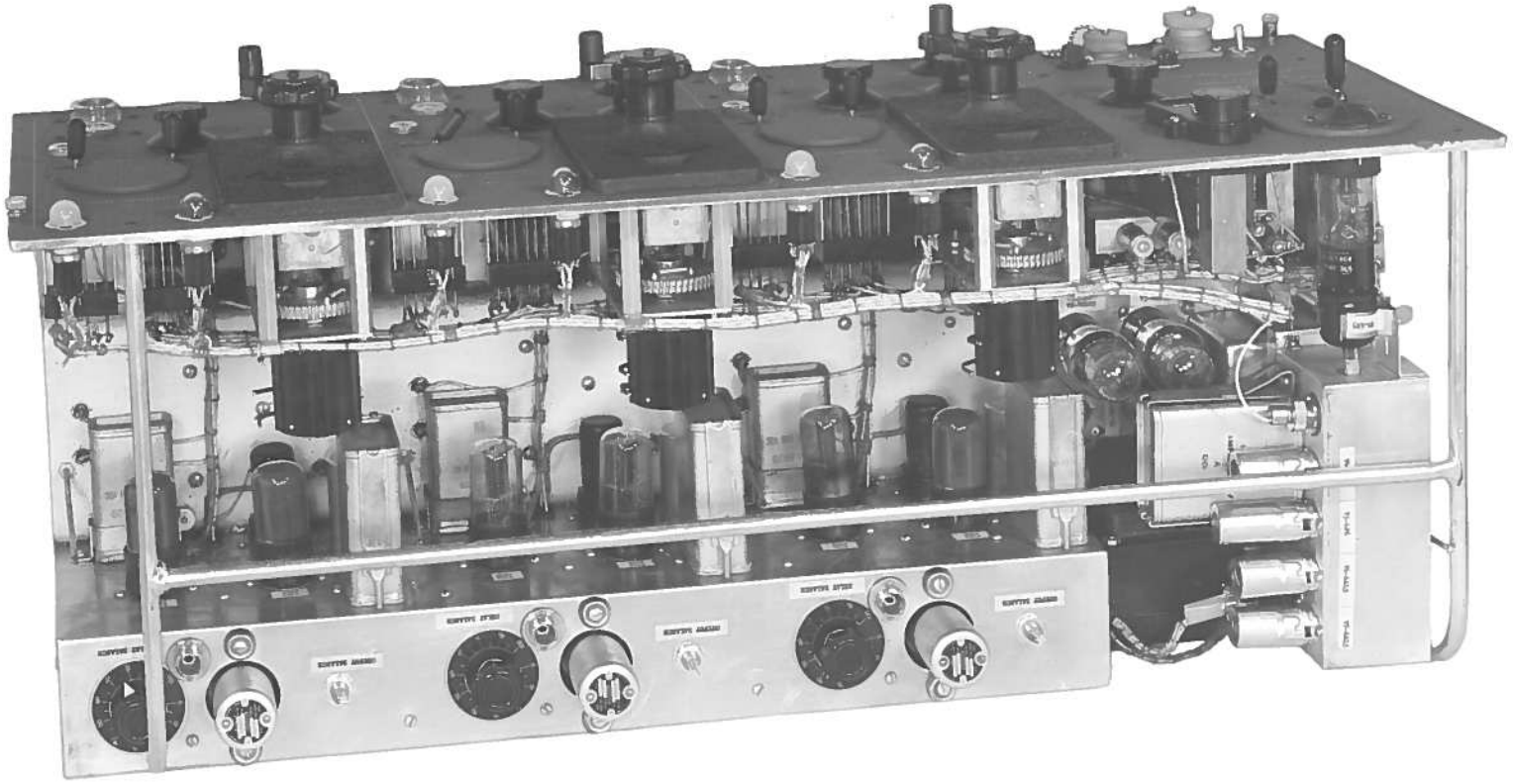
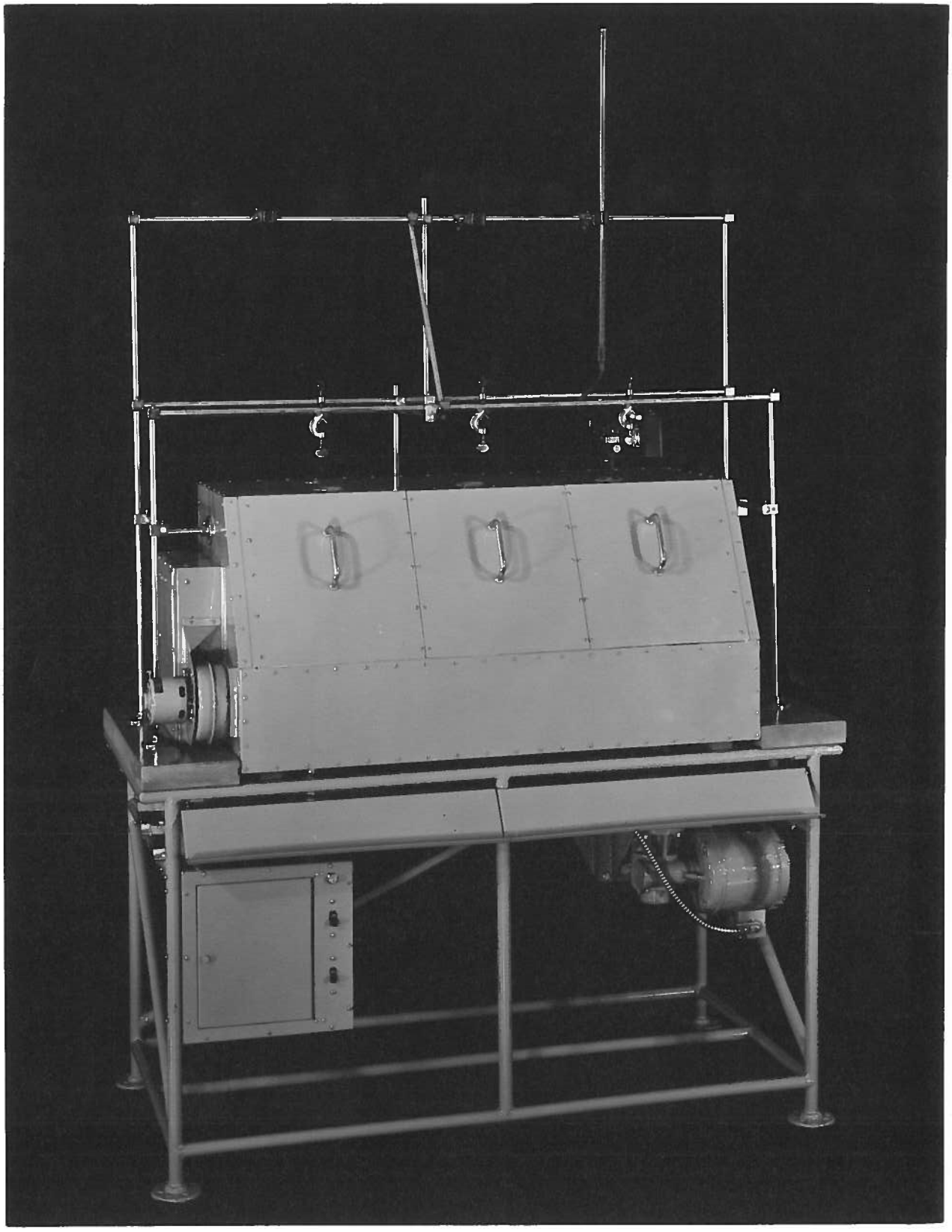
These reports are of a preliminary nature and the material in them will later be combined into two or three reports prepared for general circulation.



pH MONITOR CHASSIS
interior view



AGITATOR TABLE AND TEMPERATURE-CONTROL CABINET ASSEMBLY
FOR pH MONITOR

INFRA-RED DETECTOR

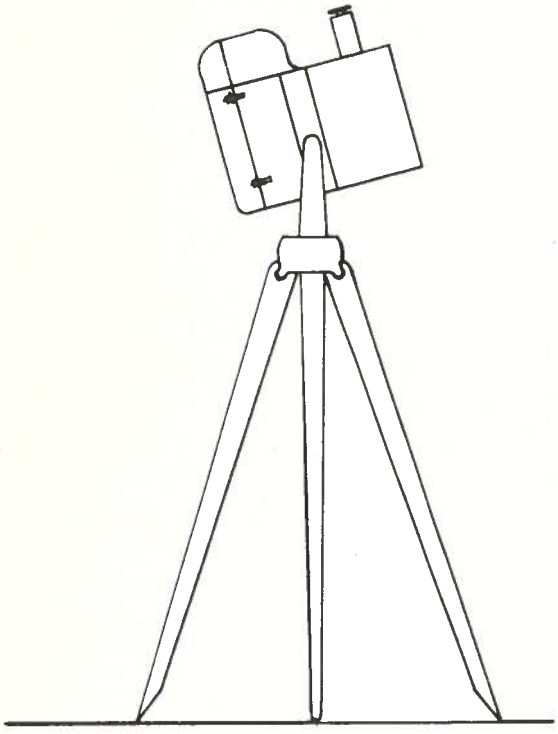
Summary. The purpose of this apparatus is to locate faulty joints in power transmission lines. These faults are located by observing the temperature difference between the joint and the conductor, this temperature difference being detected by means of thermal radiation focused on a bolometer. A thermistor-type bolometer used in an a-c bridge circuit has been found to be the most satisfactory form of detector.

Progress. Development of the electrical circuits has been completed and final mechanical and optical design of the instrument is continuing.

