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NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

PROGRESS REPORT

FOR

APRIL - JUNE 1952

OTTAWA

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National Research Council of Canada

Radio and Electrical Engineering Division

PROGRESS REPORT

APRIL - JUNE, 1952

Comments or inquiries regarding subjects appearing in this report should be addressed to the Radio and Electrical Engineering Document Office, National Research Council, Ottawa, Canada

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PROGRESS REPORT

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I — SPECIAL ANTENNA PROBLEMS

THE USE OF RIDGE WAVEGUIDE FOR SCANNERS

The use of ridge waveguide for a variable-phase scanner has been proposed a number of times in the literature. A slotted-waveguide array is built with ridge guide in such a manner that the ridge can be moved in and out periodically. By moving the ridge, the wavelength in the guide, and hence the phase shift between radiators, and the direction of the main lobe in the radiation pattern, are changed.

Apart from the mechanical problem of reciprocating motion of the ridge, there are a number of electrical problems connected with such a scanner. The excitation of the slots must remain reasonably constant over the range of ridge penetrations required, so that the radiation pattern remains equally good for all scan positions. Leakage of power where the ridge enters the waveguide must be avoided. Since the characteristic impedance of the guide changes with ridge penetration, a suitable matching section must be inserted between the waveguide feed and the input to the slotted array.

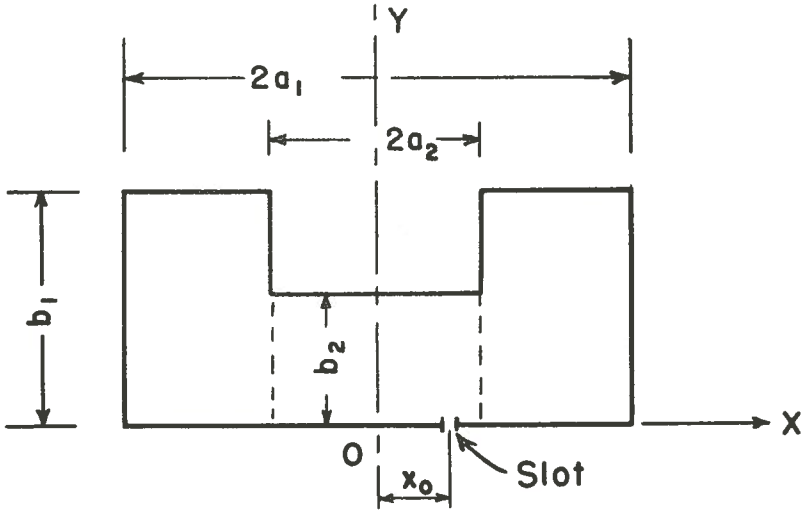
The above problems are similar to those encountered in the design of variable-width waveguide scanners (Eagle and GCA systems). The mechanical problem appears to be somewhat simpler with the ridge-guide scanner because of the smaller mass that has to be moved. Higher scanning rates should, therefore, be possible. Power leakage can be avoided by proper choke design, and a suitable input transformer can presumably be built, as in the case of the Eagle scanner. The problem of keeping the excitation of the individual radiators constant appears to be less straightforward. The Eagle and GCA systems use dipole radiators excited by short probes parallel to the electric field in the waveguide. Since the electric field is a slowly varying function of position near the center of the guide, the excitation of the dipoles does not change too much as one of the side walls of the guide is moved in and out. The effect of the change in the characteristic impedance of the guide on the dipole excitation can be compensated by properly locating the radiators with respect to the fixed side wall of the guide. With longitudinal shunt slots replacing the dipoles, this is no longer feasible. This type of slot is excited essentially by the transverse

current in the broad face of the guide. This current is proportional to the transverse derivative of the electric field, and, therefore, changes most rapidly near the center of the guide where slots must be located to obtain the low coupling required for long arrays.

It appears from the above that longitudinal shunt slots cannot be used with Eagle-type scanners. Other types of slots, such as inclined shunt slots in the fixed narrow face of the waveguide, may prove feasible, but they are difficult to handle theoretically because of the large slot-to-slot coupling. With the ridge waveguide system the use of longitudinal slots in a broad face of the guide might be quite feasible. The scan achievable with this system is, however, more restricted than in the Eagle scanner.

Cut-off ratios and impedances for ridge waveguide have been calculated approximately by S.B. Cohn (Proc. IRE, 1947). Cohn's impedance formula was modified by T.G. Mihran (Proc. IRE, 1949) by taking account of the discontinuity capacitance at the ridge in an approximate fashion. For the purpose of obtaining good values for the resonance conductance of shunt slots for an arbitrarily proportioned ridge-guide cross-section, more accurate formulas are required.

A rigorous expression for the field inside the ridge waveguide can be obtained, at least in principle, by Hahn's method. The cross-section is divided into sub-regions (see illustration below). Suitable series solutions are chosen for the sub-regions and matched along the common boundary. The coefficients in the series and the cut-off wavelength of the ridge guide can be computed from an infinite set of linear equations by a process of successive approximations. This was done for a large range of relative widths and penetrations of the ridge.



A knowledge of the fields permits the calculation of such parameters as the cut-off ratio (i.e., the ratio of the cut-off wavelength in ridge guide to that in the full rectangular guide), the guide impedance, and the normalized shunt conductance of a narrow longitudinal slot of resonant length (shown at $x = x_0$, $y = 0$ in the illustration above). There is good agreement between the above theoretical results and recent experimental results obtained at Stanford University by means of a Kron network board. There is also good agreement in most cases with Cohn's approximate theory as far as cut-off ratios are concerned,* but not as far as impedance is concerned.

Computations indicate that it is not possible to keep the normalized conductance of a shunt slot constant for different penetrations of the ridge. The criteria as to how much variation can be tolerated are the permissible deterioration of the radiation pattern and the permissible reduction in antenna efficiency. In the case of a non-resonant array designed with a cosine amplitude distribution and 5 per cent loss in the termination, it was found that a variation of ±30 per cent in the slot conductance is quite tolerable. The beam width is increased by a negligible amount; the nulls in the side-lobe structure are partially filled in, but the maximum side-lobe level is increased only from 5, to 6 or 7 per cent. The efficiency of the array is reduced by 7 per cent in the worst case.

