Progress report for July - September 1949

National Research Council of Canada. Radio and Electrical Engineering Division

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REPORT ERA-175

UNCLASSIFIED

LABORATORIES

OF

THE NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

PROGRESS REPORT

FOR

JULY - SEPTEMBER 1949

OTTAWA

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Report No. ERA-175

Laboratories

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The National Research Council of Canada

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I

RADAR

ECHO SOUNDING

Interest was expressed by the Canadian Hydrographic Service in our proposal to develop a unit that would combine the functions of echo sounding and radar position-fixing. By this means, an instantaneous fix and sounding could be obtained on photographic film for future plotting, with no requirement for visual fixes on shore markers.

A commercial depth recorder was modified to display soundings, on a type-A scan, on the screen of a three-inch cathode-ray tube (the usual paper-recording feature of the instrument being retained). The Radar Display Photographic Equipment (see page 5) was used to provide a simultaneous photographic record of the PPI display and the echo-sounder type-A scan. After developing, the film was projected on an enlarged marine chart in order to determine the ship's position at the time of exposure, and the sounding at this point was read from the sounding display on the same frame of the film.

The Upper Rideau Lake, an irregular-shaped body of water about 80 miles south-west of Ottawa, was chosen for the experimental trials because it is very shallow in some parts and contains several uncharted rocks and shoals, and also because there was a suitable berth available at Westport.

The equipment in use was capable of recording all the data required for plotting soundings from microfilm, on sounding craft of any normal speed. However, the only shallow-draft craft which could be procured was a barge, 18 by 30 feet, on which a house was mounted. Great difficulty was experienced in maneuvering this unit, even in a light breeze. The entire craft was propelled by a 22-hp outboard motor, the maximum speed possible being only three miles per hour. Photographs were taken every 14 seconds by an automatic timer. Thus, soundings were taken about 60 feet apart at maximum speed. An excellent track was obtained from the radar records and the soundings were noted from each frame. Readings on the paper recorder were also observed in case some abrupt obstacle existed between the 14-second observations. A report, summarizing the work on this project during the present season, is being prepared for publication.

It should be noted that Upper Rideau Lake, though only 5½ square miles in area, is a very irregular body of water. Because of this, and because of the difficulty in maneuvering the barge, the time taken to cover the lake was considerably greater than would be required in open water with a faster and more maneuverable vessel. It is estimated that in open water, running at 10 miles per hour, with courses one-eighth mile apart, one square mile could be sounded in approximately one hour, without the necessity of a visible shoreline to fix the position of the soundings.

Thirty-five runs were made across Upper Rideau Lake to give adequate coverage for submarine contour plotting. In addition, records were taken on one run down Big Rideau Lake and Lower Rideau Lake in the course of the return trip of the barge to Ottawa.

MICROWAVE LIGHTHOUSE

At the request of the Department of Transport, an investigation is being made into the possibility of providing shipping, particularly those vessels too small to take advantage of radar equipment, with a simple, inexpensive, microwave navigational aid. The narrow beams available at microwave frequencies suggest that microwave systems might serve to replace the function of a lighthouse under conditions of poor visibility. One system, using highly directional antennas at the beacon site ashore, as described in the previous report, has been given experimental trials.

During the period under review, a second system, involving a moderately directional receiving antenna aboard ship, and a simple coded transmitter with an omnidirectional antenna ashore, has received attention. Work during the past few months has been centered on the construction and testing of a microwave direction finder (a pelorus). This consists of a crystal video receiver mounted in a box, the front face of which is shaped to serve as a reflector for a three-centimeter dipole array(see photo). Two such receivers and their containers have been built and have undergone operational tests satisfactorily on the experimental vessel "Radel".

The receiver consists of a silicon-crystal diode, similar to the type used on radar equipment, and five stages of audio amplification. The reflector is a section of a paraboloid, 6" x 16". A two-element array coupled to a wave guide feeds the received signal, which is pulsed, or square-wave-modulated to the silicon-crystal diode, where it is rectified, and the resulting output is amplified and fed to a pair of phones. In use, the whole assembly, weighing about 12 pounds, may be turned so as to receive the maximum signal, which may be located with an accuracy of ± ½°.

Model of Direction Finder
used in Microwave Lighthouse tests on Lake Ontario

It should be emphasized that this equipment is rugged, and simple to operate, as the only controls provided are a volume control and an "on-off" switch. Tuning is not required, as the input has a moderately broad bandwidth. The precise bandwidth has yet to be determined. Provision for tuning can be added, if required, but present indications are that tuning is not necessary. Tests to date on the "Radel", using magnetron modulators ashore, with peak powers and pulse widths as small as 6 kilowatts and 1/4 microsecond, respectively, and using a choke coupling as a radiator, have shown that the maximum ranges coincide with the optical line of sight. In order to obtain these ranges it was necessary to substitute a paraboloid of the same dimensions for the parabolic cylinder shown in the photograph. A further test, using a klystron with a power output of 1.4 milliwatts, with square-wave modulation, gave a maximum range of 1 mile, indicating that a somewhat higher-powered klystron may be adequate for most purposes.

The accuracy of position-fixing was checked by taking simultaneous bearings on three transmitters, the fixes thus obtained being checked against a radar fix obtained by taking the range to two known positions. The positions agreed within ± 1/4 mile, at ten-mile ranges. The greater part of the error can be attributed to yawing of the small vessel on which the tests were made.

Homing was also tried, and was very successful, accurate bearings being taken to within a few feet of the transmitter.

With regard to range, anomalous propagation occurred on many occasions, and ranges greatly in excess of the line-of-sight path were obtained. On one occasion signals were heard out to sixteen miles. An effort is being made to determine the frequency of occurrence of such propagation conditions on Lake Ontario. At present this work is confined to photographing the screen of a three-centimeter radar set at Scarboro Bluffs, at five-minute intervals. This will not yield the desired information, since the radar antenna is 200 feet above the surface of the lake. However, it does permit the exploration of suitable techniques for an expanded program of this nature which is now under consideration.

MERCHANT MARINE RADAR

MMR-B - Final operational trials of the prototype models of the simplified, low-cost merchant marine radar have been completed. No difficulties have been encountered which would indicate the necessity for major design changes. Both prototype models were

operated for lengthy periods during field trials, often under adverse conditions of temperature and humidity, but no major breakdowns were experienced.

Further work on this project will be concerned with the development of auxiliary devices, with position-fixing in conjunction with the echo-sounding program, position-fixing for microwave beacon experiments, etc. One of the sets will continue to be used as a navigational radar on the experimental vessel "Radel".

A portion of the electrical test specification has been written and forwarded to the Canadian manufacturer of the equipment to enable test procedures to be set up and to establish a basis for quality control in production.

Radar Reflectors

A number of tests were made of the over-water reflection obtained from a number of different radar reflectors, including two metal corners of different dimensions, two light-weight wire-mesh reflectors intended for use with life rafts, a metalized papier-mâché sphere and an 18-inch paraboloid with shorted wave-guide feed. These reflectors were placed at a known height above the water on a 2" x 2" wooden mast. The mast projected from a wooden tower which was weighted and sunk in the water at such a depth that the top of the tower was just protruding from the surface of water. The distance between the reflectors and the radar was 1800 yards. Transmitted power and returned signal power were measured directly by means of a calibrated, pulse signal generator. The data recorded in these tests is being analyzed and the results should soon be available in report form.

Improvements in Minimum Detection Range

A stacked antenna unit, using two modified Type-268 reflectors, was constructed and tested with an MMR-B set, using one antenna for receiving and the other for transmitting. In using this arrangement, it was necessary to dispense with the T-R cell in order to connect the receiving antenna to the r-f head. This disturbed electrical conditions within the r-f head to such an extent that it was impossible to obtain more than 0.2 milliamperes of receiver crystal current. However, a considerable improvement in minimum detection range was noted, due to the use of the two antennas. These tests will be continued when time permits, and an attempt will be made to obtain quantitative data on the difference between common and separate transmitting and receiving antennas.

Radar Display Photographic Equipment

During the past few years it has become common practice to employ photography to facilitate the recording and analysis of radar and other CRT displays.

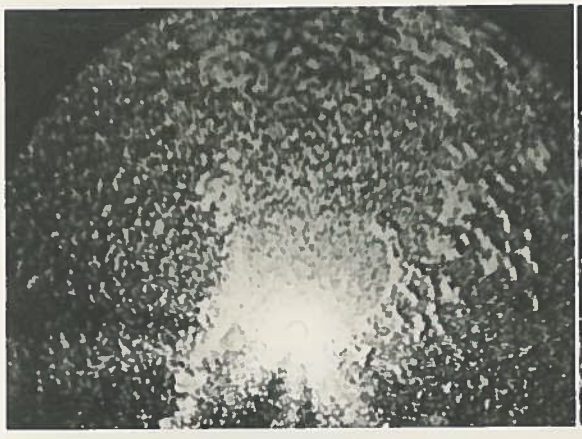
A great deal of difficulty was experienced with early setups used for photographing the radar PPI display, particularly with the lack of rigidity of the camera-CRT mount when the equipment was used in the field, and with the adjusting and servicing of the circuits. Also, it was found desirable to be able to view the display directly while it was being photographed.