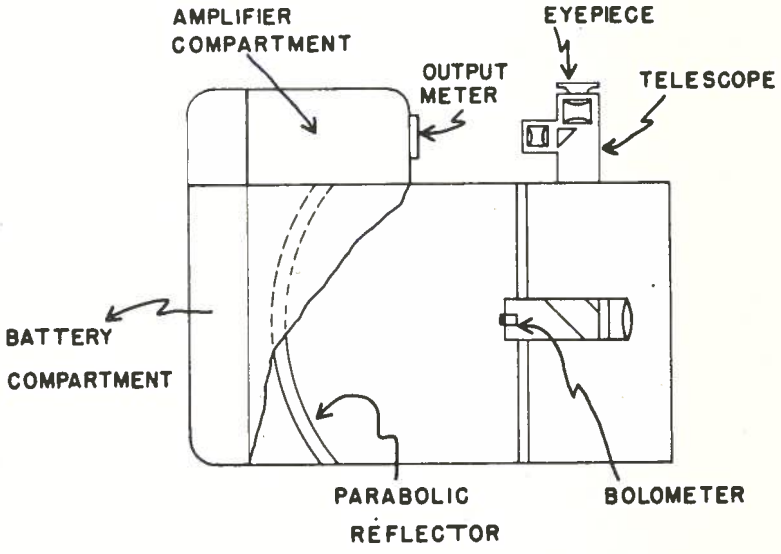
Rejection of harmonics generated in the bolometer bridge is now accomplished by using a rectified output which is phase-sensitive, rather than a narrow band-pass amplifier. However, a parallel-T network, tuned to reject the second harmonic of the bridge supply frequency, is also required in order to prevent the output stage of the amplifier from being overdriven by the second harmonic component of the bridge output. The output meter, a 50-microampere, zero-center meter, will be mounted as shown in the illustration and will be observed through the sighting telescope.

It was originally planned to make quantitative measurements of temperature with the instrument by using an optical system which, up to the maximum range of the instrument (about 100 feet), would cover the bolometer element with the image of the wire. Thus, readings would be taken by balancing the bridge while focussed on the wire, and then again while focussed on the joint. In this way a comparison of the temperature of the joint and wire would be had. However, discussion with the Optics Section of the Division of Physics indicated that this arrangement was rather impractical because of the high accuracy of sighting required and because of the possibility of movement of the wire. It was therefore decided that, for the present at least, the instrument would be used only for qualitative measurements taken by transiting the instrument across the joint and the conductor in turn, and observing the difference in deflection. To avoid parallax errors in sighting and to facilitate reading of the instrument, a sighting system was designed with which the observer will be able to sight along the axis of the parabolic reflector and at the same time observe the output indicator.

Sub-miniature tubes are used throughout and, in order to facilitate servicing in the field, all circuits are constructed as plug-in units. These circuits will be mounted about the top of the nine-inch barrel containing the parabolic reflector, and the batteries will be mounted on the back of the unit behind the mirror. This unit, which will be completely self-contained, will be supported on a tripod in such a way that it may be tilted to various



INSTRUMENT AND TRIPOD.



SECTIONAL VIEW OF INSTRUMENT HEAD.

PROPOSED FORM OF INFRA-RED DETECTOR

angles and also rotated about the optical axis of the paraboloid in order to line up the long axis of the bolometer strip with the power-line conductor.

SUPPRESSED ANTENNAS FOR HIGH-SPEED AIRCRAFT

Summary. Various suppressed airborne antennas intended for navigation and communication purposes are under development.

Progress. Attempts to match and to broad-band the combined localizer-omnidirectional range antenna have been continued. In order to gain broad-band characteristics the dipole elements have been flared out while maintaining the U-shaped "deerhorn". Results are still inconclusive.

A full-scale model of the VHF communication antenna, consisting of a pair of slots, one on each side of the tail cone, has been built in preparation for matching.

MEASUREMENT OF THE PULSE CHARACTERISTICS OF RECEIVING TUBES

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 measurement of pulse characteristics was begun with limited personnel.

The project has been temporarily discontinued owing to the pressure of work of higher priority.

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.

Progress. The basic guidance unit has been constructed. This is a frequency-modulated device for detecting obstacles.

The method under investigation for warning the operator of obstacles in his path consists of applying an electrical shock selectively to the fingers of one hand, each finger corresponding to a pre-determined distance from the operator to the obstacle. This method was given indoor trials and appeared very promising.

Experimentally, two systems based on the above method were set up. The first system employed a single power-amplifier stage driving five series-tuned L-C circuits, each of which provided a shocking voltage for one of the five fingers. The second system employed five tuned power amplifiers for the same purpose. Both systems have so far proved somewhat impractical for portable equipment, since the coils employed in the L-C circuits were much too bulky and the five power-amplifier stages required excessive battery power.

Accordingly, an investigation into the design of a more compact coil for the L-C circuits will be made and this, it is hoped, will lead to the development of a unit of satisfactory dimensions.

REGULATED POWER SUPPLIES FOR LABORATORY USE

Details relating to the characteristics of these units have been given in previous NRC progress reports. The supplies have been made in two ranges. One type is a 400-ma unit, operating over a range of 250-325 volts, while the other is a 125-ma unit, with a range of 650-800 volts. The units have, in addition to excellent regulation, an output impedance of less than 0.3 ohms in the case of the lower-voltage unit, and less than 0.5 ohms in the case of the higher-voltage unit.

The drift referred to in the previous progress report was found to be associated with defective voltage-regulator tubes. The regulation for line voltage variations between 105 v and 125 v and load current variations between zero and full load is now better than ± 0.5 volts.

Nine 300-volt units have been completed and are at present in use in the Sussex Street Laboratory. Five of the 800-volt units have been finished and six more of the 300-volt units, now being wired, will complete the project. (See photos- "General Purpose Regulated Power Supply").

NRC Report ERA-156, now in preparation, will contain a detailed description of these units.

Miniaturized Regulated Power Supplies

As an example of miniaturizing techniques, a voltage-regulated power supply using miniature tubes throughout, has been designed. Six of these units have been built in the laboratory.

The photographs ("Compact Regulated Power Supply") present an exterior view and a view with the supply opened up to permit access to the tubes. The regulator circuits are mounted in the upper section and access to the circuit components may be gained by removing the cover. The components of the power supply proper may be exposed by the removal of the bottom plate.

The characteristics of the supply are:

Input: 105 v to 125 v, 60 cycles.

Output: 1. Positive, 250 v to 300 v at 0 to 80 ma.

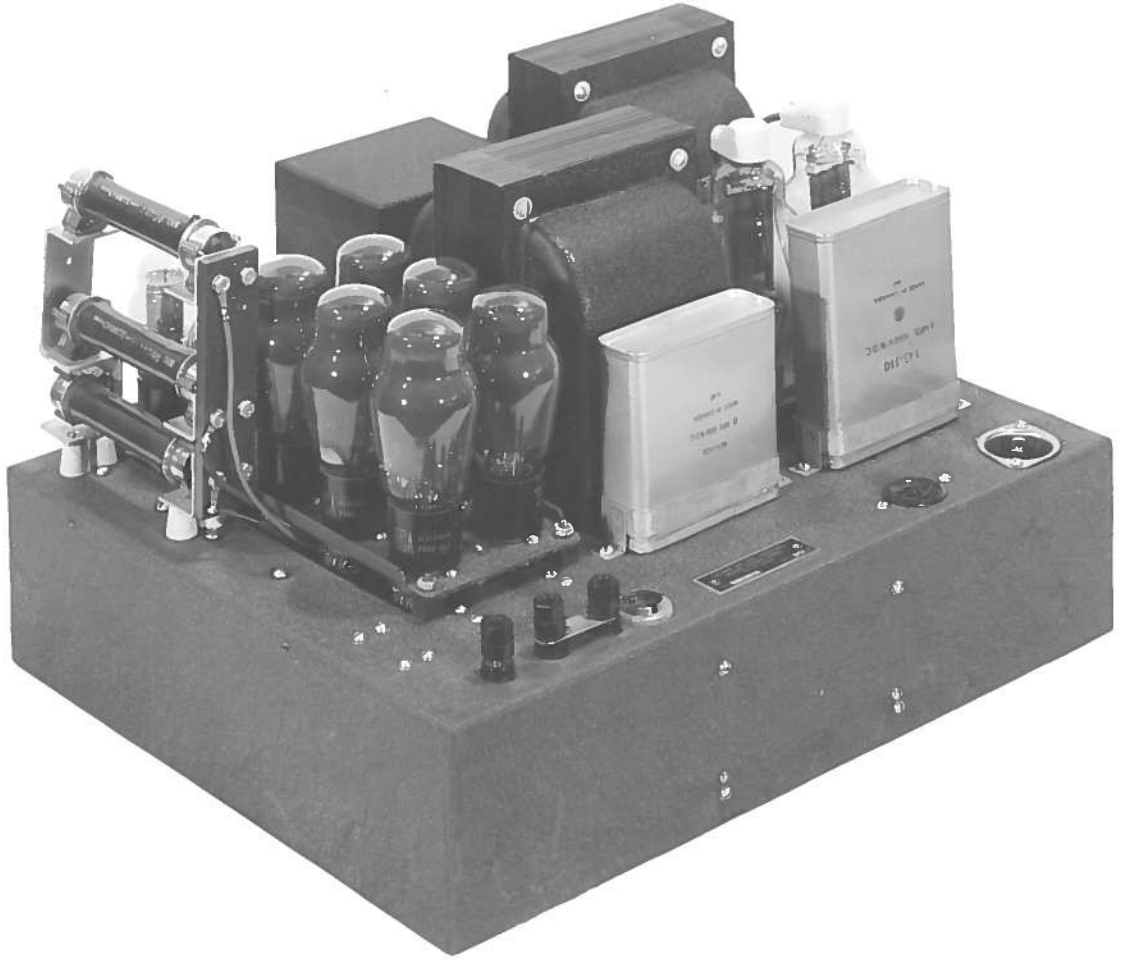
2. Negative, 150 v to 20 ma (VR-regulated).