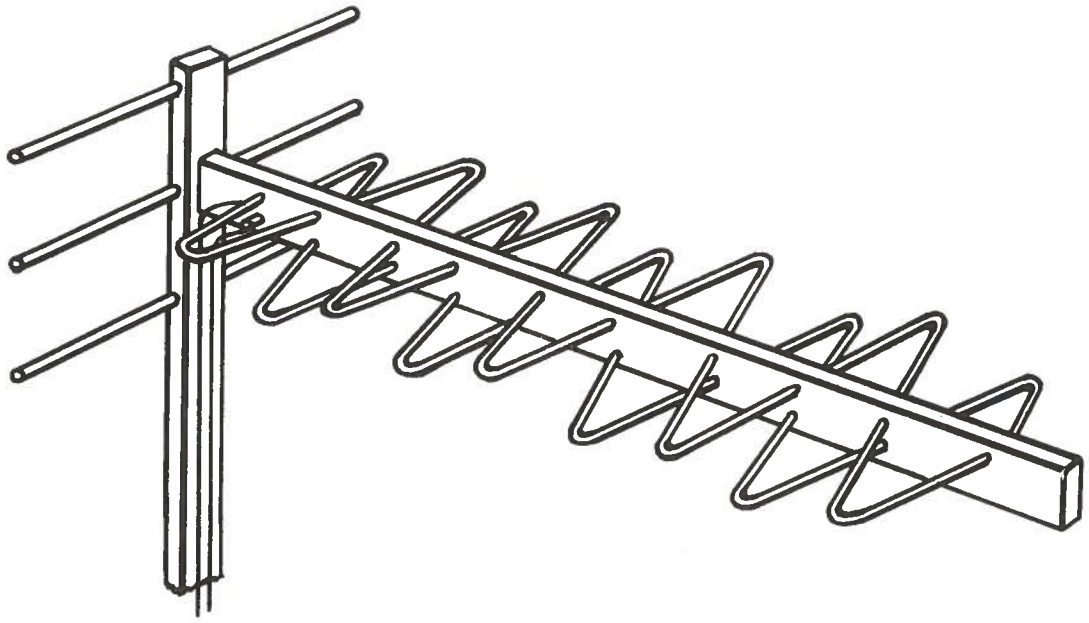
It appears from the theory outlined above that a ridge-guide scanner with a 10-degree scan might be quite feasible.

SERIES-RHOMBIC ANTENNA FOR VHF

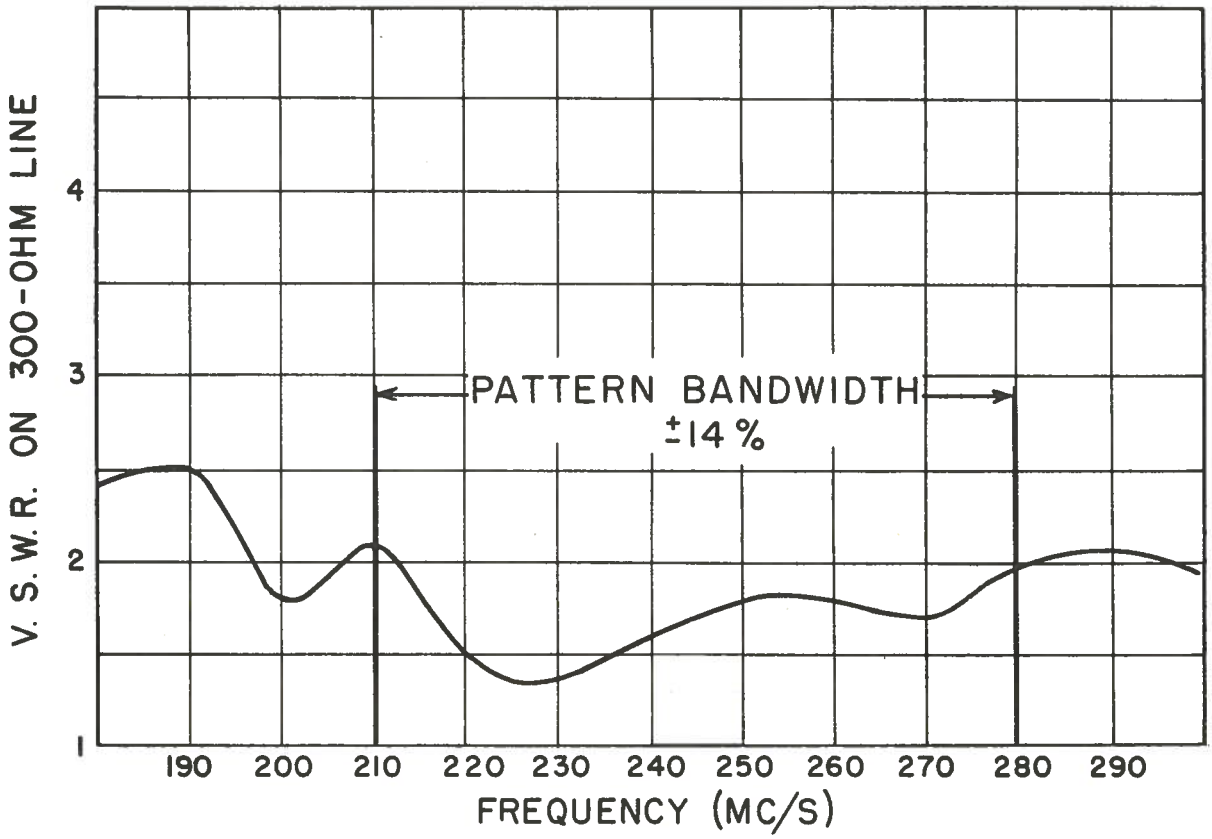
At present the Yagi antenna is extensively used where a directional antenna of small physical size is required for VHF applications. However, the use of an antenna of this type is restricted to a relatively small bandwidth, from five to ten per cent, since its impedance and pattern characteristics change rapidly with frequency. An attempt, therefore, has been made to design an antenna of much the same size as the Yagi, having equivalent gain, but greater bandwidth.

Essentially, the antenna consists of a number of rhombic antennas connected in series and fed with a balanced transmission line. The proportions of this antenna are considerably different from those of the conventional rhombic antenna which is several wavelengths long. By making the angle of the rhombic sections of the order of ten degrees only, the half-width of each rhombic section is approximately 0.55 wavelength, while the length is approximately 0.18 wavelength.

*It should be noted that the agreement extends only to Cohn's approximate formula, not to his curves which contain some numerical errors presumably due to the use of inaccurate values for the discontinuity capacity.



EXPERIMENTAL SERIES – RHOMBIC ANTENNA



V. S. W. R. vs. FREQUENCY
(OPEN-CIRCUIT TERMINATION)

Thus, five such sections in series give an antenna 0.9 wavelength long. A considerable reduction in the width of the antenna can be achieved by placing the two halves of the antenna one above the other instead of side by side, as shown in the accompanying figure. A separation of 0.08 wavelength between the halves appeared to give the best impedance characteristics. The voltage standing-wave ratio produced by the antenna on a 300-ohm line was found to depend only slightly on the termination. An impedance bandwidth of 3:1 was obtained with an open circuit termination, based on a voltage standing-wave ratio of 3:1 on a 300-ohm line. A portion of this curve is shown in the figure.