In order to facilitate repair and adjustment of the electronic circuits and to provide a rigid, compact cathode-ray-tube and camera setup, the new equipment is made up of two units. A cabinet, 15½ inches long, 26 inches high and 20 inches deep contains the power supply, sweep, range marker and monitor units in two drawers which can be withdrawn on slide runners for adjustment and servicing, if necessary.

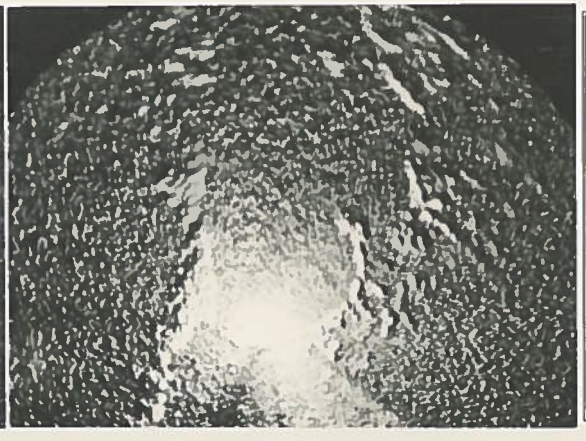
The camera-CRT unit is approximately 30 inches long, 20 inches high and 18 inches wide and consists of welded steel angle-frame in a sheet metal enclosure. Slideways are used to mount the camera on top of a rigid metal plate which forms the top of the angle iron frame, and the main (10-inch-diameter) cathode-ray tube is mounted inside the cabinet on the underside of this plate. The camera is, therefore, located immediately above and behind the face of the cathode-ray tube. An image of the cathode-ray tube display is formed at the camera by the use of two, heavy front-silvered mirrors, each mounted at 45° to the axis of the cathode-ray tube. The camera used is a 35-mm motion picture camera modified for electrically operated single-frame exposure.

The position and focus of the camera are adjusted so that the cathode-ray tube utilizes the full width of the negative frame, i.e., 5/8 of an inch. Since the length of the negative frame is 7/8 of an inch, there is sufficient space to record additional information. In view of this, a 3-inch-diameter cathode-ray tube was mounted alongside the main 10-inch PPI cathode-ray tube to provide a type-A display for the depth recorder of the echo sounding equipment (see Echo Sounding, Page 1).

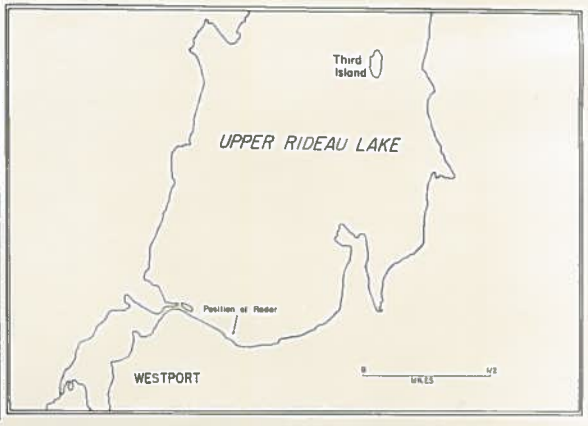
The camera is operated from an electric timer, adjustable for both exposure and interval time. Titling is obtained by writing on a slide which is inserted in front of the cathode-ray tubes. During operation, the two displays can be viewed directly from the front without interfering with the operation of the camera.



Portion of PPI Display
obtained with Standard Receiver



Portion of PPI Display
obtained with Logarithmic Receiver



Map of Corresponding Area

Performance of Standard and Logarithmic Receivers
in the presence of heavy rain clutter
(Both receivers operating at full gain setting)

Logarithmic Receiver

A comparison was made of signals received through a heavy rain storm by a standard MMR-B receiver and a receiver using crystal diodes in the grid circuits of the i-f stages, to provide logarithmic response. Quite a marked improvement was noted in the ability of the logarithmic receiver to detect, in the presence of dense clutter, fixed echoes, such as shorelines and small islands (see photo). This was particularly noticeable at full gain settings of both receivers. It was felt that the use of a logarithmic receiver may be preferable to the application of swept gain in overcoming difficulties due to signals received in the presence of sea clutter.

RADAR AIDS AT HARBOUR ENTRANCES

The aim of this project is to determine methods by which shore-based radar equipment may be used as an aid to navigation at harbour entrances. The work is carried on jointly by the National Research Council and the Department of Transport. Present tests are being made at Camperdown Wireless Station ("VCS") at the entrance to Halifax Harbour. An experimental installation has been made on the First Narrows (Lions Gate) Bridge at Vancouver.

Halifax Installation

The standby set, which is a complete and independent radar system, has been installed at Camperdown. This set will ensure continuous radar service in the event of failure of the main set. This continuity of service is necessary, as a ship proceeding with shore assistance must continue to receive this assistance until it has passed out of the surveillance area, otherwise the ship's master might be left in a situation to which he would not normally commit his ship.

The camera unit to be used for recording the radar data was installed, but it was subsequently removed, as it failed to operate satisfactorily and time was not available to locate and correct the fault.

Vancouver Installation

The installation on the First Narrows Bridge is now in full operation using a 60-cycle power supply and a two-crystal duplexer.

The operational procedure is as follows: The signal station on the First Narrows Bridge has a radio-telephone set which operates on 1630 kc, a frequency in common use on the West Coast. The signal station staff observe the radar display, and broadcast at frequent intervals the position of shipping, referred to the bridge, or to well known landmarks, e.g. "A ship is now entering the west end of the Narrows", or "There is a tug and tow outbound opposite Calamity Light".

Position of a vessel is also given on request. No difficulty has been experienced with regard to identification, as the position provided by radar is a confirmation of the position obtained by other methods which have been in use by vessels on this coast for many years. The chief value of the radar system is in the provision of information about the state of traffic, especially in the narrow channel over which the First Narrows Bridge passes. Comment to date has been very favorable.