3. AC, 6.3 v at 3.5 amperes.

GENERAL PURPOSE REGULATED POWER SUPPLY

300 volts, 400 ma

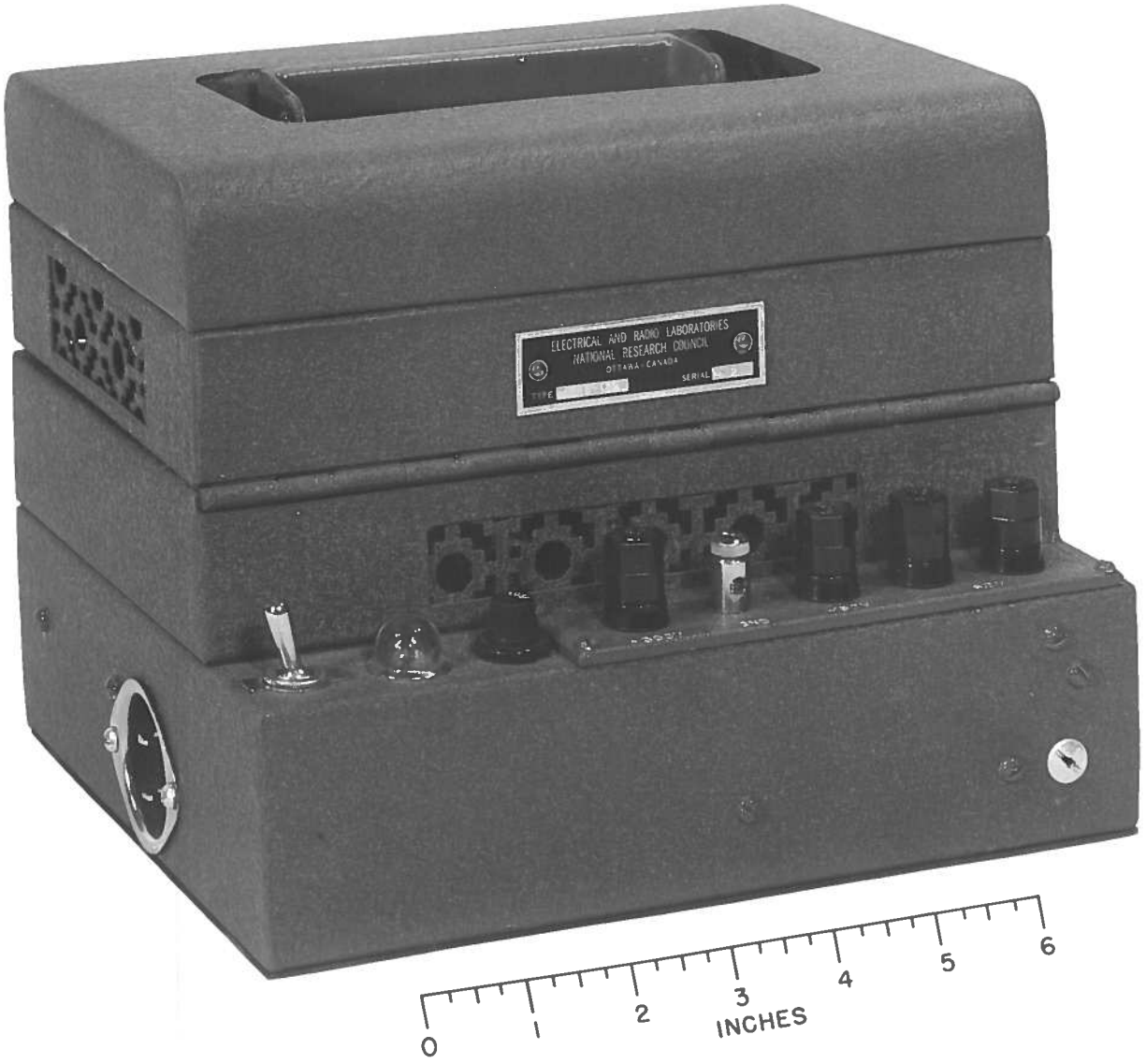
front view



GENERAL PURPOSE REGULATED POWER SUPPLY

300 volts, 400 ma

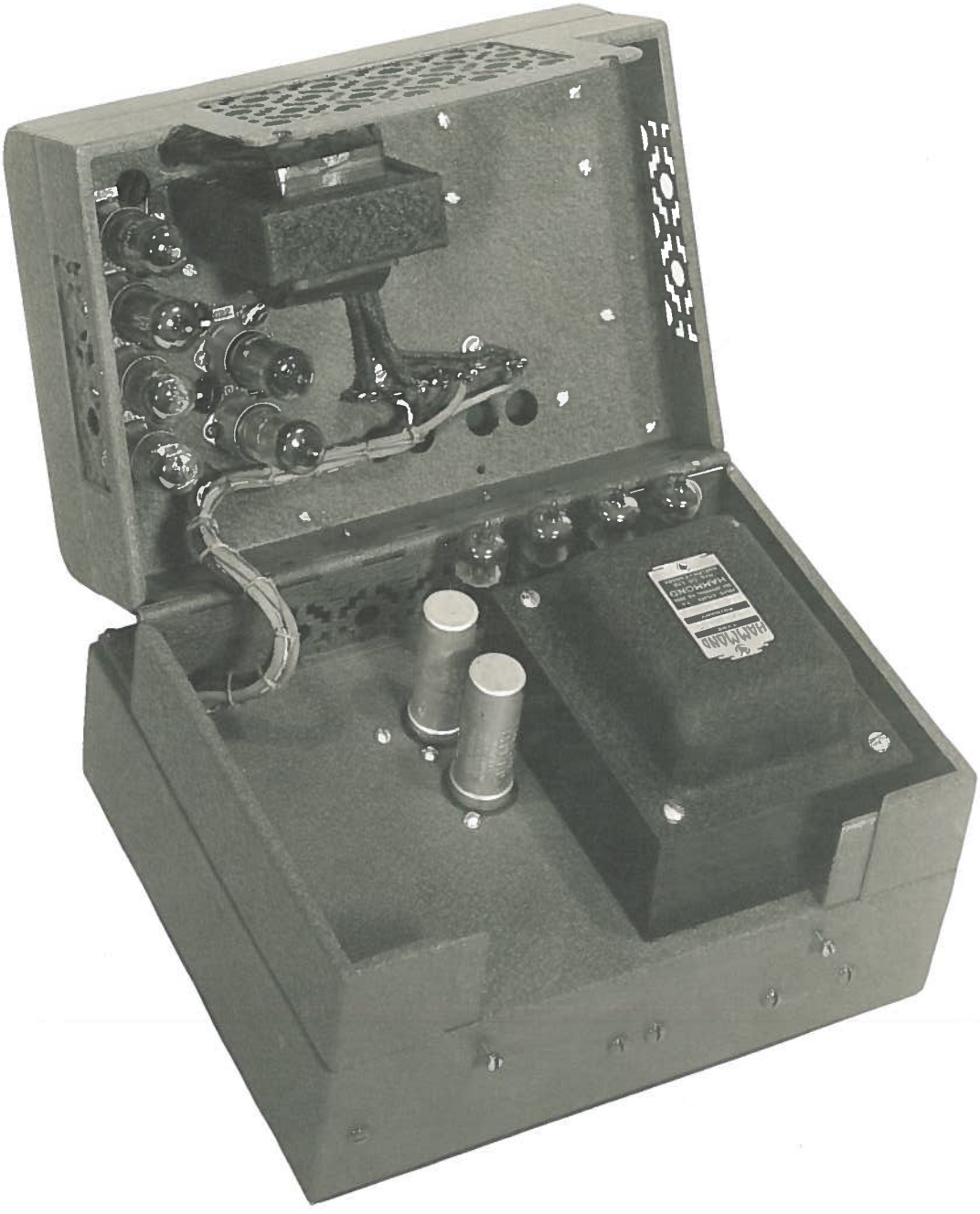
rear view--cover removed



COMPACT REGULATED POWER SUPPLY

250-300 volts, 80 ma

front view



COMPACT REGULATED POWER SUPPLY

250-300 volts, 80 ma

vacuum tubes exposed

Constancy of Output:	Within ± 0.25 v for the line and load changes above.
Output Impedance:	Approximately 0.6 ohms.
Ripple:	Approximately 3 mv.

MASS SPECTROMETER

Summary. The electronic portion of this instrument is being constructed for the Division of Chemistry. The circuit design follows very closely that of a mass spectrometer used at McMaster University, but the mechanical design has been modified considerably in order to facilitate servicing.

Progress. Wiring and checking of the main rack and thirteen chassis has been completed and this equipment has been installed for the Division of Chemistry.

The remainder of the work on this project consists of the construction of a motor-control unit which will provide automatic sweeping of the magnetic field, and of an automatic shunt selector for the "Speedomax Recorder." In addition, the operator's desk and the trim for the main rack is to be provided.