A study of the antenna radiation patterns indicated best performance with an open-circuit termination. As shown in the sketch of the antenna, a small ground screen, consisting of three rods 0.6 wavelength long, was used to improve the radiation patterns at the ends of the bands. Under these conditions a pattern bandwidth of ± 14 per cent was obtained. In the frequency range shown, the antenna gain, as computed from the radiation patterns, varied from 6 db to 8 db compared with that of a dipole, while the side lobe level did not exceed -10 db.

It is seen then that while the antenna is lightly longer than a four element Yagi, it has equal or superior gain and approximately three times the useful bandwidth.

RHOMBIC ANTENNA FOR UHF TELEVISION

A description of this antenna appeared in the previous issue of this report.

The power gain of the antenna has been measured by direct comparison with a half-wave dipole. It was found to be from 4 db to 10 db in the frequency range 380-980 megacycles. Since a direct comparison was made, these figures take into consideration the power loss in the terminating resistance.

II — AIDS TO NAVIGATION

REMOTE FOG-ALARM CONTROL

A microwave (3.2-cm wavelength) radio link to provide remote control of automatic fog-alarm stations has been designed and an experimental equipment constructed. The requirements for such a system and the major features of design were outlined in earlier issues of this report.

The complete receiving equipment was installed in a lorry in order to conduct a long-range test. To obtain line-of-sight transmission over a reasonably long path the transmitter and control unit were installed in a hut about half way up a 200-foot tower. The received signal was found to be quite adequate to ensure positive operation of the receiving equipment at 10 1/4 miles. Although this range was about the limit, as predicted from shorter range tests, the difficulty of finding an accessible test site at a range greater than 10 1/4 miles discouraged a desire to investigate the maximum range capabilities of the equipment directly. Also, since it is unlikely the equipment will be required to operate over a range exceeding 5 miles the preceding tests demonstrated that the signal would always be adequate for positive operation.

The equipment was shipped to Prince Rupert, B.C., where an installation was made between Barrett Rock and Holland Rock at the approaches to the harbour. The installation was completed and tested in three weeks.

Owing to the occurrence at Prince Rupert of tides as high as 23 feet, two transmitting antennas were installed at the Barrett Rock control point. One antenna was 11 feet higher than the other, and a waveguide switch allowed either antenna to be selected. Because of the presence of the water surface, nulls in the order of 20 db were observed at the receiving antenna on Holland Rock. Since the height of the null varied with the tide, the signal level could be restored by switching transmitting antennas. However, over the 4 1/2 miles separating Barrett Rock and Holland Rock there was about 25 db excess signal at the receiver, so that operation was quite satisfactory even when the receiving antenna was in a null.

By the end of June the equipment had been in operation approximately two weeks with no difficulties being reported.

MERCHANT MARINE RADAR

Navigation and Docking Radar

This radar equipment was designed to meet the requirements for radar navigation in very narrow or restricted waters such as river channels and harbours. The experimental and console sets have been described in earlier issues of this report.

The major effort in the design was concentrated on obtaining a high-definition display with exceptionally good minimum detection range. During recent trials aboard the M.V. "Radel II" the performance was satisfactory on short-range targets, but the sacrifice in long-range

detectability was undesirable. These tests have demonstrated that it is not practical to obtain a compromise in long and short range performance using a wide bandwidth intermediate-frequency amplifier, even though the pulse length is switchable.

In order to avoid this compromise the problem becomes one of providing a receiver that is of optimum design for both long and short transmitter pulses. In short, either an intermediate-frequency amplifier having a switchable bandwidth or two interchangeable amplifiers are required.

Considerable thought has been given to the design of a switchable-bandwidth receiver. An experimental amplifier has been built in which the bandwidth can be switched from 15 megacycles for a transmitter pulse of 0.1 microsecond to 4 megacycles for a pulse duration of 0.8 microsecond. The amplifier consists of a conventional cascade of staggered triples for wide bandwidth operation. For narrow bandwidth operation the amplifier will consist of the cascaded center frequency stages only, with the interstage damping resistors increased proportionally. This amplifier is ready for testing and although it represents one method of obtaining dual bandwidth operation, there are electrical and mechanical difficulties involved in the design which may render it impractical.

A considerable amount of time has been spent in designing and testing wide-band high-gain 60-megacycle intermediate-frequency amplifiers. One of the major difficulties in such work is the lack of a sweep signal generator with adequate sweep width and constant high level output. A signal generator employing a phase-shift ring-oscillator circuit which will meet these requirements is under construction.

Antennas

(a) Vertically Polarized Slot-in-Line Antenna

Operational tests showed that the vertically polarized slot-in-line antenna used with the NAD Radar had a very poor vertical radiation pattern. On checking, the pattern was found to be broken up into a series of three beams, the outer pair being of the same amplitude as the central beam. Owing to the thickness of the walls necessary to provide excitation for the slots, slot-in line waveguide array is wider than standard three-centimeter guide. This allowed a second-order mode to propagate in the horn which had a throat dimension the same as that of the non-standard guide. By narrowing the throat of the horn to one inch, symmetrically with respect to the slots, and soldering it to the face of the slot-in-line antenna, the outer pair of beams disappeared, leaving only a wide vertical beam

normal to the face of the horn. The beam width was reduced to twenty degrees at half-power by making the horn a more nearly optimum design.

To avoid frequent replacement of the tape covering the slots, it was removed entirely, and a window of rigid Vinylite sheeting, thirty thousandths of an inch thick, was placed across the aperture of the horn.

(b) Horizontally Polarized Antenna

A horizontally polarized slotted-waveguide antenna has been designed which is mechanically interchangeable with the vertically polarized antenna now in use. It is composed of two, separate, identical antennas, one for receiving and one for transmitting.