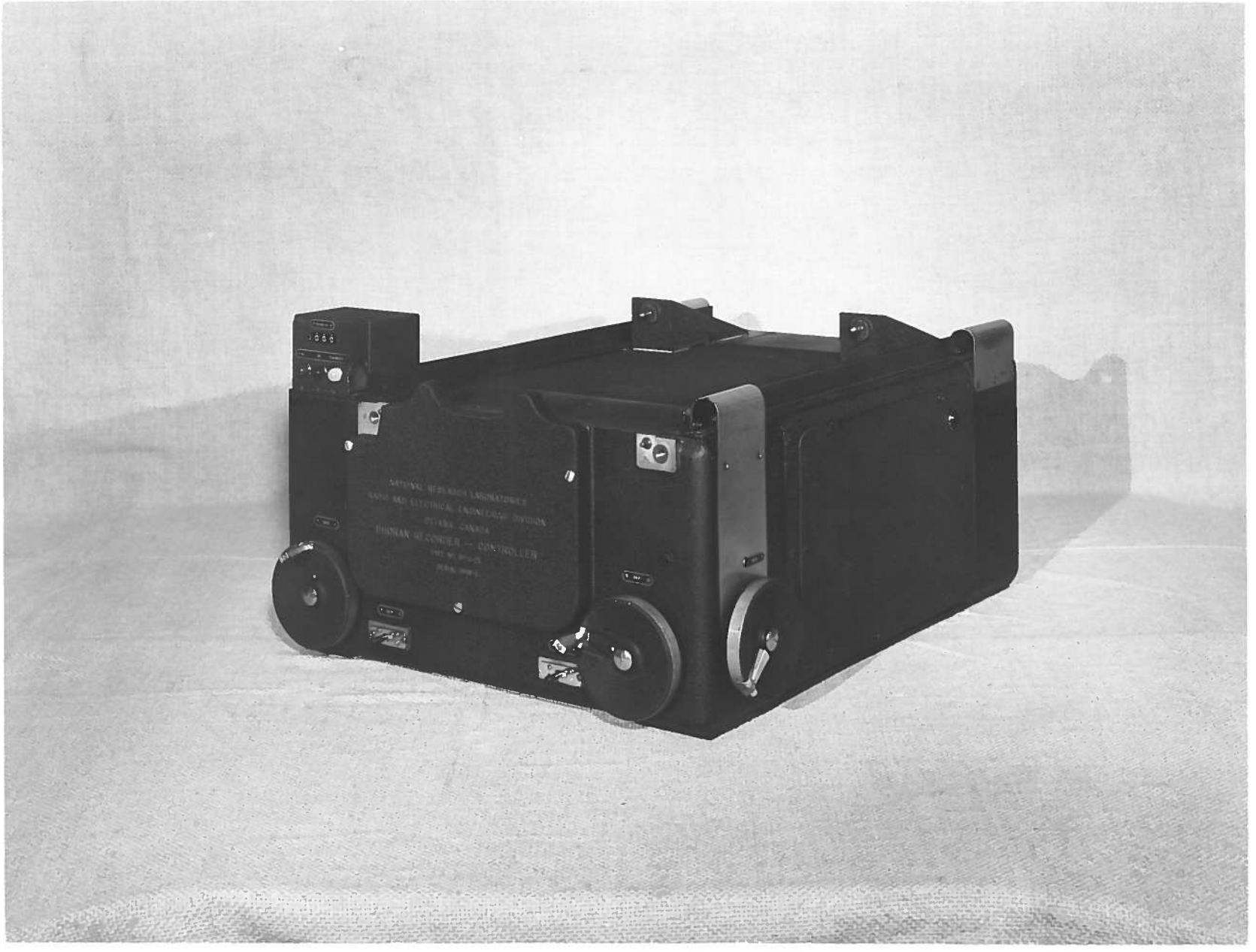
SHORAN AIDS TO AERIAL SURVEY

Shoran Recorder-Controller

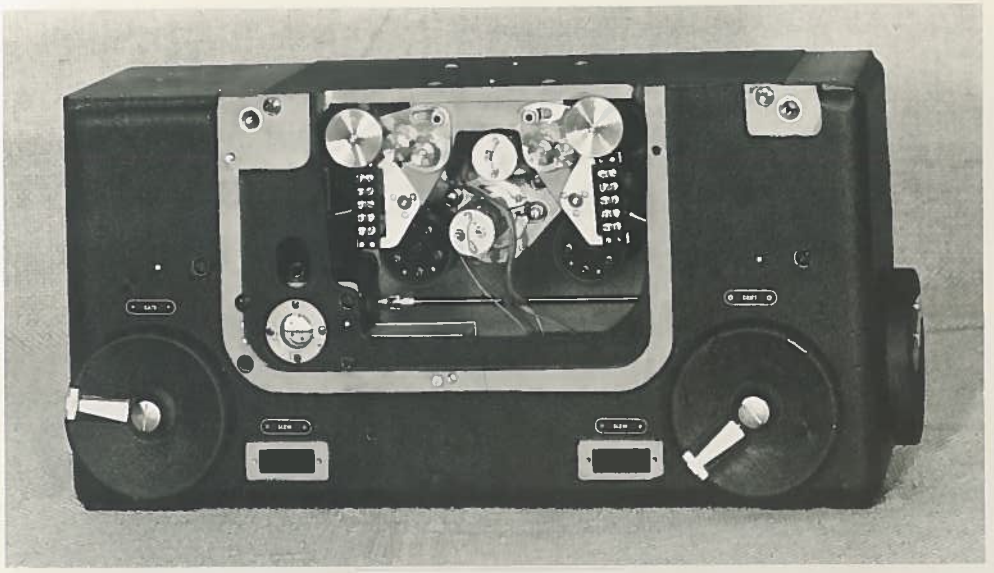
This instrument was developed for use with Shoran radar in its application to aerial survey. In addition to providing means of photographically recording at specific intervals the radar-determined distances and certain other instrument readings, it is a dual-channel control mechanism for the airborne Shoran receiver-indicator. The operator manipulates the controls to maintain the marker pulse and the pulses received from the ground stations in alignment on an oscilloscope, thus providing accurate measurement of the distances to each of the two ground stations in terms of mechanical motions indicated on dials.

The photograph on the following page shows the complete recorder-controller. Provision is made for mounting the Shoran indicator-receiver on top of this unit. The front portion, on which the handwheels are located, contains the control mechanisms and an interior panel on which the indicating dials and other instruments are mounted. The rear portion contains the recording camera, a photographic flash unit and an auxiliary cathode-ray oscillograph for recording the operator's tracking error.

The control system consists of two channels, one for each of the distance measurements required (these being designated "Rate" and "Drift" distances, a nomenclature retained from wartime usage). Each channel is a mechanical aided-laying tracking system operated by a single handwheel. An explanatory gearing schematic is shown.

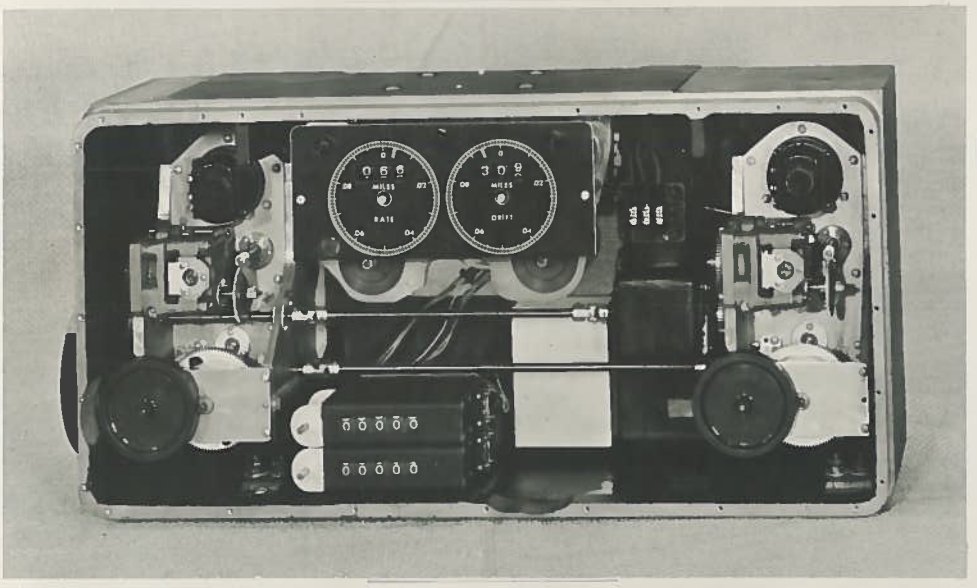


The Shoran Recorder-Controller



external view

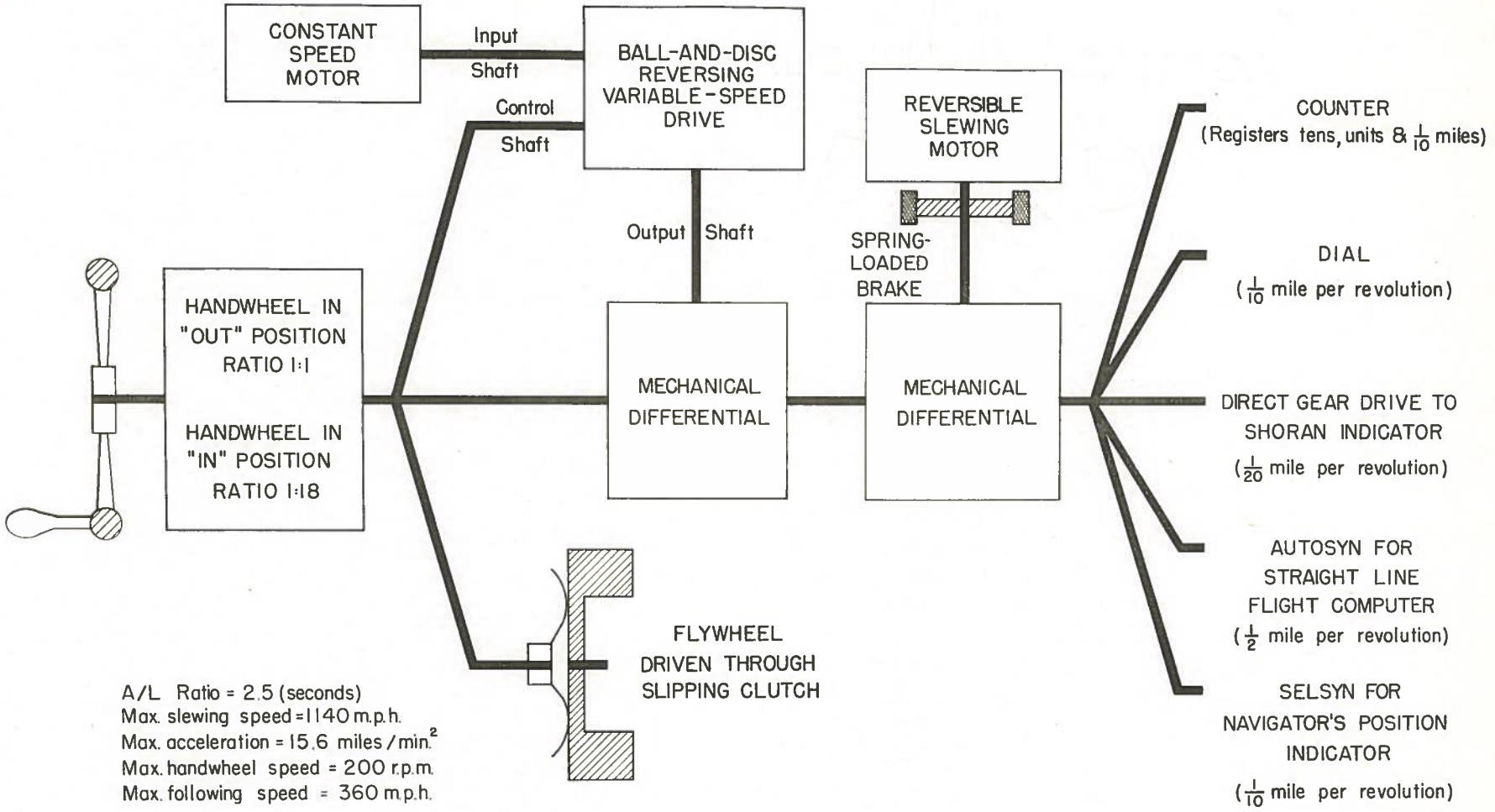
Front Subassembly of Shoran



internal view

Recorder – Controller

Sample Film Record



SHORAN RECORDER-CONTROLLER

SCHEMATIC OF CONTROL SYSTEM

(One Channel Shown)

Rotation of the handwheel turns the recorder dials and other output shafts directly and also alters the rate of rotation being fed from the variable-speed drive. The gearing ratios that determine the proportion in which these two actions occur are such that an aided-laying ratio of 2.5 (seconds) is obtained.