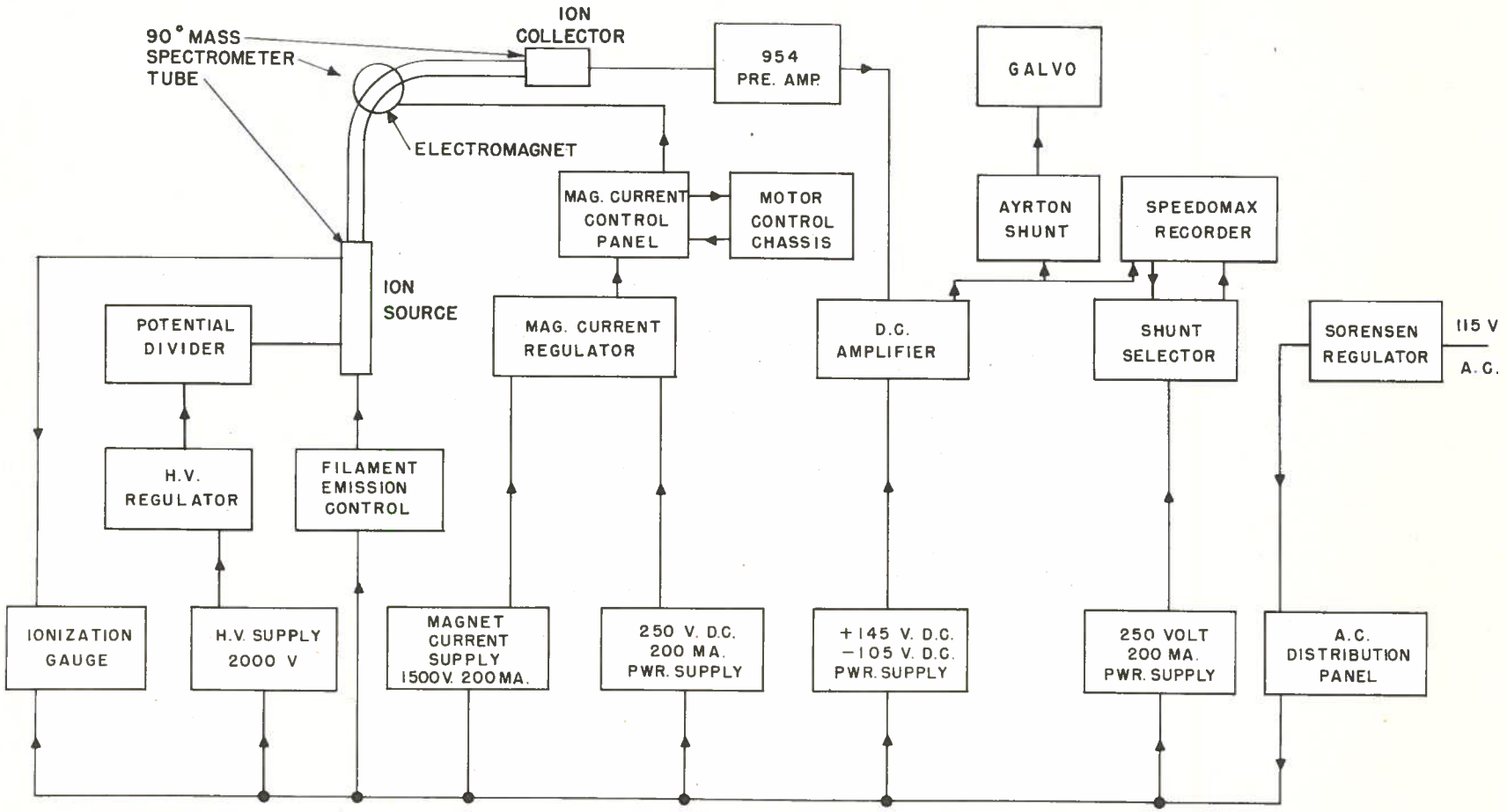
Owing to pressure of other work, completion of the project has been delayed, but, meanwhile, the spectrometer is being operated manually in the Division of Chemistry, pending the construction of the motor-control unit.

II
RADAR

SHORAN AIDS TO AERIAL SURVEY

Summary. Shoran systems for measuring geodetic baselines and for topographic mapping are being tested as part of a program to accelerate the accurate survey of Canada. Equipment is being developed or modified to suit Canadian conditions and the whole problem is being examined from the viewpoint of suggesting modifications to apparatus or procedure.

Progress. During the period under review ground stations were set up at Orleans (near Ottawa), Scarboro (near Toronto), Trenton and Petawawa. These stations provide six lines whose lengths are known accurately from data supplied by the Dominion Geodetic Survey. The Shoran-equipped aircraft, by flying at constant altitude back and forth over the mid-point of each line, measures the radar distance to the two ground stations at the ends of the line. The technique employed is essentially that developed



MASS SPECTROMETER

Block Diagram

ERA-159

by the U.S. Army Air Forces and these distances are being measured to provide experience and to determine the accuracy of the present equipment. Flights have not been made as frequently as desired due to a number of causes, but the results to date are moderately encouraging.

Some preliminary work, employing different aerials at the ground stations, has indicated that a 360-degree field-of-view may be useable, with attendant advantages when installing the ground stations.

PRECISION RADAR RECORDING ALTIMETER

Summary. This instrument was designed to expediate 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. The 8,000-square mile area, chosen as a sample mapping area, has been entirely surveyed, but final analysis of the records by the Dept. of Mines and Resources is not yet completed. Results thus far look very satisfactory. The Anson aircraft, together with the altimeter installation, has been loaned to the Topographical Section of the Dept. of Mines and Resources for the summer months, according to a previous arrangement. A 100-square-mile area at Chalk River will be surveyed. This work will be carried out by personnel of the Dept. of Mines and Resources as part of the above-mentioned summer program. No further work on the altimeter program by NRC is anticipated, other than routine checking and maintenance of the gear being used by the Dept. of Mines and Resources.

The instrument to be used for checking the range calibration of the altimeter was completed and is now in satisfactory operation.

Work has been completed on the differential altimeter designed to correct the graphic record continuously during flight for fluctuations of the aircraft from level flight. This instrument replaces the 16-mm camera which provided photographic records from which manual corrections were previously made. A report is being prepared on this instrument.

A general manufacturing specification for the altimeter was written and forwarded to the RCAF. It is their intention to purchase twelve of these instruments for their aerial surveying.

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. This information is presented on a meter in the cockpit, the scale of which is graduated from 0-100 miles.

Status. Owing to a re-allocation of frequencies this equipment can not be employed on civil airways, as originally intended, but the RCAF propose to use a modified version of it for service requirements. The National Research Council supplied a complete airborne RDI equipment to the Canadian Marconi Company to aid them in designing the new 200-mc distance and homing indicator gear ordered by the RCAF. Further developmental work has been done on the ADF antenna and associated circuits in order to provide the left-right indicator attachment required by the RCAF.

During the period under review the ADF antenna was installed in an RCAF aircraft and given a flight test. It was found that the mechanical strength of the antenna was inadequate and a new type of antenna is being constructed.

PRECISION RANGING GONIOMETER

Summary. A small goniometer, accurate to within ± 0.3° was required for range-measuring applications. Several types of inductive goniometers were constructed and tested, of which two similar units, designated the "Type I-A" and "Type I-B", met the accuracy requirements. The errors in these goniometers, as measured by the resistance-divider method, were ± 0.25° and ± 0.30° respectively. In order to test the goniometers with the additional circuit components a phase-shift test unit was designed and built.

Several small capacitive goniometers were obtained from the American War Assets Corporation, and in one of these the circular dielectric rotor plate was replaced by the correctly-shaped cardied rotor plate.

Progress. The calibration of two of the capacitive goniometers, one with a circular dielectric rotor plate and one with a cardiod dielectric rotor plate, was checked. Using the resistance-divider method the angular error was found to be ± 1.8° and ± 2.3°, respectively. Since the cardiod rotor plate was supposed to give improved accuracy, an attempt was made to find why this was not so. It was finally concluded that there were two main reasons for this:-

1. Since the units were rather poorly constructed, it is very probable that the large eccentricity error and other errors introduced by faulty construction are not the same in both goniometers.

2. A mathematical analysis revealed that the error introduced by the circular rotor plate was partially cancelled by the error resulting from the spacing between the quadrant plates.

Because of the large error present in these capacitive goniometers, a new unit was designed using the same principle but with several mechanical refinements. Construction of this goniometer has begun.

It became necessary to check the inductive goniometers, together with the additional components which give a phase-shifted constant amplitude output. To this end, the capacitances of a series of silvered-mica condensers ranging from 1,000 μμf to 5,000 μμf were very accurately measured. These condensers were used in a bridged-T network to measure the inductance of the goniometer field coils. A tuned output amplifier, a low-impedance cathode-follower input stage, and a second harmonic parallel-T filter were also constructed for use with the bridge. In order that the effect of stray capacitances might be eliminated, the inductance was measured at two frequencies - 100 kc and 200 kc. These frequencies were checked by beating them against a 50 kc crystal.

After the inductances of the "Type I-A" goniometer field coils had been measured, the necessary resistances and capacitances for use in the network were selected - the resistances being adjusted to the correct value by grinding and the capacitances by the use of trimmers.

The phase-shift test unit, in the meantime, had been completed and found to operate satisfactorily, although some difficulty was experienced in tuning the unit correctly. A definite step-by-step procedure was necessary.

The first check of the "Type I-A" goniometer revealed an error of ± 3.0°. By adjustment of the components this was reduced to approximately ± 1.0°, but work is continuing in an effort to reduce the large first harmonic cosine error which is as yet unexplained.

MERCHANT MARINE RADAR - (MMR-B)

Summary. A design has been produced and a model constructed of a low-cost, simplified, marine navigational radar. The equipment consists of two parts besides the antenna unit. The rack, containing the transmitting and receiving units and power supplies, measures approximately 14" wide by 19" deep by 27" high, and the display unit, containing the 7" cathode-ray tube and circuits and all operational controls, measures approximately 12"by 12"by 18" deep.

The display, with its mounting cradle, can be fitted on the top of the rack to form a console unit (see photograph)

Merchant Marine Radar-Type B

(Experimental Model)

or located up to 100 feet from the rack in cases where remote operation is desired.

Progress. The experimental model was completed in June and given laboratory tests before being installed in the Marine Section tower for a complete operational check.