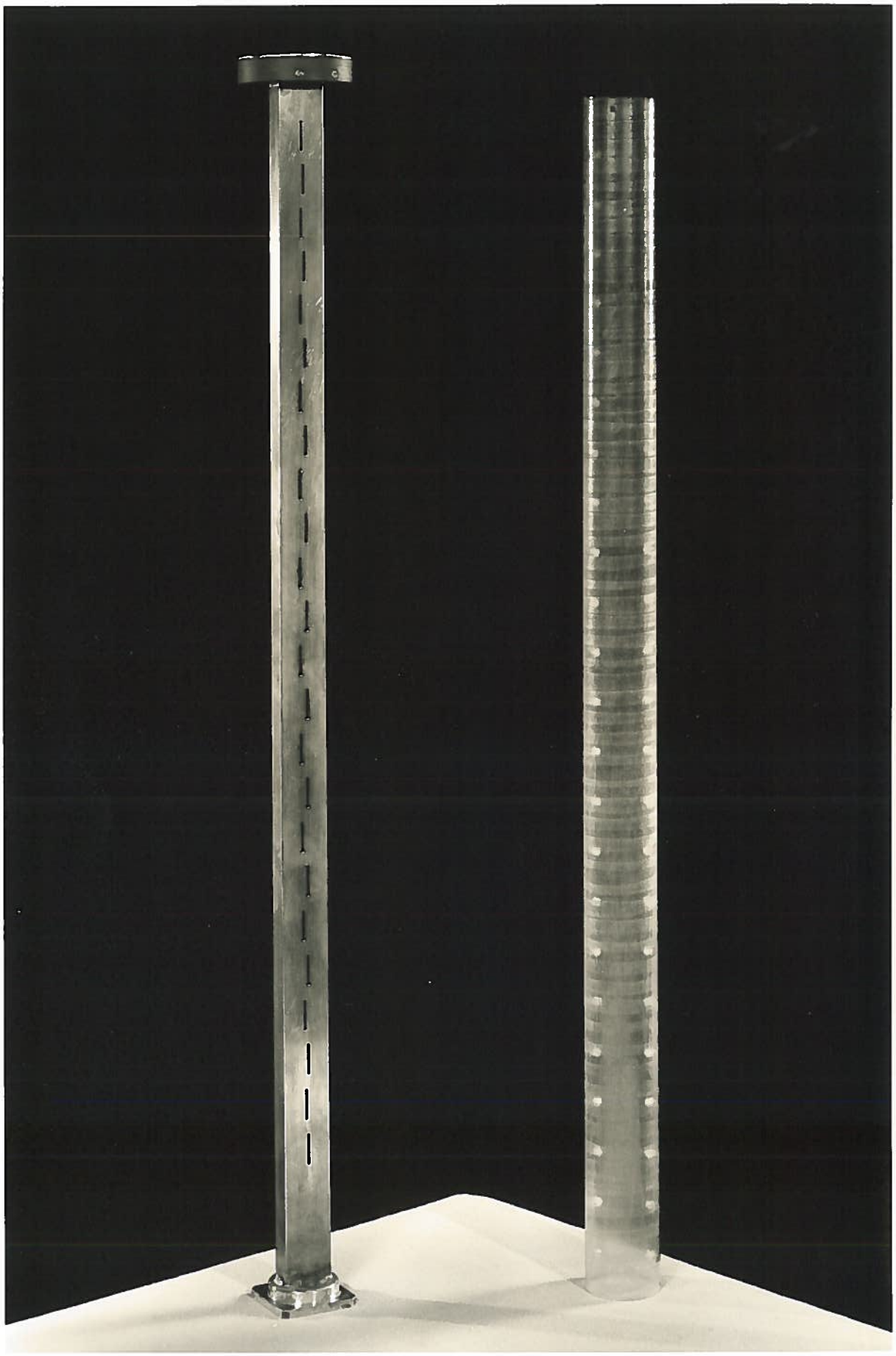
The slots are cut in the narrow face of the waveguide. The conductances were chosen so that the near field across the aperture is approximately cosine-squared. The far field pattern from this distribution has a first side lobe maximum of 3 per cent, and the second less than one per cent.

The beam is narrowed in the vertical plane by means of a horn with a five-inch aperture. Since slots in the narrow face of waveguide must be tilted with respect to the vertical in order to couple to the energy in the guide, there is a small amount of unwanted vertical polarization. This vertical component gives rise to vertically polarized lobes which appear in the horizontal plane at about ± 40 degrees to the main beam, with an amplitude of about 15 per cent of the horizontally polarized beam. To suppress these lobes, a grating of thin vertical strips, with a separation of one-half inch, was placed across the narrow dimension of the mouth of the horn. With the grating in place, the vertically polarized lobes are reduced to less than one per cent of the horizontally polarized main beam.

The front of the antenna is covered by a 0.030-inch Vinylite sheeting for weatherproofing.

Pattern measurements made on an experimental model show that the beam width at half-power in the horizontal plane is 1.7 degrees and in the vertical plane 17 degrees. The maximum side-lobe level in the horizontal plane is about 2 per cent, and in the vertical plane there are no appreciable side lobes.

The prototype of the antenna is in the process of construction.



RESONANT SLOTTED ARRAY WITH PLASTIC COVER
FOR USE AS A BEACON ANTENNA

MICROWAVE BEACONS

General

During the month of June the M.V. "Radel II" was used to demonstrate the "Microwave Lighthouse" equipment in Nova Scotia at Shelburne, Lockeport, Liverpool, Lunenburg, Ketch Harbour, Halifax, Isaacs Harbour, and Canso.

Port Dover Beacon Installation

The chief aspects of this installation were outlined in the previous issue of this report.

The antenna requirements were for horizontal polarization with 130-degree beam width at half-voltage in the horizontal plane, and a five-degree beam width at half-voltage in the vertical plane. Longitudinal slots cut in the broad face of rectangular wave guide have an E-plane pattern suitable for the broad beam. An array of these slots was cut at resonant spacing in standard X-band waveguide which was long enough to give the required vertical beam width (see photograph). To keep the side-lobe level low, the slot offsets were calculated to give a cosine field distribution along the array. There were 24 slots in the completed array. The measured beam width at half-voltage was 5.2 degrees in the vertical plane and 126 degrees in the horizontal plane. The voltage standing-wave ratio at the input to the array was 1.05 at the design frequency.

In order to weatherproof the array, a cylindrical cover was moulded from clear, rigid, Vinylite plastic 0.030-inch sheeting. The joint was made by allowing an overlap and then riveting with plastic rivets. The cover was mounted so that this thicker portion was on the side of the antenna away from the slots. Two small holes were placed near the lower end of the antenna for ventilation. The top was made from Bakelite. No cement was needed for weatherproofing the antenna.

UNDERWATER TELEVISION

Improvements have been made to the underwater television equipment in preparation for participation in research studies of the spawning habits of lake trout. The program will be carried out jointly by the Canadian Wildlife Service of the National Parks Branch and the National Research Council. Production of a sixteen-millimeter film on the above subject will be attempted.