Two gearing ratios are provided on the handwheel drive to enable the Shoran operator to maintain pip alignment for any usual aircraft maneuver without too small, or too great, a rate of handwheel rotation. The flywheel assists the operator in maintaining a constant rotational speed of the handwheel when such is required, while the slipping clutch disengages during more irregular motion. The reversible slewing motor enables the operator to make rapid alterations of dial settings. The friction brake provided on the shaft of this motor prevents the differential from driving this shaft, thus reducing the backlash in the reduction gearing.

The second photograph shows external and internal views of the front portion of the recorder-controller. The operator's handwheels are shown in the external view, the rate handwheel being duplicated at the right-hand side of the unit to provide control of one channel by a second operator, if necessary. The two large gears at the top can be moved upwards on swinging links to engage the gears on the Shoran receiver-indicator. The latter gears operate the goniometer systems which are the precision distance-measuring portions of the Shoran equipment. Key switches for the control of the slewing motors are mounted in the positions adjacent to the handwheels.

The internal view shows the mechanical details, the dials and counters in the center being mounted on the rear of the assembly which contains the Autosyns, Selsyns, and slewing motors. The assembly comprising the flywheel, variable-speed drive and handwheel gearing system for each channel is shown on either side of the unit, the constant-speed motor being mounted just to the right of the center dial assembly.

The rear portion of the recorder-controller contains a unit which illuminates the indicator panel by means of an instantaneous flash from a triggered gaseous discharge tube. A cathode-ray tube, with its associated sweep circuits, is mounted along one side of the recorder-controller. A shrouded mirror is provided to shield the fluorescent screen from the flash, while permitting the trace on the screen to be photographed by the camera. An enlargement of a sample frame of the 35-mm photographic record is shown. (A Distance Indicator meter, shown in the center of this photograph is a dummy in the Radar Altimeter Indicator position).

The camera is a 35-mm motion-picture camera, modified for single-shot operation by the addition of a solenoid system. No shutter is used in the camera, the cathode-ray tube being normally biased to cut-off, and being turned on by the removal of this bias for a period of approximately 1/10 second. By means of a system of relays, the correct sequence and duration of pulses are applied to the camera, the flash unit and the cathode-ray tube control chassis.

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During the past nine months the main emphasis in Shoran work has been on the design and supervision of construction of the recorder-controller, and of its associated apparatus. Also a system of junction boxes and interconnecting cables was evolved to provide for the installation in an aircraft of the complete Shoran equipment.

A Lancaster Survey Aircraft was equipped according to this plan, with those items of apparatus required for Shoran geodetic survey purposes. This aircraft has been used in the RCAF Shoran survey operations in Western Canada this summer. Considerable valuable information was obtained as to the suitability of the equipment in actual use.

II

RADIOPHYSICS

TUBE LABORATORY

The work in this laboratory during the period under review has been concentrated on two projects:

(1) the study of the causes of the decay of electron emission from oxide-coated cathodes and
(2) the design and construction of equipment for the millimeter-wave region.

Other work carried out during this period includes -

(a) further study of the radio-frequency mass spectrometer
(b) the development of an electronically controlled attenuator for the three-centimeter waveband.

A considerable portion of the available time was spent in re-fitting after moving the laboratory to a new location.

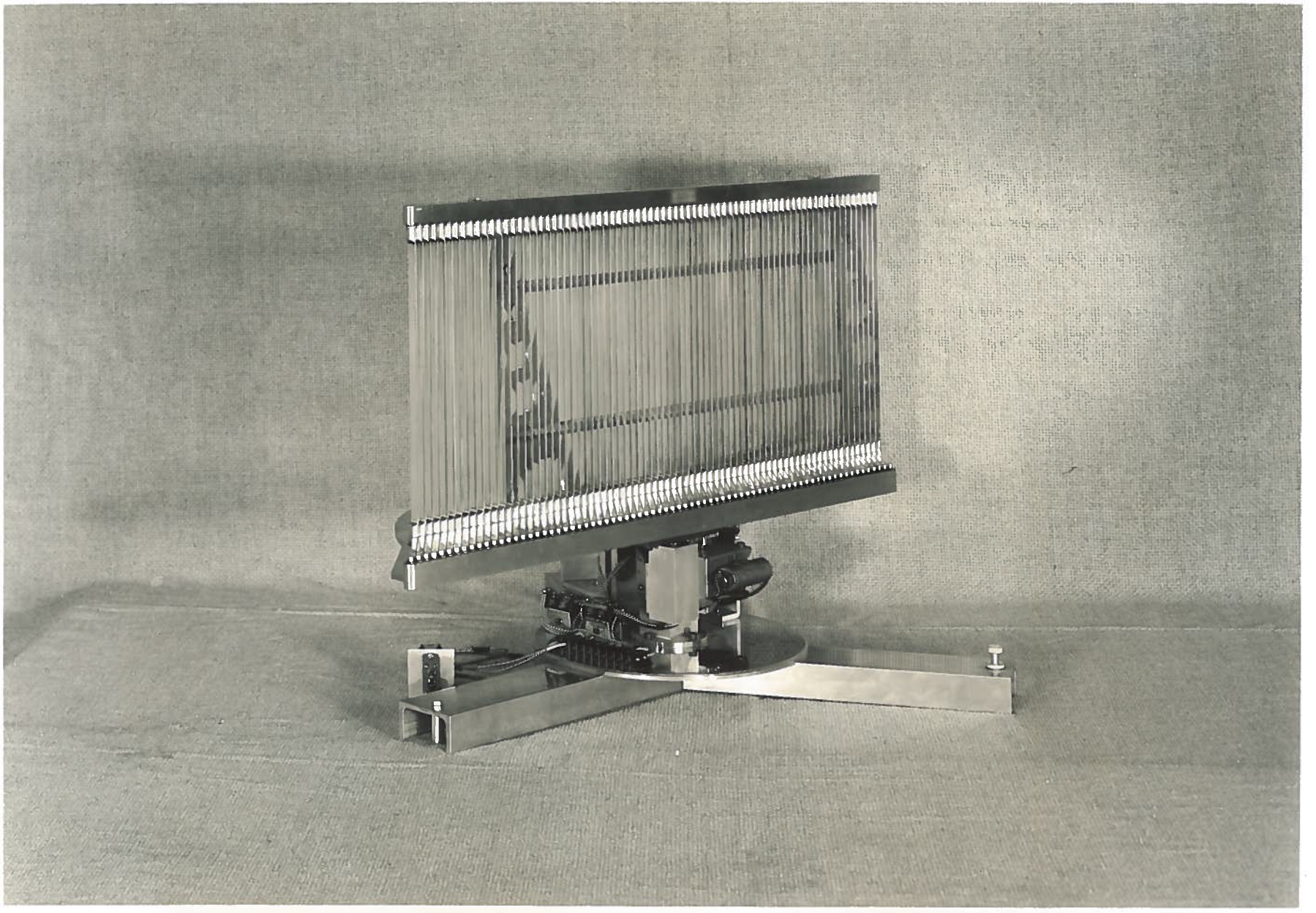
Emission Decay Phenomena

The investigation of long-period emission decay from oxide-coated cathodes under space-charge-limited conditions is continuing. A description of this type of decay was given in the previous report.

The influence of current density on the rate of emission decay has been studied using commercial tubes. It has been found that so long as the anode potential is below the ionization potential of residual gases in the tube a high cathode-current density is favourable to long life. It is thought that the increased current density causes an increase in the electrolytic production of barium impurity centres in the oxide coating and thus improves the emission properties of the coating. A group of special diodes is being constructed to check these results.

A number of spectrographic tests have been made on the light from an emitting cathode. Strong barium and strontium lines have been observed at quite low current densities with exposures of about one hour. One tube showing these lines very clearly after activation was aged for a hundred hours. Although the electronic characteristics had not changed measurably, on re-examination no lines could be observed.

Investigation of the difference in emission density between pulsed and d-c operation has indicated that the low d-c emission is caused by an anode effect. Electrons bombarding a contaminated anode cause disintegration of the surface layer, and the ions so formed



Millimeter-wave Echelette Spectrometer

return to the cathode and cause emission poisoning. Under pulsed conditions the cathode can recover between pulses. With a clean anode, or with potentials below the breakdown potential of the barium compound on the anode, d-c emission and pulsed emission are almost identical.

Millimeter Wave Research

A reflecting echelette spectrometer has been constructed to cover the wavelength range 1-10 mm (see photo). The grating is made up of 75 vertical reflectors. A mechanical linkage causes the plane reflecting surfaces to remain at a fixed angle to the incident r-f wave; thus, the receiver may remain at a fixed position. The grating is mechanically driven and the output from the receiver is fed to a pen recorder. In this way the spectrum of an oscillator may be automatically recorded.