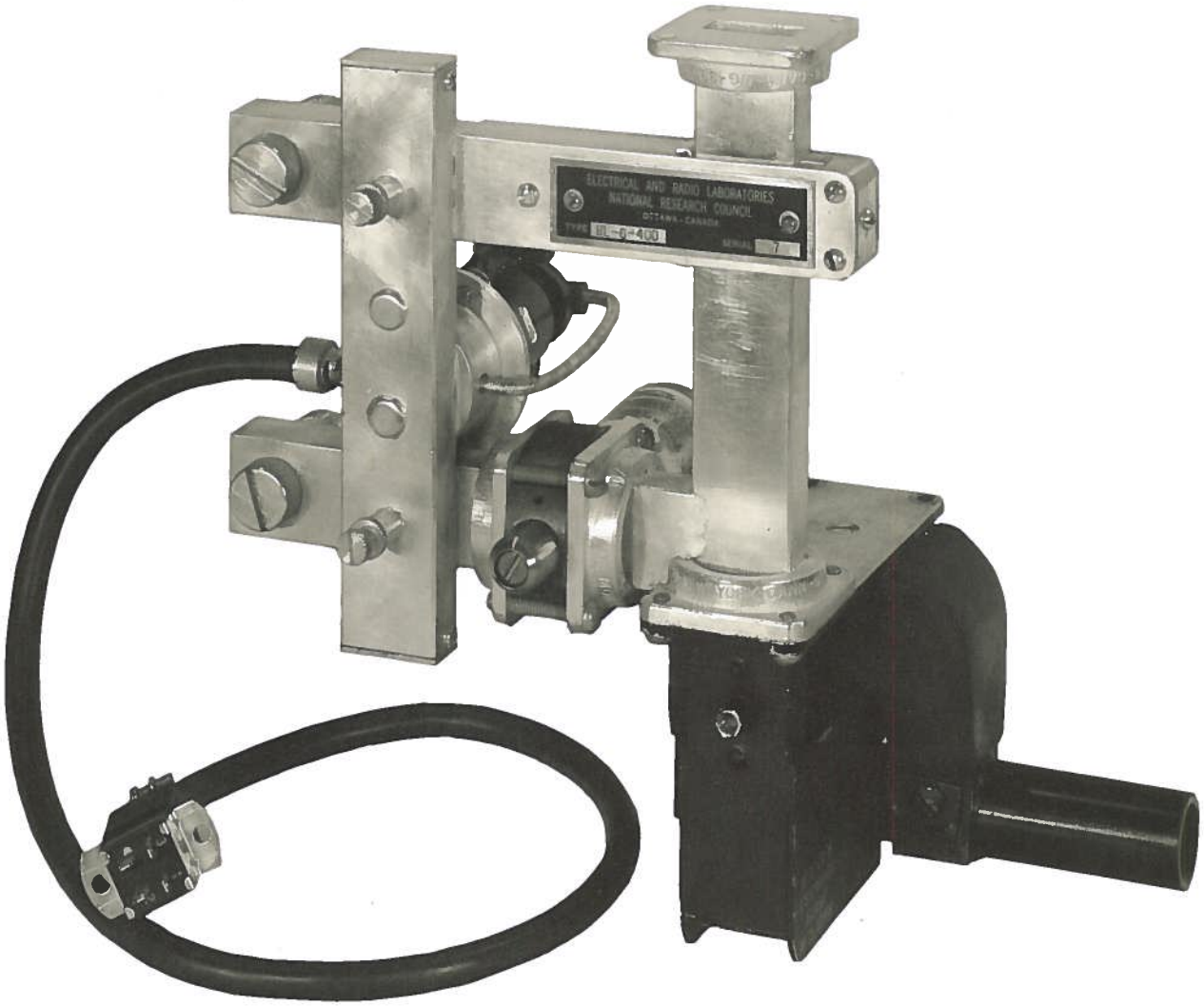
A temperature run indicated that adequate cooling of the rack unit was provided by the small fan installed, but some additional cooling in the display unit was found necessary. As it was not possible to fit a fan or blower in this unit conveniently, due to limited space and the possible introduction of electrical noise and hum, additional cooling was obtained by drilling holes to form louvres on the underside of the case which allowed air to pass up through the component strips. The prototype design will provide for additional cooling to overcome this difficulty.

During the latter part of June, the experimental model was installed on the M.V. "Radel" for radar trials on the Ottawa River and Lake Ontario. It was found that a minimum detection range of better than 25 yards could be consistently obtained with a small radar target buoy, as was the case with the earlier rough experimental equipment. No major faults or difficulties appeared during these preliminary trials.

The r-f head used in the experimental model, (see photograph) is an entirely pre-tuned system, the only adjustments, aside from T-R cell and local oscillator tuning, being two screw adjustments for setting the A.F.C. and receiver-crystal current levels. To overcome interaction over the whole frequency band between these crystal-current screws, two fixed matching studs of proper dimensions were added.

Recently, more exhaustive tests have been made on the r-f system using a number of local oscillator tubes. Some of these tubes were type 2K25 and some type 723 A/B. A small percentage of the type 723 A/B did not operate satisfactorily over the entire frequency band in both of the r-f heads used for these tests. Since these discontinuities always occurred at the high frequency end of the band some further experiments are being made in an attempt to eliminate the possibility of such discontinuities or to shift them out of the operating range.

The experimental model fitted in the M.V. "Radel" will be given complete sea trials. Range and bearing discrimination trials will be carried out and compared with the results obtained last summer using the first experimental equipment. The trials will also serve to provide operating experience with the set and to disclose any weaknesses or undesirable features.



RADIO-FREQUENCY HEAD ASSEMBLY FOR MERCHANT MARINE RADAR (MMR-B)

front view

The display unit from the first experimental set has been fitted with a specially modified 35-mm movie camera which will be used to photograph the PPI picture. A special cathode-ray tube with photographic characteristics superior to the P7 long-delay screen is used in this display. A separate trigger unit has been constructed, so that either the main or the photographic display unit can be made the master in controlling the modulator trigger. Thus, when photographing the PPI picture is the main objective, the photographic display unit can be made independent of adjustments made with the main display controls, with the exception of receiver gain. This system allows the use of a type of cathode-ray tube best suited for photographic purposes and a light-tight camera hood, so that it becomes unnecessary to black out the cabin. The main display is then used for general viewing and the adjustment of the gain control for obtaining the best picture.

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 ("VCS"), 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. At the same time, a survey of suitable sites for a harbour radar aid is being made in the Vancouver port area.

Progress.

Camperdown station. Experimental operation continues. At present the equipment is put into operation when the surface visibility drops below two miles. Plotting is done at 15-minute intervals and the position, identity (when known), and other pertinent details are recorded.

No information has been passed to shipping this season, other than to the Halifax Pilot Boat, pending further work on identification of ships, the installation of a stand-by radar set, and the establishment of operational procedure.

Identification of ships having communication by wireless (375 kc and 500 kc) is possible using existing shore-based, direction-finding equipment. The Department of Transport is installing cathode ray direction-finding equipment with Adcock-type antennas in order to simplify the operational procedure, and to determine whether adequate bearings can be obtained in the range 2-3 mc by this means. The National Research Council is also continuing with the modification of an automatic radio compass for experimental work in the same frequency range.

In this equipment, manipulation is much reduced, and the information is presented directly on the radar display.

Preparation is under way for the installation of a stand-by radar. In view of the complex nature of radar equipment and of the possible dangers resulting from failure of the equipment during operation, it is considered necessary to install a simple, independent radar set, to provide an alternative means of operation.

The Halifax Pilot Boat has been making considerable use of the information received via radiophone regarding incoming ships. This information gives a two-hour warning of the approach of an inbound vessel, and also enables the pilot boat to locate the vessel readily in thick fog. Further experimental work is required to improve this service, as the boat now in use is much smaller than the boat previously employed, and is not a satisfactory radar target. It is proposed to mount a radar reflector on the pilot boat to overcome this difficulty.

In January, two radar reflectors were mounted on buoys in the harbour approach. The intent was to determine the effect of the added weight and wind load, and of icing during the winter season. The performance of these buoys has been satisfactory, and no difficulty has been experienced with icing, despite the severe winter. The radar performance of the reflector on the Inner Automatic Buoy has been very satisfactory. Reports have been received stating that the buoy is visible to a range of 10 miles on both 3-cm and 10-cm radars. The reflector is a ring of ten trihedrons, 31 inches on an edge. The other reflector, which is on Lighthouse Bank Buoy, consists of three complete trihedrons, each one foot on a side, in a vertical row, so disposed as to give a maximum lobe every 20°. The radar performance of this buoy has not been as satisfactory as anticipated and the reflector is being moved to a new position to make further tests.

Vancouver Survey. At the request of the Department of Transport and the National Harbours Board, a survey is to be made of suitable sites for a Harbour Radar Aid in the Vancouver port area.

To facilitate this and other surveys, a truck (see photo) has been fitted with radar, communication and photographic equipment. The truck and equipment may be operated independently of commercial power sources, as it has a trailer fitted with a gas-driven motor-generator set, capable of supplying the full load required by the radar and other equipment.

The radar set is a Canadian Type 268 equipment, modified to operate with a quarter-microsecond pulse length and an antenna with reduced beam width and side lobes. PPI displays of five, seven and twelve inches are used. The twelve-inch PPI display is equipped with ranging and bearing facilities designed

RADAR-EQUIPPED TRUCK USED FOR HARBOUR SURVEILLANCE SITING TESTS

Trailer contains mobile power supply

for ease of reading, and for high accuracy. The ranging device is a movable pip, with range displayed on an illuminated meter. The bearing is obtained by a cursor displayed directly on the tube phosphor, thus avoiding parallax at the tube face. The numerical scale is projected optically onto a ground glass screen above the tube. Both bearing and range of a target can be obtained without the necessity of consulting external scales.

One of the sites proposed is on the Lions' Gate Bridge, over the First Narrows at the entrance to the harbour. The difficulty of mounting a single antenna above or below the bridge so as to give a clear view uninterrupted by the bridge structure, has been avoided by constructing a servo mechanism which will drive two antennas in synchronism, within ± 1/4°. One antenna will be mounted on one side of the bridge, the other on the other side, with the width of the bridge between them; thus each antenna will have a clear view of the harbour on that side upon which it is mounted. A simple switching mechanism will select the proper antenna, and the resultant display will show both views of the harbour in the proper orientation on the PPI.

Provision has been made for taking both still and motion pictures of the PPI display. It is hoped that the necessity of manual plotting during fog may be avoided by one or other of these methods.

Equipment is also available for communication with ships during the survey.