The improvements carried out include incorporation of five hundred feet of cable of zero buoyancy to connect the submersible

television camera to the surface equipment. The cable will be reeled on and off a cable spool. Parts to complete the cable spool were nearly finished, but the delivery date of some of the underwater cable is doubtful. The sixteen-millimeter motion picture camera was modified to remove an objectionable shutter line that appeared on the film. In order to obtain a positive film record for projection purposes while avoiding a film reversal process in development, the camera monitor unit was modified to provide a negative rather than a positive display. The power of the forward-reverse screw was increased to one-quarter horsepower. Flues were added to this screw to permit raising the camera from the bottom. A motor and movable ballast were added to the submersible equipment to allow adjustment of the inclination of the camera by remote control. The television chain was operated with fair success with a one-cylinder gasoline engine driving an eighteen-hundred-rpm two and one-half kilowatt sixty-cycle power source.

ANOMALOUS PROPAGATION OVER WATER

The method employed in detecting and determining the height of low level ducts (inversions at 0 to 50 feet) over Lake Ontario has been described in earlier issues of this report.

During the period under review the equipment has been in continuous operation recording data which are analysed and tabulated. A number of trends have appeared during the past few months. It was observed that, in general, the degree of trapping or ducting varied with the absolute value of "M". This was not so on a day-to-day basis but only over the three month period. Barometric pressure alone did not seem to have any direct correlation with the observed conditions. It was also noted that, as the relative humidity rose above approximately 90 per cent, the degree of trapping decreased appreciably, indicating the breaking up of the ducts.

Final conclusions cannot be formed until a complete analysis of the accumulated data has been made, but at the present time it would appear, for example, that it is not possible to forecast from aboard a ship the onset or termination of trapping by simply recording relative humidity, temperature, and pressure.

SHORAN AIDS TO AERIAL SURVEY

Tests made to investigate the overall drifts in the AGC chassis already constructed were carried out over a period approximately equivalent to that of the survey operations of a normal summer. Initially, appreciable drifts and fluctuations seemed to be present, but it was found that many of these were due to variations in supply voltage, etc.

Although the high value of gain caused rather large variations of the regulating potential when the input level of approximately 3 volts was held constant, these variations were equivalent to input signal level variations of very small magnitude. The overall equivalent signal strength variations, both for short and long periods, were so small that their effect on the overall delay stability of an AGC-controlled Shoran ground station would be negligible.

A set of power attenuators for use in further tests on AGC systems has been constructed. The intention is to use these units in a test system over a one-mile path, to reduce the range of signal strengths to that received at a ground station during field operations. Distance measurements made under these conditions will reveal the actual change in delay in the ground station encountered during operations, and will be carried out for various systems such as the AGC system, gain-riding, and maximum gain-setting techniques.

III — ELECTRON-TUBE RESEARCH

INTRODUCTION

The annual IRE Conference on Electron-tube Research was held in Ottawa this year. This was the first time that it had been held outside the United States. The conference was attended by 186 delegates and was quite successful.

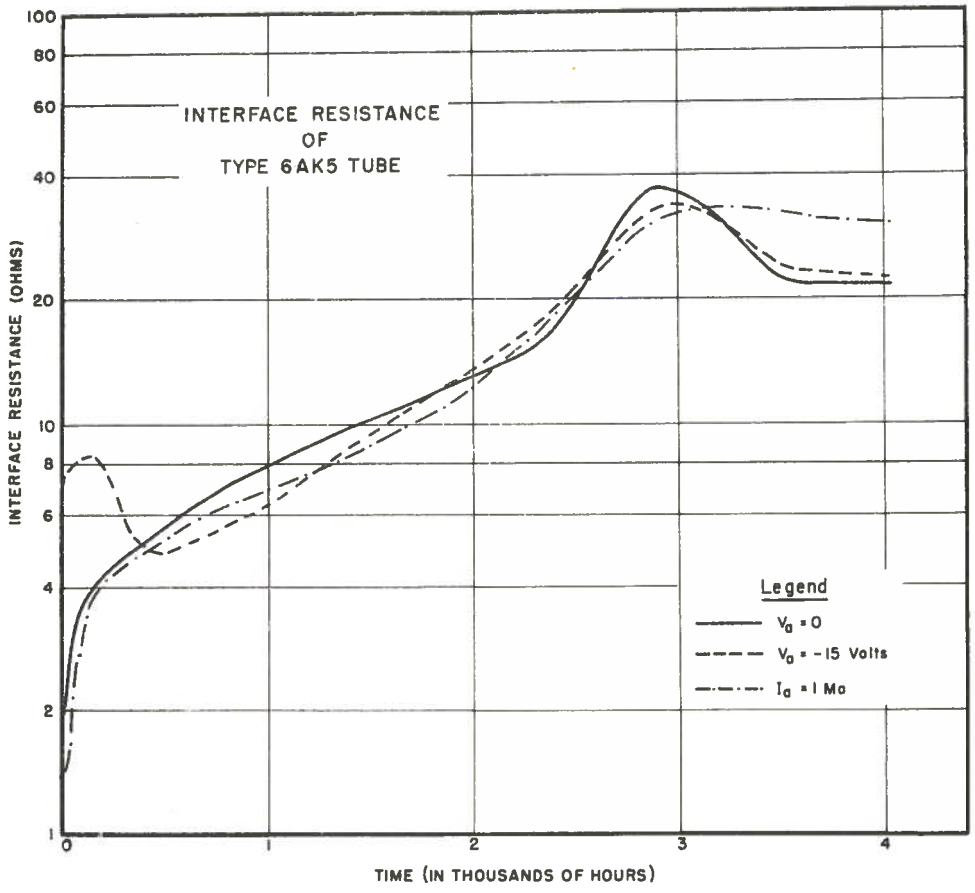
Some modifications in the design of the X-band travelling-wave-tube detector have been made and another tube has been completed.