An automatic hob grinding machine for the fabrication of magnetron anodes has been designed and is now being constructed.

R-F Mass Spectrometer

A description of this device was given in the last report.

Velocity separation of ions has been observed. It was intended to use this device as a leak-detector, since, in its present form, it has a low dispersion. However, it now appears that this unit will be no simpler than the conventional magnetic mass spectrometer as modified for leak detection.

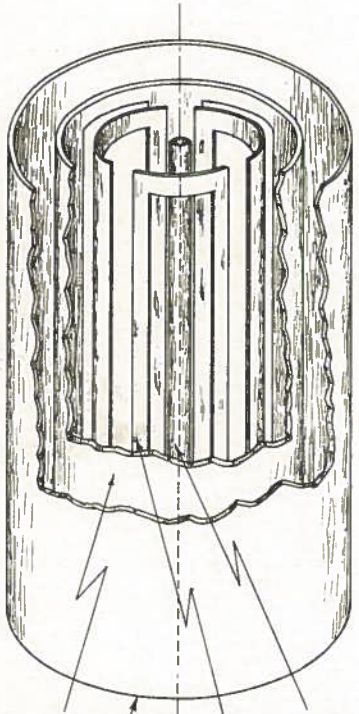
Electronic Attenuator

It is believed that a simple device for the low-level modulation of microwave energy would be useful for communication and for other purposes. To this end a coaxial diode has been constructed which couples three-centimeter power from one wave guide to another. The attenuation of the r-f energy through this coaxial device is controlled by the current through the diode, the filament acting as the centre conductor and the anode as the outer conductor of the coaxial line. The diode is filled with neon to a pressure of 3 mm. Attenuations of 10 db with a space current of 5 milliamperes have been observed.

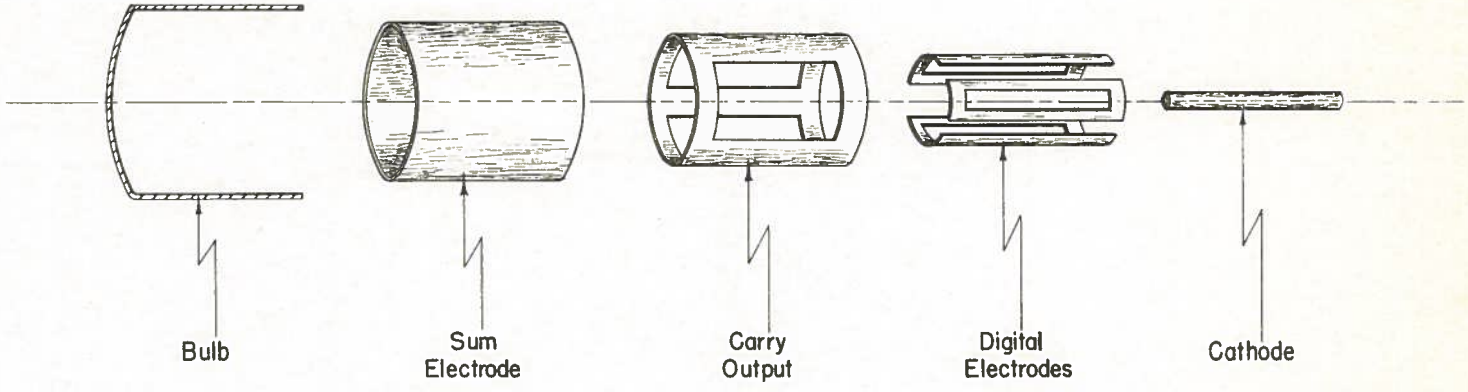
Binary Adding Tube

This tube was designed in collaboration with the Computation Center of the University of Toronto. A diagram showing the construction of the tube appears on the following page. Input pulses representing the addend, augend and carry-digit are applied to the three digital electrodes causing electrostatic focussing of

Cutaway view



Exploded view



BINARY ADDING TUBE

ERA 175

the radial electron beam onto the proper output electrodes in accordance with the function table for binary addition.

A contract for the production of these tubes has been placed.

SHOOTING-STAR RADAR

Summary

A program of observation of meteors is being carried on under the joint auspices of the Dominion Observatory and the National Research Council of Canada, with the objective of adding to the existing knowledge of meteors and of the upper atmosphere. The paths, positions and velocities of the meteors can be determined by triangulation from three radar stations. A continuous-wave system installed at Ottawa enables the Doppler whistles of the meteors to be photographically recorded.

Progress

Analysis of the Doppler-whistle films continues. Despite a new reducing and computing schedule which keeps the machines in full-time operation, the analysis has fallen several months behind the accumulation of new observational data. At the end of September, the total number of meteor velocities measured was about 9,000 --- and, still not one meteor with hyperbolic velocity had been found. A question arose in a discussion with Dr. Lovell of Manchester, concerning the possibility that very fast meteors, if they exist, may not be recorded. Our instrumental limit of resolution is quite high, at least twice the parabolic velocity limit, and we cannot visualize any anomaly in the physics of the ionization produced by meteors just over the parabolic limit that would prevent them being detected. Therefore, at the moment, we think that it is unlikely that we are simply failing to observe meteors with hyperbolic velocity that might actually exist. Our experience has been that the faster meteors in the elliptical velocity range (11-74 km/s) produce the better records, and we think that the statistics may even be unfairly weighted in the 60-74 km/s bracket because of this effect.

Monthly routine 48-hour runs with the Ottawa radar station and the South Gloucester Doppler station were made, sometimes with the assistance of visual observers. Several equipment changes have been made with a view to further improvement of the recording techniques.

During the Perseid run in August, a bright (-4) Perseid meteor occurred. The records of this meteor were the best ever made of any meteor, according to Dr. Millman of the Dominion Observatory. Three-station radar records were obtained which yielded the velocity and a rough radiant position. The meteor appeared on the Doppler film as well, though the velocity was not measurable, as the meteor did not reach the $\alpha = 90°$ point. Several trained observers, both at Ottawa and at Arnprior, plotted the path of the meteor. Rotating shutter direct cameras at Ottawa and Arnprior obtained excellent photographs which, when the computation is completed, should produce quite accurate figures on velocity and path position. Most important of all, a spectrum of the meteor was secured which, for the first time, shows spectral lines in the shutter breaks, that is, it furnishes a spectrum of the light coming from the meteor trail rather than from the head of the meteor.