X/S TRIALS

Summary. An X-band and an S-band radar have been installed at the Scarboro Field Station in a hut 195 feet above, and overlooking Lake Ontario. Both equipments are fitted with power-monitoring instruments, calibrated pulse-signal generators for measurement of returned signal, and specially modified 35-mm movie cameras to record the A-scan display. A land-based target site is so located that the intervening path is almost entirely over water. The target site is equipped with instruments to measure precipitation rate, drop size and distribution, field strength and rate and character of snowfall. The object of these trials is to make absolute measurement of snow and rain clutter signals in these two frequency bands and to correlate this data with precipitation rate and drop or flake size and distribution measurements recorded simultaneously.

Progress. Due to unsuitable access to the Lakeside target site during poor weather and the lack of proper security without continuous watch, a new location was found on a height of land at about 4,000 yards greater range and on approximately the same line of sight. A small tower was assembled to mount

the six-foot corner reflector and a portable hut was located near the tower to house the rain gauges, drop-size measuring equipment, field-strength recorder, and photoelectric densitometer. The hut has been supplied with hydro-electric service and the gas-electric plant, necessary at the Lakeside site, is no longer required. This is a distinct advantage where close voltage regulation is essential. A second small tower, located 200 feet from the hut, carries the modulated light source for the photoelectric densitometer.

A new field strength receiver-recorder of increased sensitivity has been completed but some adjustments are necessary before operation can be considered satisfactory. Some changes may be necessary in the i-f amplifier design to make it more stable. The best calibration accuracy that can be obtained with the commercial pulse-signal generator available is probably not better than ± 1 db, although relative values of attenuation can be obtained with considerably greater accuracy. Sufficient data has not yet been secured to correlate the output of the photoelectric densitometer and the sensitive rain gauges for a sufficiently wide range of precipitation rates. The rain gauges employed are satisfactory for rates as low as one millimeter per hour, but the photoelectric densitometer, if calibrated, would record rates considerably below this figure. It is hoped that the photoelectric densitometer, though lacking absolute calibration, will give very accurate relative data and indicate fluctuations or very rapid changes in precipitation rate. Precipitation rates of several millimeters per hour intensity are necessary to produce radar echoes at the range of the target site, and, to date, it has been most unfortunate that there have been practically no storms of sufficient intensity to provide useable data.

Both the X-band and S-band radars are equipped with paraboloidal antennae and the feed systems have been modified so that either vertical or horizontal polarization can be obtained. It is proposed to use this facility in an attempt to measure the variation in sea clutter with polarization.

Two radar target buoys have been sited at ranges of 3,000 and 4,000 yards on a bearing of 140° true from the radar hut. One buoy is fitted with a cluster of ten corner reflectors known as a "Double Crown of Thorns" and the other buoy with a single, complete trihedron, (produced by three intersecting planes mutually at right angles, giving eight triangular corners with a common vertex). In both cases, the dimensions of a single triangular corner are the same, namely 31 inches along each side.

These target buoys, aside from their use in radar discrimination and other trials with the M.V. "Radel", will

also serve as fixed targets on which to set the antennae for the polarization - sea clutter tests. The two buoys are identical except for the reflectors, and comparison trials of their effectiveness as radar targets will also be conducted with the M.V. "Radel".

MOTOR VESSEL "RADEL"

A considerable amount of installation work has been done during the past few months in preparation for the coming season's activities. A frequency-modulated receiver and transmitter have been installed for communication between the vessel and the Scarboro Field Station or a proposed mobile unit. A Bendix communication set has been installed for communication with other ships and coastal stations. To facilitate starting the main Diesel engine in the event of loss of compressed air, an auxiliary air compressor, electrically driven by the diesel-electric equipment, has been installed. Merchant Marine Radar (MMR-B) equipment was also installed in the vessel. Comparison trials will be made between this equipment and its commercial prototype. A comparison will also be made of a parabolic slice antenna and a small pillbox antenna. The Merchant Marine Type 268 Radar equipment is still on board and will be given comparison trials with the MMR-B equipment in confined waterways.

A trial run was made on the Ottawa River with the magnetic compass torque amplifier. This equipment was designed to provide automatic steering from magnetic compass control. The trial run demonstrated that a course could be maintained within one-quarter of a compass point. An additional attachment to the steering mechanism permits blind steering by means of a toggle switch, with the magnetic compass disengaged.

Small radar buoys for use in buoy-pattern trials were set out on the Ottawa River. Sufficient experience was gained to indicate that the design is satisfactory so far as handling of the buoys is concerned. Later in the season maximum range trials will be conducted and the optimum spacing of the buoys, when laid out in patterns, will be determined. Department of Transport radar buoys will be used in the determination of the most suitable type of reflector for maximum range.

In July, the vessel will proceed to Toronto where work, begun last year, will be continued on radar mapping of the lake shorelines and harbour entrances, and trials of blind navigation in and out of all available small harbours will be made. In addition, observations will be made on Lake Ontario of conditions of abnormal propagation of radar signals.

III

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. The system devised for accurate timing, and described in the previous report, has been constructed. The unit employing the 1-mc crystal-controlled source, which provides multiple frequencies up to 30 mc, has been constructed. However, further frequency multiplier stages will be required in view of the change in heterodyne frequency described below. The experimental 150 kc-to-60 cycle reduction unit, which provides a source of synchronization for the remainder of the equipment, has been built and put into operation. An alternative source of synchronization based on 60-cycle line frequency will be used. The equipment required for this purpose has also been constructed.

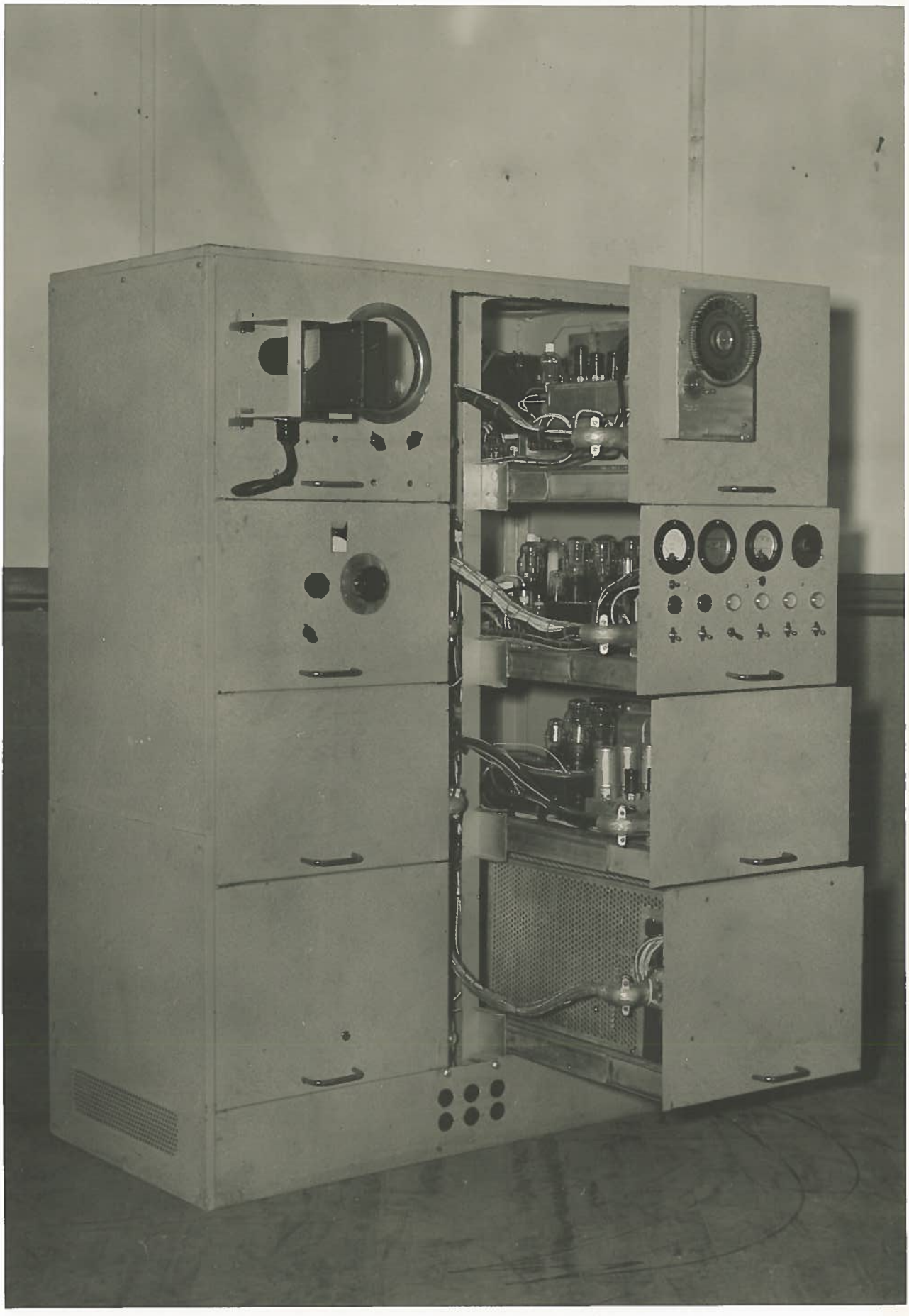
It has been found that problems associated with the transmitting and receiving system necessitate the use of much higher heterodyning frequencies in this system than were previously employed. The common oscillator frequency is now varied from 121-140 mc, while the fixed-frequency oscillator operates at 120 mc. This eliminates amplification of the oscillator frequencies in the wide band-pass amplifier of the transmitter, which operates over a band of 1-20 mc. More uniform response at higher levels is also realized from the heterodyne mixer of the transmitter. The transmitter itself has been re-designed so as to incorporate these changes and the first i-f channel of the receiver will be revised for operation at 120 mc.

The electronic unit which is employed to trigger the 16-mm camera was completed. Sample records may be selected, omitting as many as seven frames between successive photographic exposures.