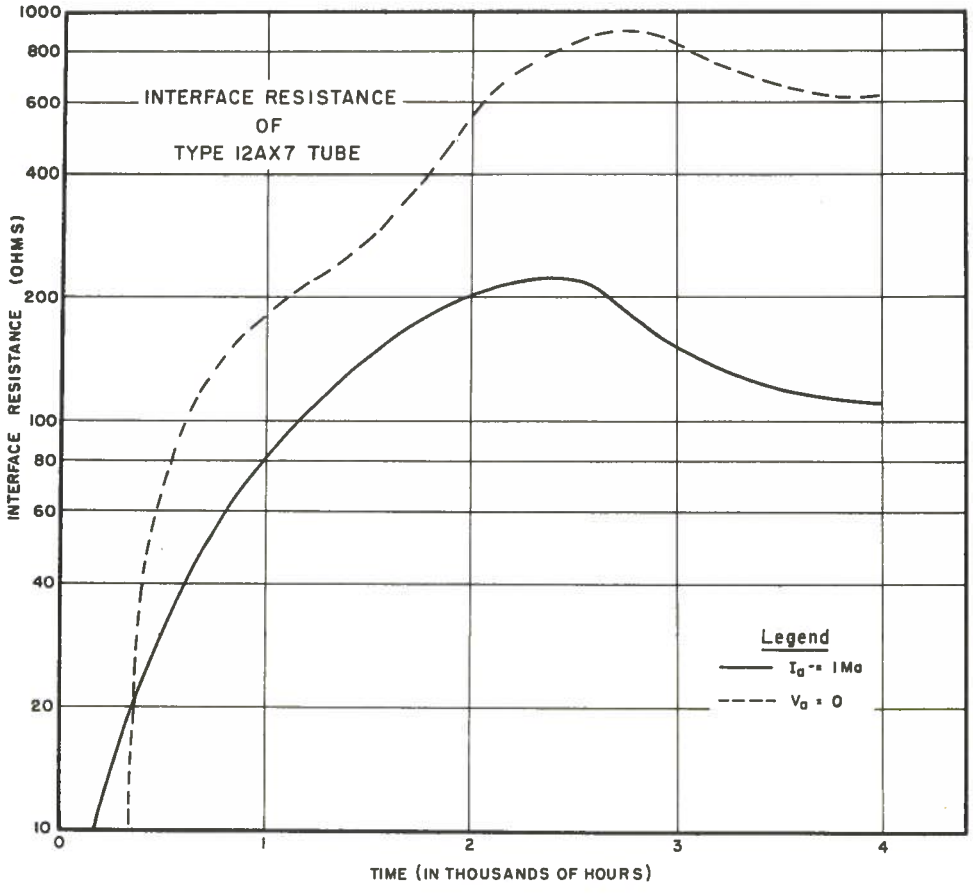
The detection of microwave energy at a potential minimum in a thermionic diode has had further theoretical and experimental investigation. A simplified theory, used only as a gross approximation, has been derived, and was described in a paper read at the IRE Conference on Electron-tube Research. Experimental results indicate that the general shape of the predicted sensitivity-versus-current curve is correct.

Interface life tests on commercial-type receiving tubes are continuing. A report describing the interface impedance bridge designed for these measurements has been issued (see Page 18). A report reviewing the causes of emission failure in receiving tubes has been prepared and will be issued as ERA-229.

A circuit for accurate measurement of gas current in receiving tubes, and also the "gas integral", is under development. An attempt will be made to correlate the gas integral with the life of the tubes.

An instrument for the measurement of equivalent noise resistance, based on the design of Van der Zeil (Electronics, April, 1952), has been constructed.


INTERFACE RESISTANCE
OF
TYPE 6AK5 TUBE
INTERFACE RESISTANCE (OHMS)
100
80
60
40
20
10
8
6
4
2
1
0
1
2
3
4
TIME (IN THOUSANDS OF HOURS)
Legend
V_a = 0
V_a = -15 Volts
I_a = 1 Ma


INTERFACE RESISTANCE
OF
TYPE 12AX7 TUBE
INTERFACE RESISTANCE (OHMS)
1000
800
600
400
200
100
80
60
40
20
10
0
1
2
3
4
TIME (IN THOUSANDS OF HOURS)
Legend
I_a = 1 Ma
V_a = 0

The operation of the linear radio-frequency mass spectrometer has been more accurately assessed, and the energy relationships evaluated in a closed form. Previously, these relationships had been evaluated graphically. Improved circuits for operating the tube are being constructed.

TRAVELLING-WAVE-TUBE DETECTOR

Modifications in the collector assembly to provide better mechanical alignment have been made. The one completed tube failed because of a heater breakage on the pumps.

MICROWAVE DETECTION AT A POTENTIAL MINIMUM

This detection effect, first mentioned by Döhler (Hochfreq. und Electroak., 54, 7, (1939)) has been examined to determine whether useful detection sensitivities can be obtained. Experimental measurements have shown sensitivities 15 db worse than a good crystal when used as a video detector.

The problem of analyzing the detection mechanism at low signal levels is complex. A simple analysis, assuming the potential minimum to be fixed in position and magnitude, was used to compute the energy gained by the electron travelling from cathode to potential minimum. This analysis results in a curve of sensitivity versus current whose general shape is in fair agreement with measurements.

Measurements have been made on co-axial diodes at a wavelength of 10 centimeters. Planar diodes have been constructed for measurements at 3-centimeter wavelengths.

OXIDE-CATHODE INTERFACE TESTS

Interface measurements of commercial tubes have been continued. The accompanying figure shows the interface resistance as a function of time for Types 6AK5 and 12AX7 tubes. The decrease in interface resistance after 2500 hours is unexpected, and may be due to instrumental errors. The reduction in the rate of growth of interface resistance when anode current is drawn may be clearly seen in the curves for the Type 12AX7 tube. Spectrographic analysis of the nickel cathode sleeve of the Type 12AX7 tube shows the following impurity content:-

	Si	Mn	Mg	Fe	Al	Cu	Ti	W
Per cent	0.085	0.17	0.05	0.05	0.18	0.02	0.023	0.8

RADIO-FREQUENCY MASS SPECTROMETER

An analysis of the operation of this tube leads to the following expression for the energy gained by an ion traversing the accelerating gaps

$$\Delta W = \frac{2\epsilon V}{\alpha} \cos\left(\frac{N\alpha}{2} + \theta\right) \tan\frac{\alpha}{2} \sin\frac{N\alpha}{2},$$

where α is the unmodulated transit angle of an ion crossing the gap, θ is the entrance phase angle, N the number of stages, and ϵV the d-c energy of the ions on entering the accelerating system.

The resolution and current efficiency of the tube may be found from the above expression.

The circuits to operate this tube have been improved and a new unit is under construction.

IV — DIELECTRIC RESEARCH

DIELECTRIC STRENGTH OF PURE LIQUIDS

No work was done on this project during the period under review. A letter summarizing recent results was published in the April, 1952, issue of the Journal of Chemical Physics.

DIELECTRIC STRENGTH OF TRANSFORMER OIL

Modifications of the test cup, so that a high power microscope could be used to observe the position of the arc in the horizontal plane, were completed at the beginning of the period. An arrangement for viewing particles and bubbles in the oil and on the electrodes by reflected light, using the above-mentioned microscope and the main gap-measuring microscope (which views the gap in a vertical plane), was constructed. This made possible the detection of particles well under a micron in diameter. Removal of particles in the oil was accomplished by applying a d-c potential of about 6 kv to a small wire situated in the plane of the gap and about 1/4 inch from each sphere. Removal of bubbles and particles from the surfaces of the electrodes themselves was much more difficult, but rubbing the spheres on nylon wipers situated in the oil was at least partially successful. Tests taken, using these precautions, led to higher values of dielectric strength than any mentioned in the literature. The maximum value obtained for the breakdown strength of transformer oil, using stainless

steel spheres, was 2.1×10^6 volts/cm. The discharge in this case took place through the shortest part of the gap, thus indicating that the apparent breakdown strength has probably not been lowered by the presence of particles in the oil or on the spheres.