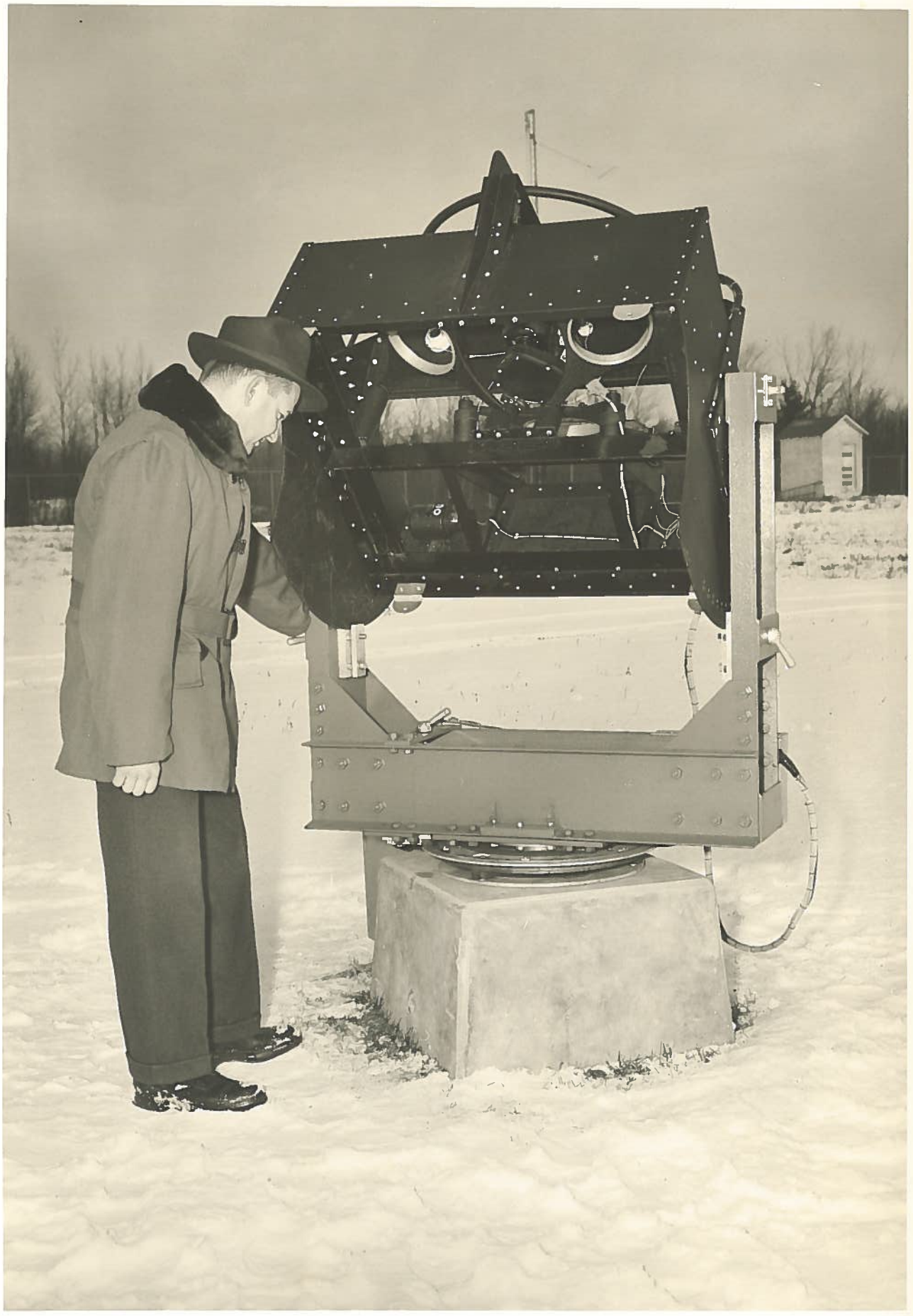
Equipment

During the summer the first of the two, triple, type-F24 camera mounts was temporarily set up at Arnprior for use during the Perseid shower. Later, it was mounted on a small trailer with folding jack arms, which served as a mobile tripod (see photo). This assembly, when completed and tested, was delivered to Arnprior for field use. A second camera mount was completed and installed on a permanent concrete base at the Metcalfe Road Field Station (see next photo) and buried cables were installed for remote control service. In the course of the above work, all of the type-F24 cameras had their cones shortened, their gear boxes checked and were given a new coat of paint.

The design of a 10-kw CW transmitter for Doppler meteor whistle work was carried on during the summer months by a university undergraduate. Although final construction has not yet commenced, a number of mock-up assemblies were made and all sketches and descriptive literature collected into an interim manual. Practically all the major components required for construction are now on hand and it is hoped to begin construction soon.

A Doppler receiver with a lower i-f frequency (430 kc instead of 10 mc) was tried. Although the narrower bandwidth improved the signal-to-noise ratio, difficulty was experienced with instability of the local oscillator, and poor image rejection. To overcome these difficulties a receiver was designed incorporating double conversion, with i-f frequencies of 10.7 mc and 430 kc, the high-frequency oscillator being crystal-controlled. This receiver has not yet been put into operation.

Mobile Tripod for Meteor Cameras



Stationary Mount for Meteor Cameras

A discriminator system was developed to determine whether the slow drift of the meteor cloud is towards or away from the observer. This system involves a low-power side-band transmitter, which is locked to a frequency 10 kc above the 30-mc unmodulated carrier of the main transmitter. At the receiving station, the video output of the receiver, after passing through a limiting and filter circuit, then contains a component, 10 kc $\pm \Delta f$, where Δf is the Doppler frequency shift due to the motion of the reflecting cloud. This output is then compared with the original 10-kc difference frequency (which is transmitted to the receiving station over a separate radio link) by methods involving both phase-discrimination and frequency-discrimination to show whether Δf is positive or negative. Some success was attained with the experimental gear but several minor difficulties remain to be cleared up.

SCR-270D Modifications

An SCR-270D early warning radar is being modified for auroral research. The set originally operated on 110 mc and was equipped with an antenna array, 8 dipoles wide and 4 dipoles high. The antenna tower was mounted on a turntable trailer, and could be continuously rotated to give a PPI display. The transmitter had a peak power of 100 kw, with 20-microsecond pulses. The proposed modifications involve reducing the frequency to about 50 mc, and the antenna system to an array 4 dipoles wide and 2 dipoles high, which will be fixed in elevation at 45° on the original turntable. The various trucks and trailers that constitute the equipment have been opened and examined and the corresponding instruction manuals studied in order to determine the exact modifications required.

Photoelectric Detection of Meteors

Preliminary tests using three photomultiplier tubes (type-931A) have shown that it is quite feasible to detect the light from a meteor of average visual magnitude. By this means it is hoped to time the visual light more accurately and relate it to the radar record. The sky will be covered by nineteen phototubes, each tube being allotted a portion of a cathode-ray sweep by means of a gate circuit. It is further hoped to obtain a rough plot of the meteor path across the sky with such a battery of cells. The radar and photoelectric records will be photographed simultaneously. The wiring of the instrument is nearing completion, although some difficulties due to noise and cold weather operation have yet to be overcome.

LARGE BARKHAUSEN DISCONTINUITIES

Fundamental research relating to large Barkenhausen discontinuities is being carried on. Particular attention has been given to influencing "germ" formation by exterior radiation such as neutron bombardment.

In the first experiments carried out here on the Berkhausen effect no mechanical stresses were applied to the magnetic materials. A coil six inches in length, with a core of the ferromagnetic material to be tested, was placed in the balance arm of a Wheatstone bridge. Using a motor-driven potentiometer, it was possible to vary the magnetic field in the coil almost linearly with time, between two field values, $-H_m$ and $+H_m$. A secondary winding of the coil was connected to an amplifier with a differentiating stage, and, via a full-wave rectifier, to a counting circuit. The field H_m was always chosen in such a way that the ferromagnetic sample was driven to saturation. Going from $-H_m$ to $+H_m$, the total number of pulses counted (N_{tot}) was equal to the number of pulses counted when going from $+H_m$ to $-H_m$. Now, the number of pulses (n) counted up to any point on the curve, when going from $-H_m$ to $+H_m$, was plotted against H, and going back, the number $N_{tot}-n$ was plotted against the field strength H. The "hysteresis loops" obtained in this way were quite reproducible.

Next, a neutron source (Ra - Bl) was placed near the coil. Then the hysteresis loops mentioned above were measured with, and without, neutron bombardment for slow and fast neutrons and for different core materials. Only in one case (bent nickel wire, non-annealed) was there any noticeable difference in the loops, and in this case, it was very probably due to errors in measurement.

During the course of these experiments a marked "after effect" was observed in the Barkhausen pulse count. When the magnetic field was brought to some particular value and held constant at that value, pulses continued to occur, the number dying away logarithmically with time. The initial number was largest on the steepest parts of the hysteresis loops.

In the next approach to the problem of detecting possible influences of external radiation on germ formation, use was made of this after effect, and decay curves were measured with, and without, neutron bombardment for different materials. Effects on the slope of the "decay curves" could not be detected with certainty.

In view of the fact that the most rapid pulse counts were observed on the steepest parts of the hysteresis loops, it was decided to continue the studies using materials with square loops next.

REFLECTION COEFFICIENTS OVER SNOW AT THREE CENTIMETERS

Summary

The absorption and reflection of radar signals caused by a covering of loose snow on radar targets is being studied. Two experimental setups are being used. The first is an outdoor range using natural snow surfaces between two towers. The second is an indoor setup using standard wave-guide techniques for attenuation and loss-function measurements in a cold chamber.

Progress

Work during the period under review was of necessity confined to the indoor setup because of the season; and the first steps towards the measurement of the dielectric constant and loss factor of snow using standard wave-guide techniques were taken.

In order to gain experience in the use of these techniques, it was decided to make measurements on dielectrics previously studied in other establishments, before going over to snow. Thus, measurements were made on dielectrics such as polystyrene, castor oil and paraffin wax, and techniques were improved until the values obtained checked closely with those of von Hippel and other workers.

The apparatus was next moved into the cold chamber where first attempts to work with snow were unsuccessful, largely because of difficulties experienced with the equipment at the low temperatures involved. Therefore, it was decided at this point to attempt to repeat Lamb's work on ice (Trans. Faraday Society, vol. 42, p. 241, 1946) while taking further steps toward the perfection of techniques.

By the end of September the equipment was functioning satisfactorily and Lamb's results on ice were duplicated by two different methods. The first method used a sample of ice in a wave guide between two identical standing wave probes. The second method used a sample of ice in a shorted wave-guide section, after the manner of von Hippel.

SOLAR NOISE OBSERVATIONS

The daily values of the sun's effective temperature as measured on a wavelength of 10.7 centimeters, and a list of the outstanding solar events of the past three months have been forwarded to the "Quarterly Bulletin of Solar Activity" and to other interested observers. The characteristics of each 10.7-centimeter noise burst are being entered on cards, to aid in statistical analysis as well as in compilation of the lists mentioned above. A sample record, showing a noise burst superimposed on a steady background, appears on the following page.

Consideration has been given to the design of a 10.7-centimeter radiometer of increased sensitivity - about seven times greater than that of the present equipment - which would be capable of distinguishing temperature differences of 1/5°C. An i-f amplifier with a bandwidth of 120 megacycles is being constructed (see "Distributed Amplification", Proc.IRE, vol.36, No.8, p.956, August, 1948). Each stage of this amplifier consists of seven tubes with the grids and plates connected to 400-ohm transmission lines.

The wiring of the r-f head assembly of the wide-band (7.5-30 cm) radiometer has been drawn up. The horn antenna for this radiometer has been matched to a ratio of 1.1 by means of a ridged waveguide section over the band 9-16 centimeters.