SOLAR NOISE OBSERVATIONS

The daily variations in the emission of 10.7-centimeter radio-frequency energy from the sun, as observed at the National Research Council during 1947, have been compared by J.F. Denisse,+ with the area of the sunspots and their

+ L'École Normale Supérieure, Paris, France; presently guest scientist at the National Bureau of Standards, Washington, D.C.



PANORAMIC IONOSPHERIC RECORDER

associated magnetic fields. When the noise variations are compared with the relative American Sunspot Number the correlation coefficient is 0.53; when compared with the sunspot area corrected for foreshortening the correlation coefficient increases to 0.76; and when allowance is made for the fact that some small sunspots have an intense magnetic field and vice versa, the correlation coefficient increases to 0.87.

Correction for the allowance mentioned above is made by multiplying the area of each spot by $\frac{H_o}{\sqrt{I}}$, where H_o is the magnetic field in the center of the spot, which can attain a maximum value of 3,000 gauss, and A is the spot area, of the order of 10^8 square kilometers. The new index then has the form $\Sigma\sqrt{A}\,H$. This quantity may be interpreted as the dimensions of the hemisphere emitting 10.7-cm r-f energy, which exists over each spot. Such an emitting surface presents nearly constant area to the earth as the spot progresses across the disk and would account for the good correlation obtained with the true sunspot area not corrected for foreshortening.

Denisse's results were reported orally at the May, 1948, combined URSI-IRE convention, held at Washington, D.C. A paper reporting his work has been submitted to the Astro-Physical Journal.

The action of the magnetic field of the sunspot has been experimentally detected during the month of June through the production of circularly-polarized radiation. This type of radiation was detected with the aid of a quarter-wave plate placed in front of the existing four-foot parabolic reflector. (See photo) The plate changes the circularly-polarized radiation into linear-polarized radiation which is received by a properly oriented dipole. Preliminary observations show that the type of polarization (left-or right-handed) is a slowly varying quantity. The maximum excess observed during June was about 6%.

Routine observations of the daily intensity of the solar 10.7-cm radiation and polarization continue.

The design of the variable-frequency radiometer has been modified so as to cover the range 7 1/2-30 cm and construction is still proceeding.

The power and control wiring of the Goth Hill Observatory has been completed in preparation for the installation of the two new 10.7-cm radiometers.

RADIO TELESCOPE
equipped with quarter-wave plate
for the detection of circularly-polarized
solar electromagnetic radiation on 10.7 cm

RADIO TELESCOPE
with quarter-wave plate removed

SHOOTING-STAR RADAR

Summary. The Shooting-Star project was initiated in 1947, as a combined program of visual, radar and photographic observation of meteors, under the joint auspicies of the Dominion Observatory and the National Research Council of Canada. The initial purpose was to achieve a close correlation of the visual and the radar observations in order to be able eventually to determine the parameters of meteors seen by radar alone. The larger objectives of the work are to add to the existing knowledge of meteors and the upper atmosphere. Some progress has been made in this direction and a phenomenological theory of radar echoes from meteors has been evolved, which suggests the existence of fine-structure characteristics in the ionized region in which the meteors appear.

The visual, photographic and spectroscopic phases of the research are supervised by the Dominion Observatory and more detailed reports are available from them. The radar program has been organized by the National Research Council. For the past year a radar station has been operated at Ottawa on 32.5 mc, with about 300 kw of peak power. The main operational periods have been during the annual visual showers, with intermittent operation at other times. In April, 1948, a second station was set up at Arnprior, 57 km west of Ottawa, and in July a third station was installed at Carleton Place, 41 km south-west of Ottawa. These stations are of considerably lower power than the Ottawa transmitter and the frequencies on which they operate are slightly higher.

Equipment. The first of the two low-power portable stations has been placed in operation at Arnprior (about 36 miles west of the home station) and, in conjunction with the home station, several days of simultaneous operation were carried out. A minute-by-minute comparison of film records taken at Ottawa and Arnprior showed that virtually every echo of duration greater than one second seen at Arnprior was also seen at Ottawa, and in most cases there was a recognizable similarity in detail.

A site for the second portable station (third point of the SSR triangle) was located on a farm near Carleton Place (about 25 miles south-west of the home station) but, due to lack of suitable buildings for housing the equipment in the vicinity, the station was set up in two trailers. This station will be put into operation in time for the Perseid shower in August.

In order to display the records taken at the three stations minute-by-minute for the detection of coincidences, two additional film projectors, similar to the one described in the previous progress report, were constructed.

In anticipation of successful three-station operation a graphical procedure for finding the position of the echo point, given three radar ranges, has been worked out and a suitable plotting table designed.

A Fairchild high-speed camera was modified to facilitate the analysis of meteoric echoes. The modification consisted of the replacement of the d-c motor by a synchronous motor in order to eliminate noise. With a film speed of 30 inches per minute, the echoes from individual pulses are discernible and the rate of growth and decay of the echo, and any amplitude modulation present, may be detected.

The design of a new high-powered transportable transmitter has been commenced and a number of components, including complete d-c power supplies obtained from American war surplus stock, have been accumulated. Construction of the transmitter will begin in the near future.

ELECTRON ACCELERATOR

Summary. An experimental electron accelerator was constructed employing a ten-centimeter cavity resonator placed in a uniform megnetic field. The electrons were accelerated by passing them successively through the resonator. Eight orbits were obtained, with no appreciable current loss from the second to the eighth orbit.

Progress. The problem of break-down across the accelerating gap has been eliminated with the voltage used at present, which is 700 kv. This has been accomplished by reshaping the cavity pole faces so that there are no sharp edges and by diligent cleaning of the inside surface.

At first, electrons were not injected externally but a copious supply was obtained by cold field emission. The next step was to construct an electron gun to inject electrons for acceleration. One of the most pronising was the insertion of a tungsten emitter into the cavity where it was heated by the radio-frequency energy present. By this means the current in the main orbit was increased fifteen times. Current increases were noticed up to the third orbit, but not beyond it.

Further experimenting is required to determine the optimum position for the filament.

A paper was submitted to "Nature" for publication, describing the operation of the accelerator.

REFLECTION COEFFICIENTS OVER SNOW AT THREE CENTIMETERS

A study is being made of the possibility of radar camouflage of obstacles to marine navigation by loose snow.

The assembly of towers and equipment for the determination of reflection coefficients over snow during the coming winter has been continued.

TUBE LABORATORY

Millimeter Wavelength Generators

Work on the construction of oscillators at millimeter wavelengths is continuing. Two types of oscillator are under development, a magnetron to operate at a wavelength of four millimeters and an electrostatically-focussed, orbital-beam oscillator.

Four-millimeter Magnetron

This magnetron is an 18-segment, open-ended, "rising-sun" magnetron of package construction. No hobs for the fabrication of the anode have so far been machined. An automatically indexing machine is being designed for grinding the hobs. One dummy tube has been assembled to test brazing techniques. The cathode for this tube will be a thoria "dispenser"-type of cathode.

Orbital Beam Oscillator

In this tube an orbital electron beam is focussed electrostatically by two co-axial cylinders, the inner cylinder being a H_{01} resonator with longitudinal slots. One model of this tube has been constructed for K-band operation but was found unsatisfactory mechanically. A second model of the tube has been constructed and is being exhausted at the time of writing.

Van de Graaff Accelerator Tubes

Two tubes are under construction for the Electrical Engineering Section. A 500-kv tube of 22 sections has been designed and the parts have been machined. Assembly of the tube is in progress. This tube employs a stack of nickel electrodes and vycor spacing rings, the seals being made with vinyl acetate cement.

A 5-megavolt tube is also being designed.

Magnetic Counter Tube

No work has been done on this tube as no non-magnetic material for the construction of the electrodes has been available.

Miscellaneous

Work has continued on the construction of apparatus for tube processing.

An electrolytic plotting tank and automatic plotting circuit are being constructed for the determination of electron trajectories in electrostatic systems.

IV
ELECTRICAL ENGINEERING

VAN DE GRAAFF GENERATORS

Summary. The construction of two Van de Graaff generators is now well advanced. One, a five-megavolt generator, will be employed in nuclear research at the Chalk River laboratories of the National Research Council; the other, a 500-kilovolt generator, will be used in the study of reactions between ionized gas molecules by the Division of Chemistry.

Progress.

Five-Megavolt Generator. During the month of April, meetings were held with representatives of the Nuclear Physics and the Engineering Design Divisions of the Atomic Energy Project at Chalk River. The status of the five-megavolt generator and of the construction of the generator building was reviewed, and plans for the control, metering and power wiring were discussed in detail. A schedule for the remainder of the work was drawn up. The date proposed for the beginning of the installation was July 1st, but since the building was not completed by that time, the date of installation was later postponed to August 1st.

The first step in the actual installation of the machine will be the erection of the tank base, together with the associated connections for electrical control, cooling water, insulating gas, and accelerator tube vacuum lines. This work will be carried out by engineers of the Atomic Energy Project.

During the period under review, the generator was set up in the Electrical Engineering Laboratory and given a series of preliminary tests under pressure. As a source of

high-pressure air was conveniently available, this was used for the tests instead of nitrogen. In order to avoid hazards associated with the use of air as an insulator, short-circuit tests only were carried out under pressures up to the maximum safe pressure (400 psi). It was found that maximum short-circuit currents under negative charging conditions increased with pressure up to 650 microamperes at 100 psi, and under positive charging conditions up to 460 microamperes at 100 psi. No attempt was made to dry the gas used in these tests and its relative humidity was found to be ten per cent.

As has been observed in other generators, motor input power increased with pressure from 2.3 kw at zero psi gauge pressure to 11.4 kw at 400 psi gauge pressure. Under the conditions of the tests, the temperature rise of the air within the tank was 23°C, with no artificial cooling. Pressure sealing was satisfactory at maximum pressure.

At the conclusion of these preliminary tests, it was decided to dismantle the machine for shipment to Chalk River so that assembly could begin there on the date proposed.