REVERSE CHARACTERISTICS OF CRYSTAL RECTIFIERS

The reverse characteristics of a number of good, commercial, point-contact rectifiers have been determined under pulse conditions. Some of these exhibit strong field emission (Schottky effect), while others, apparently made of very pure germanium, conform to the characteristic predicted on the assumption that tunnel effect is the important mechanism. The agreement between experimental and theoretical data is quite remarkable. A paper describing these results has been submitted for publication.

Preliminary measurements on multicrystalline germanium supplied by the NRC Division of Applied Chemistry have indicated that the material is suitable for use as a low-voltage rectifier. The samples are rather small for dependable conductivity and Hall effect measurements.

A furnace for growing single crystals of germanium has been designed and partly constructed. Completion awaits arrival of the Vycor (quartz substitute) body.

V — ELECTRICAL ENGINEERING

ELECTRONIC DETECTION OF FLAWS IN PAPER

The sensitivity of the flaw detector has been less than is desired owing to noise in the first stages of amplification. Considerable work has been done on measurements of the noise, and on methods of reducing it as much as possible. A circuit to discriminate against the signals due to the noise has been designed and built, and shows considerable improvement over the previous system. A sheet of paper on which a short piece of #40 wire has been placed as a standard defect can be detected and rejected reliably. The wire is considerably smaller than most of the spots on the samples originally obtained from a manufacturer. However, the sensitivity is not yet great enough for reliable detection of some of the other defects which are objectionable, and which should be rejected by a completely satisfactory flaw detector.

1200-KV IMPULSE GENERATOR

A period during which the impulse generator was not required for routine testing was devoted to attempts at improving the shape of

the output-voltage wave form. It had been noted that, when the generator was set up for testing transformers, the front of the wave contained numerous irregularities, some of which were quite large.

Tests showed that smooth waves could be obtained by operating at greatly reduced voltage and substituting small low-voltage capacitors and resistors in place of the conventional wave-shaping components. The performance of the conventional components was improved slightly by placing them at a distance from the generator, but it seems probable that a large improvement could be obtained only by extensive shielding.

It has been found that during the summer the generator may discharge unexpectedly while being charged. Tests show that this occurs most frequently on warm days when the relative humidity is above 70 per cent and very rarely on days when the relative humidity is 50 per cent, or lower.

A-C LINE VOLTAGE STABILIZER

The stabilizer was demonstrated at the Canadian International Trade Fair. Considerable interest was shown in the exhibit.

VI — ELECTROMEDICAL RESEARCH

DEFIBRILLATION AND STIMULATION

During the period under review emphasis was placed on the investigation of methods of cardiac defibrillation. Two new methods were tried. In the first, intra-cardiac application of the voltage was employed. A catheter carrying two or more ring electrodes at the tip was inserted through a vein to the right atrium and the voltage was applied between the electrodes. This method was successful in two cases out of seven. In the remaining five tests it failed to quell fibrillation in the more remote region around the apex of the heart. Further, the high current required for defibrillation by this method (3.0 amperes) was sufficient to burn the tissue surrounding the electrode.

In the second method the catheter electrodes were connected in parallel to form a single electrode, and an additional dispersive electrode was placed on the chest over the apex of the heart. In this case the current path included a greater portion of the ventricular tissue, and defibrillation was accomplished in several cases where the heart was small. However, with a large heart, or one where the current path was increased by the presence of fatty tissue, it was not possible to achieve defibrillation, and recourse had to be made to open-chest defibrillation using disk electrodes.

A direct-coupled preamplifier was constructed to drive a dual-channel Brush recorder so that it could be used for simultaneous recording of the electrocardiogram and blood pressure.

A report (ERB-266) on heart stimulation was published, and a report on electric defibrillation was completed.

DIATHERMY

A request was received from the Defence Research Board to co-operate with them on an investigation of the vascular response of the peripheral circulatory system to temperature, which is being carried out at the Winnipeg General Hospital. An NRC engineer spent two weeks at the hospital setting up diathermy rewarming equipment lent to them by the Division and assisting in the preliminary tests.

PASTEURIZATION BY HIGH-FREQUENCY DIELECTRIC HEATING

Tests were conducted to determine the effectiveness of this method in the pasteurization of bottled ale. Sample bottles of unpasteurized ale were heated to temperatures between 120°F and 150°F. Subsequent tests were carried out to determine the extent of "chill haze", which is an indication of the expected shelf life. No significant difference was noted between ale pasteurized by this method and by water immersion, the method commonly used.

The samples pasteurized at 120°F had a slight pasteurization flavor; those pasteurized at 140°F had a flavor comparable to that of ale pasteurized by hot water, while those treated at 150°F had a pronounced pasteurization flavor.

A group of "after fermentation" samples were pasteurized to determine the effect on bacteria and yeast. Following incubation of the samples, no bacterial growth or yeast groups were noted.

VII — RADIO ASTRONOMY

SOLAR NOISE OBSERVATIONS

Regular observations of 10.7-centimeter solar noise were continued with the four-foot parabolic reflector. Successive readings with the two radiometers associated with the reflector showed results which differed by six per cent. This difference, greater than usual, fell to two per cent on re-calibrating the component units. Some statistical work on the degree of correlation between daily changes in solar flux with sunspot area was resumed, and showed that a high degree of correlation still continues for the year 1951.

A mechanical break in the 150-foot waveguide array was repaired, and alterations in the mounting of the radiometer were made. Elimination of a rotating waveguide coupler reduced transmission loss by about three decibels. A compact loop-type directional coupler was made, and is now used to supply local oscillator power for the crystal mixer. The average power illumination of the array was examined by a travelling probe and found to be uniform at a wavelength of 10.3 centimeters.

Daily solar drift curves are now being made with the 150-foot array. These curves show the location of sources of 10.3-centimeter emission on the solar disc as it is scanned by motion produced by the earth's rotation. A preliminary scheme is being set up to aid in the reduction of these observations. The time of transit — determined by the squint angle — varies with the local oscillator frequency: approximately 45 minutes of arc (3 seconds of time) for a local oscillator change of one megacycle. In order to fix the frequency arbitrarily, a resonant cavity of a Q of about 5000 has been set up. This enables the local oscillator frequency to be determined to within one-third of a megacycle.