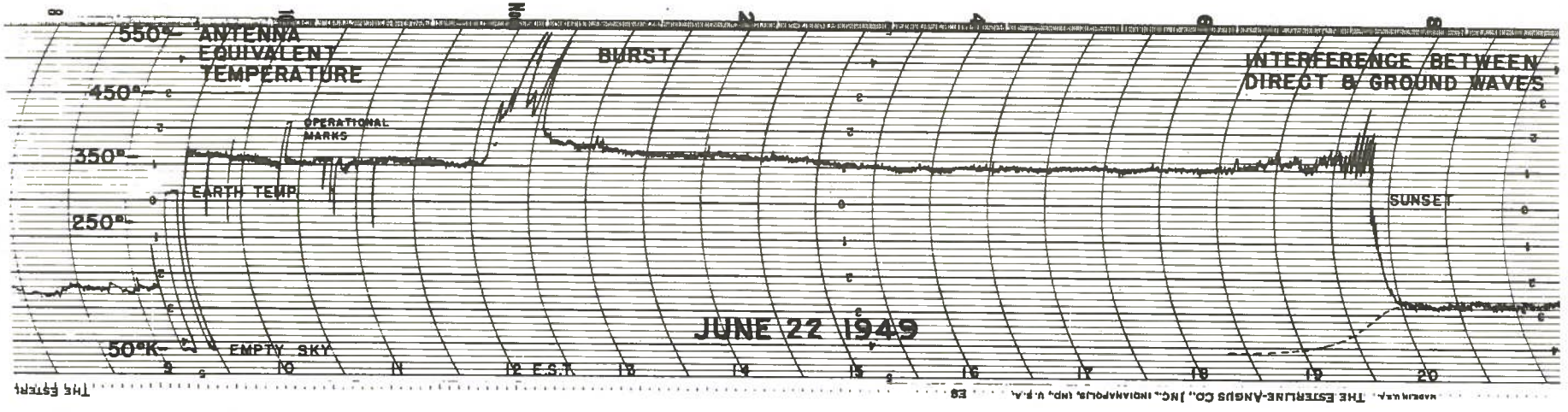
A conversion loss tester for ten centimeter crystals has been set up as part of the standard equipment to maintain the radiometers in operation.

An instrument has been designed and constructed for measuring the signal strength of pulses returned from the E region of the ionosphere. A continuous recording of the signal strength is made by the instrument for the purpose of observing sudden ionospheric disturbances and correlating the occurrences of these disturbances with solar noise bursts received by the radiometers on 10.7 centimeters and 1.5 meters.

The equipment employs vertical incidence, pulse-type transmission at about 500 watts. The transmitter can be operated on any frequency in the band 1-16 mc. 100-microsecond pulses are transmitted at a recurrence frequency of 30 cps. A delta-type flat-top antenna is used for transmitting.

The receiving system uses a modified doublet antenna. A modified commercial receiver is used in conjunction with a specially designed pulse detector, integrator and noise balancing circuit. The received information appears as a continuous paper recording.

A paper entitled "Simultaneous Observations of Solar Radio Noise on 1.5 Meters and 10.7 Centimeters" was published (see page 25).



Record of Solar Noise on 10.7 Centimeters
showing a noise burst superimposed on a steady background

ELECTRON ACCELERATOR

Summary

A new type of electron accelerator has been constructed and a detailed investigation of its performance is proceeding. This accelerator operates with a constant magnetic field, and an accelerating potential of at least 500 kilovolts developed across a resonant cavity. The accelerating power is derived from a ten-centimeter magnetron. Final energies of five million electron volts are obtained.

Progress

Preparations for the use of the higher-powered BM-735 magnetron, operating on 10.0 centimeters, have continued. Certain components of the new r-f system have been revised, and a water load suitable for operation in a vacuum has been built. Since the BM-735 magnetron is not tunable, the resonant cavity must be tuned. It has been found necessary to redesign the cavity tuner previously proposed.

The replacement of the present 10.7-cm system with the new 10.0-cm system still awaits delivery of a modulator suitable for driving the BM-735 magnetron.

A rearrangement of the operating controls now permits remote operation of the accelerator.

Further studies have been made of the intensity, hardness, and angular distribution of the X-ray output of the mcahine.

III

ELECTRICAL ENGINEERING

1200-KV SURGE GENERATOR

A new surge generator is being designed to replace the one now used in the Electrical Engineering Laboratory. The new generator will have a somewhat higher peak voltage and numerous mechanical refinements which will facilitate its operation.

The generator will be capable of producing peak voltages up to 1200 kilovolts, and the maximum available energy will be 15 kilowatt-seconds. The waveform will be controlled by the resistors in the discharge circuit and will be adjustable to any one of the standard waveforms called for in the various Standards set up for impulse tests.

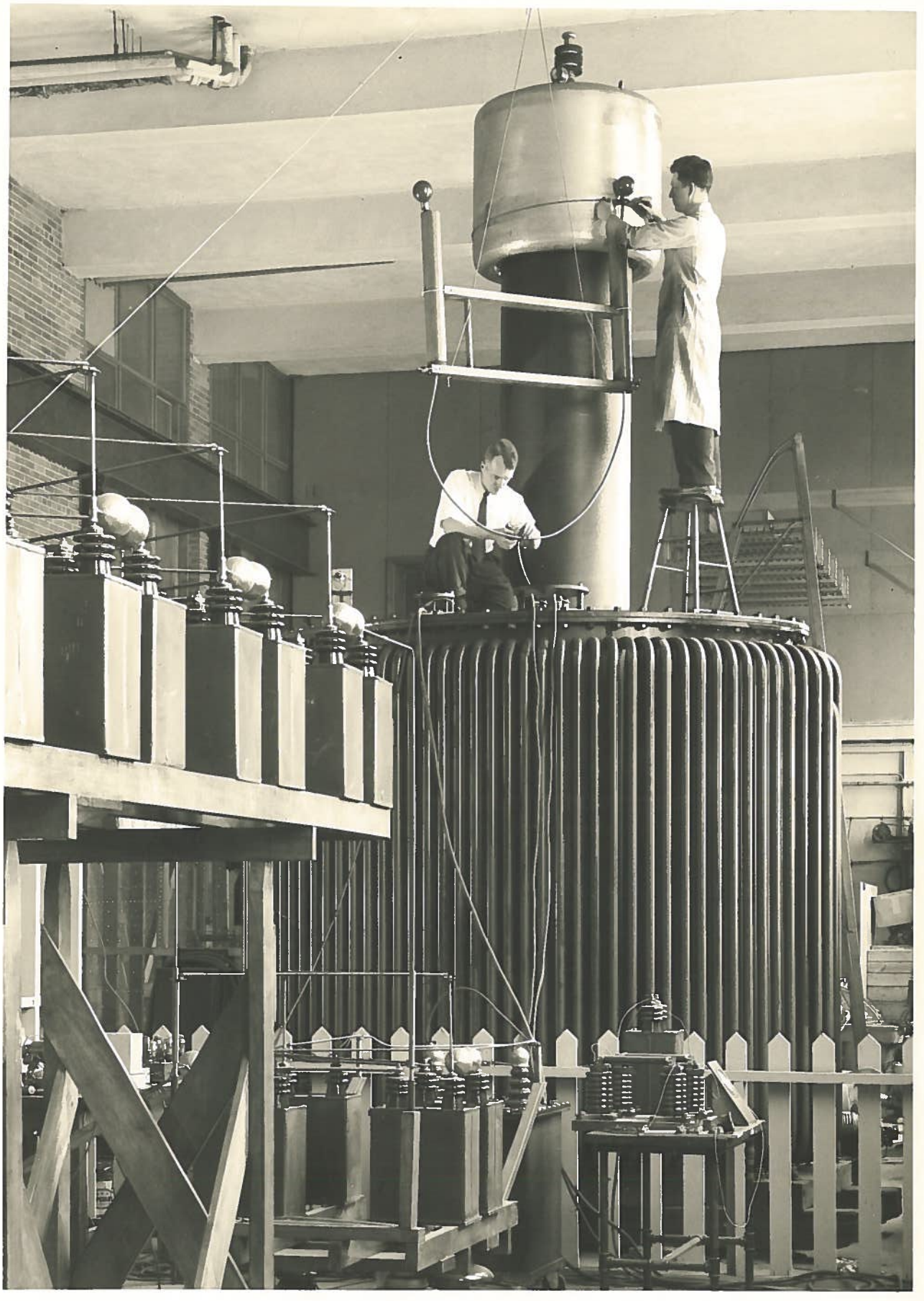
The capacitors and sphere gaps from the present surge generator will be used in the new one. All gaps will be mechanically coupled and motorized for remote control from a desk. Interlocks, Thyrite resistors and devices for short-circuiting the condensers, when necessary, will provide protection for personnel and the charging power supply. Most of the structural members will be high grade electrical Bakelite tubing. The control console will consist of two parts, a desk for the generator controls and a cabinet containing the oscillographs.

The general design of the generator has been agreed upon, the final design of a few components has been completed, and parts for the shorting devices and condenser mountings have been built.