Five-Hundred-Kilovolt Generator. The assembly, consisting of the generator and the 30-kv power supply, has been completely rewired with special aluminum-shielded conductors in order to reduce the effect of high-voltage surges, originating in the machine, on the power and control circuits. The metering and control panel has been constructed and wired and arrangements have been made for the cable connections between the generator and the control panel in their final location.

A testing chamber was constructed for making high-voltage flash-over tests of insulators under pressure. Two new types of insulators have been designed and partially tested during this period. One of these used molded Lucite as an insulator, the other was a glass and dural assembly bonded by Plastilock, and constructed in such a way as to limit the maximum cold flow in the Plastilock. Tests in the compression chamber indicated that the electrical characteristics of both types were satisfactory and that the mechanical performance appeared to be suitable. However, as the Lucite type can be constructed more conveniently, a complete set of these will be fabricated and tested. If satisfactory, they will be used instead of the Plastilock-bonded insulators.

Design and construction of all components of the accelerating tube except the filament assembly has been completed. The assembly of the tube will be carried out by the Tube Laboratory of this Division. A Machlette tube is available for use until this tube will be completed.

The remainder of the work on this machine will consist of complete checking with the new insulators in place and the installation of one of the accelerating tubes for final testing.

HIGH-SPEED RECORDING OSCILLOGRAPH

Summary. This instrument is being designed to record the voltage waveform of the one-million-volt surge generator located in the Electrical Engineering Laboratory. A sealed-off tube and a fluorescent screen will be used.

Progress. The original scheme of designing a direct-coupled phase inverter for vertical deflection is being followed. This type of circuit will simplify positioning of the spot. Separate power supplies are being constructed for each stage of the circuit in an attempt to stabilize its operation.

An intensifier circuit, designed to maintain uniform intensity across the face of the tube when an exponential sweep is used, was constructed. The circuit employs thyratron tubes in order to produce a very sharp rise of voltage. Automatic compensation for changes in sweep rate is provided. Preliminary photographs of the trace indicate that the above scheme operates satisfactorily.

Besides the trace of the transient under investigation, four additional traces must be recorded on the same negative in rapid sequence. This is necessary in order to provide complete calibration of the surge wave. To facilitate the adjustment of the surge generator, it is desireable that these five separate traces, when viewed on the oscillograph screen, appear to occur simultaneously. To this end, both mechanical and electronic switching methods are being investigated.

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 the laboratory's standard frequency service. The regulator operates in the field of the d-c motor driving a Westinghouse 30 kva sine-wave alternator.

Due to the absence of the engineer-in-charge no further work has been done on this project.

BREAKDOWN TESTS OF LOW-VOLTAGE DISTRIBUTION CABLE

Considerable difficulties have been encountered, due to pothead failures, in the 60-cycle breakdown tests of the paper-insulated lead-covered cable samples. The pothead design used was of the stress-cone type. An investigation into condenser pothead design has begun.

BRUSH RESEARCH

The aim of this project is to investigate the unusual behaviour and extremely rapid wear of carbon brushes at high altitudes. Conditions of brush wear at these altitudes will be simulated in a small low-pressure chamber in which the test equipment will be set up.

All of the test equipment described in the previous progress report has been constructed during the period under review, except the thermometer required for the measurement of slip-ring temperature. Two attempts were made to construct a glass thermometer curved so as to fit inside the slip-ring. However, the mechanical strength of both thermometers proved inadequate at 3450 rpm.

The equipment for measuring brush friction has been built, using commercially available strain gauges, and has been found to be quite sensitive.

A carbon sealing gland, required for passing the drive shaft through the side of the low-pressure chamber, was fabricated and tested for wear under conditions similar to those which will exist in the low-pressure chamber. The seal failed after one hour's operation. However, after impregnation with cadmium iodide, the rate of wear appeared to be negligible.

CONTROL BOX FOR STANDARD-TEMPERATURE LAMPS.

This equipment provides facilities for the control and measurement of the current supplied to the standard-temperature lamps used by the Heat Section of the NRC Division of Physics. Tests have shown that the precision and stability of the current adjustments available from the completed unit are adequate and a report describing the essential features of the device will be prepared.

VOLTAGE STABILIZER FOR RADIANT PANEL TESTS.

This stabilizer was designed to supply 2 1/2 amperes, at 80 volts d-c, from the 110-volt line for radiant panel tests carried out by the Heat Section of the NRC Division of Physics. The voltage regulation required was 1/4%. The unit has been constructed, tested and installed and is now operating satisfactorily. A paper on the subject of the degenerative shunt regulator used in this unit is being prepared.

CSA-APPROVAL TEST WORK

During the period April to June, 1948, two oil burners were given initial examination and five revised

models of previously rejected burners were tested. Electric component parts were checked for four companies. Use of the components was recommended for one company and the others were requested to make alterations.

The above tests were covered in nine preliminary reports, four of which contained recommendation for tentative CSA listing. Four manufacturers were notified that revisions must be made to their equipment before further tests could be undertaken.

Four final reports were completed and printed, and three others were drafted.

V
STANDARD FREQUENCY SERVICES

Routine maintenance and operation of the Standard Frequency Services was continued.

VI
PAPERS AND PUBLICATIONS

"The History and Development of Van de Graaff Generators", R.M. Morris, Ottawa Section AIEE, April 20th, 1948.

"A Precision Radar Recording Altimeter", B.I. McCaffrey, National Convention, IRE, Toronto, Ont., April 30th-May 1st, 1948.

"A Phenomenological Theory of Radar Echoes from Meteors", D.W.R. McKinley and Peter M. Millman[x], Royal Society of Canada, June, 1948, Meeting, Vancouver, B.C.

"The Operation of a Magnetic Resonance Accelerator for Electrons", H. LeCaine, Royal Society of Canada, June, 1948, Meeting, Vancouver, B.C.

"Emission of Radio Frequency Energy from the Sky", A.E. Covington, URSI-IRE Convention, Washington, D.C., May 3rd, 1948.

....

"Recent Canadian Radar"
B.G. Ballard, Engineering Journal, Vol. 31, No. 7, July, 1948.

The more common uses of radar of general interest to the engineer are described. Studies in the field of radar undertaken in cooperation with the National Research Council

[x] Dominion Observatory, Ottawa.

by various universities and by the Defense Research Board are dealt with. Three examples of radar employed as a tool in research are given, namely, its use in accelerators, solar noise and meteor studies.

The application of radar to marine navigation, harbour surveillance and marine and aerial mapping at the National Research Council is discussed, as well as the development of a suitable radar altimeter.

"Solar Noise Observations on 10.7 Centimeters",
A.E. Covington, Proc. IRE, Vol.36, No.4, April, 1948.

Daily observations of the 10.7-cm solar radiation show a 27-day recurrent peak which has a strong correlation with the appearance of sunspots. In the absence of large spots the equivalent temperature of the sun is 7.9×10^4 degrees K. Sudden bursts of solar noise show a sharp rise lasting one or two minutes and a gradual decline to pre-storm value or to a somewhat higher value. Average burst duration is ten minutes.

"Fault Location on High-Voltage Overhead Transmission Systems",
W.G. Hoyle, Conférence Internationale des Grands Réseaux Électriques à Haute Tension, Sec. 217, Session 1948.

As the length and inaccessibility of transmission lines increase, the location of faults by the usual method of line patrol appears less and less satisfactory. For this reason, an instrument was developed which enables sustained faults to be located from the end of the line. The instrument utilizes the radar principle of measuring pulse reflection time and gives an accuracy of the order of one percent. Details of the instrument are given, and the results of tests on two lines, one fifty miles, the other one hundred miles in length, are described. Included are oscillograms showing the appearance of the lines under the various simulated fault conditions. Operation on lines up to the maximum length now in existence appears quite feasible. Some disadvantages of the instrument are indicated, and a suggested program for further development is given.

"Voltage Regulators of the Shunt Type",
W.G. Hoyle, Review of Scientific Instruments, April, 1948.

A general equation for the shunt regulator is derived, giving the relation between the nominal required input voltage and the maximum shunt regulating current for any per unit variation of the input voltage, and for any load. The necessary relation between the shunt regulating current and the output

current for maximum electrical efficiency is obtained. It is shown that, for a fixed load, the maximum average efficiency of any shunt regulator is $(1-(k)^{\frac{1}{2}})^2$, where k is the maximum per unit variation of the voltage to the regulator.

"A Note on Four Complex Meteor Radar Echoes",
P.M. Millman[x], D.W.R. McKinley, Journal of the Royal Astronomical Society of Canada, Vol. 42, No. 3, May-June, 1948.

The radar echoes of four bright meteors, one Geminid and three Lyrids, are studied in detail. All four echoes have an enduring portion of complex character, centered at a height of 90 km, and at least three have an instantaneous component which seems to move with the velocity of the meteor itself. Measurements made on these echoes indicate velocities of 35 km/sec. for the Geminid shower and 48 km/sec. for the Lyrid shower.

"On the Utilization of the Optimum Prime Factors in Spot Roentgenography". A.M. McNabb, M.D.[xx], and Isaac L. Newton, American Journal of Roentgenology and Radium Therapy, Vol. 60, No.1, July, 1948.

The prime factors affecting the quality of roentgenograms are discussed in relation to apparatus currently available for utilizing roentgenoscopic film technique.

An apparatus is described which improves the quality of roentgenograms and extends the field of this technique, utilizing:

1. A rotating anode tube.
2. A light-weight moving grid of original design.
3. A photoelectric timer of the basic Morgan design.

--- --- ---

"A Proposal for a New Ohmmeter Scale",
E.L.R. Webb, (Divisional report ERB-195)

The basic reason for the non-uniformity of spacing of scale divisions of present ohmmeter scales is examined and a new scale based on the RMA series of values is suggested as an improvement.

"Cable Tests for the Northern Electric Company, Ltd.",
F.C. Creed, (Divisional report ERB-199A, restricted).

[x] Dominion Observatory, Ottawa.

[xx] Medical Arts Building, Ottawa, Ont.

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