The preliminary layout of the waveguide components for a radiometer to be mounted behind the ten-foot reflector has been completed. The design of the control circuits has been finished and some of the wiring has been commenced.

VIII — STANDARD FREQUENCY SERVICES

Routine operation of the Standard Frequency Services was continued. The Type 832-A final amplifier tube in the 150-megacycle transmitter was replaced with a Type AX-9003 tube resulting in improved performance over the previous type.

A low-frequency oscillation in one of the 100-kilocycle crystal clocks was found to be due to burnt-out components. Replacement of these components corrected the fault.

Some changes were made in the Standard Frequency feed to the Dominion Observatory to improve its reliability so that the crystal-controlled clocks might be rated with the Observatory clocks.

The present multivibrator frequency dividers used in the frequency standard are not too satisfactory in the event of power failure, and several alternative methods of frequency division are being investigated. An experimental multivibrator chain with a low counting factor per stage is being built as a possible solution to the problem.

IX - PAPERS AND PUBLICATIONS

"Theory of Waveguide-fed Slots Radiating into Parallel-plate Regions", presented by H. Gruenberg at a combined URSI - IRE (Antenna and Propagation Section) meeting held at Washington, D.C., April 24-26, 1952.

"Description of Interface Bridge and Low Voltage Regulated Supply", presented by P.A. Redhead at a meeting of the Montreal Section of the IRE held on May 21, 1952.

"Microwave Detectors", presented by P.A. Redhead at the IRE Conference on Electron-tube Research held at Ottawa, June 16-17, 1952.

"Theory of the Reverse Saturation Current of Germanium Point-contact Rectifiers," presented by J.H. Simpson at the IRE-AIEE Conference on Semiconductor Device Research held at Urbana, Ill., on June 20, 1952.

"The Construction and Use of a Small Telescope", presented by W.M. Cameron at a meeting of the Ottawa Section of the Royal Astronomical Society of Canada held on April 17, 1952.

"Wind Power", presented by H.E. Parsons at the Annual Meeting of the Engineering Institute of Canada held at Vancouver, B.C., May 7-9, 1952.

The following papers were presented at a meeting of the Canadian Association of Physicists held at Quebec on May 29-31, 1952:

"Functions of Union Radio Scientifique Internationale", by D.W.R. McKinley, and "UHF and Microwave Tubes", by P.A. Redhead.

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"Radio-frequency Rewarming in Resuscitation from Severe Hypothermia", W.G. Bigelow,* J.A. Hopps, and J.C. Callaghan,* Can. J. Med. Sci., vol. 30, no. 3, pp. 185-193, 1952.

> Twenty-seven dogs and monkeys were restored to normal body temperature from near-lethal limits of cold, using a radio-frequency rewarming technique. Induction cable applicators were chosen for their facility of arrangement and comparative safety. There was no evidence of optimum frequency among the three radio frequencies used. However, the rate of rewarming was dependent upon the spacing of coils from the body, with most satisfactory rewarming resulting from the use of ½ in. thick rubber pads. Dogs were rewarmed at an average rate of 11.1°C. per hour, using the ½ in. spacing and a frequency of 13.56 megacycles per second.

* Department of Surgery, University of Toronto

"Symmetrically Placed Inductive Posts in Rectangular Wave Guide", H. Gruenberg, Can. J. Phys., vol. 30, no. 3, pp. 211-217, 1952.

> A theoretical expression is derived for the susceptance of two symmetrically placed inductive posts in rectangular wave guide. Universal curves are drawn up that are valid for all rectangular guides in their normal operating range, for different post diameters and offsets. Reasonable agreement has been obtained with experiments at 10.7, 4.74, and 3.20 cm. wave lengths.

"High Values for the Electrical Breakdown Strength of Liquids", W.C. Edwards, J. Chem. Phys., vol. 20, no. 4, p. 753, 1952.

"Pulse Delay-Line Design Chart", C.A. Epp, Electronics, vol. 25, no. 6, p. 150, 1952.

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

"Bridge for Measuring the Interface Impedance of Oxide-coated Cathodes" (ERA-213), by L.R. McNarry.

> Rapid measurement of the interface impedance of oxide-coated cathodes is made possible by the instrument described in this paper. The bridge is balanced at three widely different frequencies, and the interface resistance and capacitance are read directly from decade units in the bridge circuit. All tubes to be tested are connected as diodes; thus the results are independent of tube characteristics. Low values of interface resistance may be read to within one ohm.

"NRC 10.7-Centimeter Radiotelescope and Radiometer" (ERA-216), by A.E. Covington.

> The construction of a radiotelescope (4-foot paraboloidal reflector) and receiver to measure 10.7-centimeter solar radio waves is described. This equipment has been in continuous use at the National Research Laboratories in Ottawa since 1947.

"Dual-Channel Rotating Coupler for Navigational and Docking Radar" (ERA-218), by F.V. Cairns.

> A dual-channel rotating coupler for the NRC Navigational and Docking Radar is described. The characteristics of this coupler are:

(a) A voltage standing-wave ratio of less than 1.14/1 in the transmitting channel, and a voltage standing-wave ratio of less than 1.20/1 in the receiving channel, over the NAD radar frequency band of 9375 ±30 megacycles per second.

(b) 0.3 decibel attenuation in each channel

(c) 76 decibels decoupling between channels

(d) An estimated power-handling capacity of 50 kilowatts.

"A Stabilized D-C Power Supply Variable From 0-25 Volts" (ERA-221), by P.A. Redhead.

A modified design of the low-voltage power supply, previously reported in "A Stabilized Power Supply for Voltages Below Twenty Volts" (ERA-187), is described. An internal impedance of 0.005 ohms has been obtained, with good long-term stability. The output voltage is adjustable from 0.75 to 23 volts. The maximum current obtainable with good regulation varies from 1.5 amperes at the lowest voltage to 0.2 amperes at the highest.

"Design of a Suppressed Localizer-ODR Antenna for the A.V. Roe Jetliner" (ERA-223), by W.A. Cumming.

Design and test data are given for a suppressed Localizer-Omnidirectional Range (ODR) antenna installed in a plastic fin cap on the A.V. Roe Jetliner. The antenna has satisfactory electrical characteristics for Localizer-ODR service over the frequency range 108-118 megacycles per second, and occupies a space 22 inches long, 9 inches wide, and 8 inches high, above the top rib of the fin.

"Electric Stimulation of the Heart" (ERB-266), by J.A. Hopps.

The principle of electric stimulation of the sino-auricular node of the heart is stated, with a brief outline of the theory of cardiac activity. Three models of the heart stimulator and various electrode assemblies are described. Procedure for stimulation is given.

Circuit diagrams and a detail drawing of the electrode assembly are provided.

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