A-C LINE VOLTAGE STABILIZER

The aim of this project is to develop an a-c line voltage stabilizer which will be free from the faults associated with line voltage stabilizers available at present. The main feature of the new design is the adaptation of the D'Arsonval-type of meter movement to a power drive for a Variac.

Tests were made to determine whether the most practical stabilizing circuit should consist solely of a lead network, or whether velocity feedback, with the additional components it involves, will be necessary. These tests were as follows:



High-Voltage Testing Equipment

A sample cable is being connected to the high-voltage transformer for a breakdown test.

(1) Long-term recordings of the output voltage were taken, using the a-c voltage-sensitive bridge described on page 20. A recording meter with a fast response and two chart speeds was used.

(2) The response to a step-function input was recorded photographically on a d-c oscillograph. The amplitude of the input was varied over a wide range.

(3) The sinusoidal frequency response was obtained at various input levels.

The results of these tests showed that velocity feedback was necessary for the correction of small line-voltage changes up to two volts. Since most of the line fluctuations are below this value, velocity feedback will be necessary.

In Test (2) above, with a step load of maximum regulator rating (29 amperes causing a 5-volt line drop), a settling time of 1/6 second was measured.

The transfer impedance of the regulator power circuit was measured and found to have a maximum value of 0.05 ohms.

The D'Arsonval-type driving motor for the Variac has been redesigned to improve some of the electrical and mechanical features: the armature coil assembly has been revised to permit the coil to be bobbin-wound and to enable coils to be changed more easily; the magnetic circuit has been concentrically designed to facilitate alignment and assembly and to ensure a uniform air gap; the positions of the components have been rearranged to decrease the over-all dimensions. Limit switches and a means of manual operation have been included in the design.

The chassis layout for the electronic circuit of the regulator and the design of the complete regulator assembly is in progress.

A-C VOLTAGE-SENSITIVE BRIDGE

In conjunction with the development of the a-c line voltage stabilizer (see above) it is necessary to have some means of detecting variations in line voltage down to 0.1%. In addition, a fast response to sudden fluctuations in line voltage is required.

The detector used in this instrument is an emission-limited diode that is sensitive to variations in filament voltage. This tube is used in a bridge circuit. The output of the bridge is amplified and fed to a panel meter. Terminals are available for a recording d-c microammeter.

The sensitivity ranges provided are ± ½%, ± 1% and ± 2% at full-scale deflection. Zero adjustment can be made for measured voltages of 95-130 volts.

Since the response time of the detector is 0.04 seconds, the response of the meter is the limiting factor.

A report is being prepared giving calibration and operating details.

500-KV ELECTROSTATIC GENERATOR

This machine is being designed and constructed for the Division of Chemistry and will be used for the study of reactions between ionized gas molecules.

During the period under review, efforts were directed towards securing improved performance of the generator under no-load conditions, i.e., with the accelerating tube removed. To obtain better observation through the windows in the tank, a temporary arrangement with half the usual number of equipotential plates was used. Charge was sprayed onto the visible upper run of the belt, with the pulleys running in the reverse of the normal direction of the belt. To simplify the investigation the glass guides for the belt were removed. This resulted in increased flapping of the belt, which, with the collecting comb in a certain position, caused excessive frictional charging. A change in comb position eliminated this trouble.

Continuous Textolite rod supports and Lucite spacer rings for the column were necessitated by the increased separation of the equipotential plates. The insulating strength of this arrangement appeared appreciably less than that of the molded Lucite units. Mock-up tests were conducted of the Textolite and Lucite combination to determine the best arrangement.

A new equipotential column design was prepared, of fabricated sheet metal construction, and with a continuous-rod supporting structure. This design is being held in abeyance pending further results from the temporary double-spaced equipotential plate setup.

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 60-cycle standard-frequency service. The regulator operates in the field of the d-c motor driving a 30-kva sine-wave alternator. Stability and adequate damping are achieved by using feedback proportional to rate of change of error and rate of change of field current. The maximum step-load variation which can be absorbed by the alternator without temporary loss of synchronism is about ten kilowatts. A load-compensating device is included in the control to permit steady-state load variations up to the full capacity of the machines.

During the period under review a study was made of the system in an attempt to correlate the theory with the experimentally derived data. Considerable difficulty was experienced in obtaining the frequency response of the various elements accurately at very low frequencies.

CSA-APPROVAL TESTING

During the period July to September, four oil burners were given initial examination, and ten revised samples of previously rejected burners and electric components for four companies were tested. Twenty-six interim reports were issued on the basis of the above examinations and tests.

Three final reports were partially or completely drafted and further work was done on three previously drafted final reports.

IV

ELECTRONICS

INFRA-RED DETECTOR

The infra-red detector was designed to facilitate the location of faulty joints in power transmission lines. Such faults are located by observing the difference in temperature between the joint and the conductor, this difference being detected by focusing the thermal radiation on a bolometer. Details of the circuitry have appeared in a previous Progress Report (ERA - 173).

During the summer months the equipment was in constant use on the lines of the Shawinigan Water and Power Company. Several joints were located during that period which were considered poor enough to require replacement. The operation of the instrument was considered satisfactory when conditions of low wind velocity and clear skies prevailed. The weight of the instrument was found, however, to be somewhat excessive for one-man operation. It is proposed to undertake the design of a much lighter model shortly.

ANTENNA APPROVAL TESTS FOR THE RCMP

A number of commercial police radio antennas of the "skin-back" and "ground-plane" type have been tested for the RCMP during the past few months. Some of these antennas were well engineered and came up to the manufacturers' claims. However, others which might have been accepted if not tested, fell far short of the claims.

MISCELLANEOUS ITEMS

Portable Radiotelephone Set

During the summer of 1948 a specification was prepared by the Radio and Electrical Engineering Division for a pack-type portable radio transmitter-receiver to be used by the Dominion Forest Service in fire prevention work. During the period under review further trials were conducted on prototype sets. A power output of 1.3 watts into a dummy load was obtained and in range trials over average wooded terrain a readable signal was received over a distance of ten miles with a whip antenna. This signal was improved and the range considerably extended by the use of a long wire antenna, as was expected.

These tests indicate that the sample examined fulfills the requirements of the specification.

Co-operation with the Banting Institute

The Division is co-operating with the Department of Surgery of the Banting Institute in an investigation of methods of rewarming subjects whose body temperatures have been lowered considerably. To date some success has been attained in the use of high-frequency diathermy as a method of rewarming. Indications are that this method will give more rapid warming with less likelihood of shock to the patient than the water-bath method. At the present time, work is going ahead on the design and construction of an experimental rewarming cabinet which will be provided with the necessary electrode systems, thermal insulation, and the like.

Dielectric Heating

A request was received from the British Columbia Research Council for assistance with a problem which had arisen during the development of a system for glueing plywood core stock. An experimental glueing operation was performed in the laboratory, and recommendations forwarded to the Council.

A preliminary investigation was carried out to determine the feasibility of using radio-frequency heating for pasteurizing honey. It was found quite practical to heat the samples of honey to the required temperatures in the laboratory. The system has certain advantages for a continuous process, but further investigation would be required to determine whether this method would have economic advantages over methods in use at the present time.

Differential Manometer

The electronic design of this instrument was revised at the request of the Division of Chemistry so as to provide greater stability. The four-megacycle oscillators, which measure minute changes of pressure by a change in frequency of their beat note, were redesigned to improve their stability, using a Clapp oscillator circuit. The oscillator outputs were fed through cathode followers rather than normal amplifiers to reduce the pulling effect of one oscillator on the other. The resulting over-all stability was more than nine times greater than that of the original circuit, remaining within 10 cycles during one day at constant (± 0.1°C) room temperature.

V

STANDARD FREQUENCY SERVICES

The transmissions of VE9FL on 2,000,000.0 cycles per second have been discontinued at the request of the Department of Transport, which reported that the station was interfering with communication on the Great Lakes on that frequency. Routine operation and maintenance of the remaining standard frequency services continued.

VI

PUBLICATIONS

"Simultaneous Observations of Solar Radio Noise on 1.5 Meters and 10.7 Centimeters", A.E. Covington and W.J. Medd, Journal of The Royal Astronomical Society of Canada, Vol.XLIII, No.3, May-June, 1949.

Simultaneous solar noise bursts on 1.52 meters and 10.7 centimeters have been recorded with a chart speed of one and one-half inches per minute. The longer wavelength noise bursts show many rapid fluctuations, as contrasted with a smooth rise and fall on the shorter wavelength.

* * * * *

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

"The Shooting-Star Radar System - Some Aspects of the Meteoric Reflection of Radio Waves" (ERB-224), E.L.R. Webb.

The reflected radio wave from the ionized meteor trail is examined in detail. Several methods of measuring velocity are explored. Notes and comments on various assumptions and approximations are included. A method of finding radial velocity of the meteor trail is also given.

"Radio-Frequency Heating" (ERB-229), J.A. Hopps.

> The basic fundamentals of radio-frequency heating are outlined, and the scope of its application is discussed briefly. Elementary equations for determination of operating parameters, typical oscillator circuits, and photographs of press and electrode systems are given.

"Phonograph Amplifier Tests for the Canadian National Institute for the Blind" (ERB-227, Restricted), J.A. Hopps.

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PHOTO INDEX

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