Notes on Fifth National Electronics Conference, held in Chicago, September 26-28, 1949

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THE NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

NOTES ON FIFTH NATIONAL ELECTRONICS CONFERENCE

HELD IN CHICAGO, SEPTEMBER 26 - 28, 1949

BY

A. C. HUDSON

OTTAWA

OCTOBER, 1949

NOTES ON FIFTH NATIONAL ELECTRONICS CONFERENCE

Held in Chicago on 26, 27, 28 September, 1949.

Unclassified

(NOTE: Appendix A comprises photostats of official abstracts of all papers presented to the Conference. These should be referred to in conjunction with the following report.)

1. "Neutron Irradiated Rectifiers" -- Lark-Horovitz, et al

Interesting and useful effects can be obtained by bombarding various semi-conductors with neutrons from a neutron reactor, or deuterons from a cyclotron or sample of polonium. The usual equivalent circuit for a semi-conductor rectifier is shown in Fig. 1. For germanium, spreading resistance R_s is found to be smaller by a factor of 10-30 than $\rho/2d$, the value expected from bulk resistivity measurements. It is also an inverse function of applied voltage in the forward direction. The bulk resistivity of germanium is a direct function of temperature.

Irradiation of germanium produces new types of semi-conductors by transmutation of some germanium atoms to gallium. Gallium is to the left of germanium in the periodic table, and thus the gallium ion forms a defect type (P-type) impurity centre. There is also some transmutation to arsenic, causing a lesser number of N-type impurity centres; however, at room temperature these merely neutralize an equal number of the gallium ions. It is also believed that neutron bombardment causes the germanium atom to take up an interstitial position in the lattice, producing two new energy levels.

Bombardment of silicon, selenium, cuprous oxide, and tellurium transforms these materials from conductors to insulators. Germanium, on the other hand, is transformed from an electron-conducting material (N-type) to a hole-conducting material (P-type). Fig. 2 illustrates this effect. Conductivity in the forward direction is plotted against bombardment time. Conductivity is measured at less than 0.15 volts in the forward direction. Below this voltage current is determined mainly by the barrier layer. The solid curve represents a material having relatively low defect-type conductivity (low concentration of impurities). It is seen that conductivity increases by a factor of 40 under bombardment. The broken curve represents an initial material having a high concentration of excess type impurity. The decreasing conductivity with bombardment is caused by production of P-type impurity centres which neutralize the existing centres.

Radiation of a partially shielded sample of germanium with deutrons can then produce a piece having both P- and N-type germanium. It is believed that this process can produce synthetic rectifiers, photocells, trigger-photocells and photoconductors.

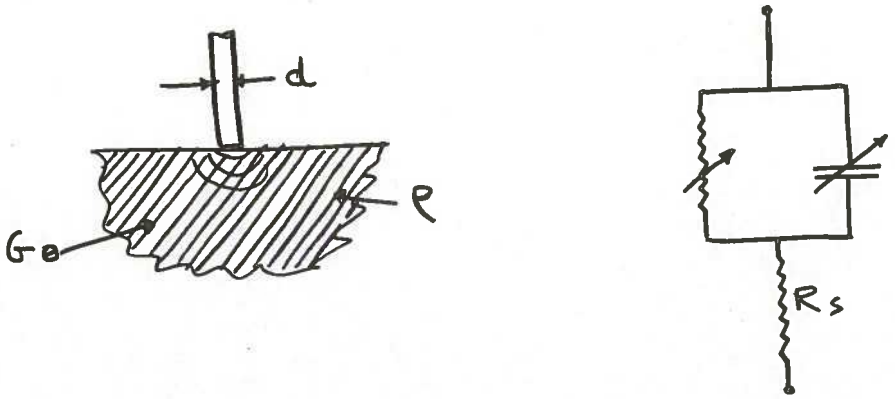
d
P
Ge
Rs

Fig. 1

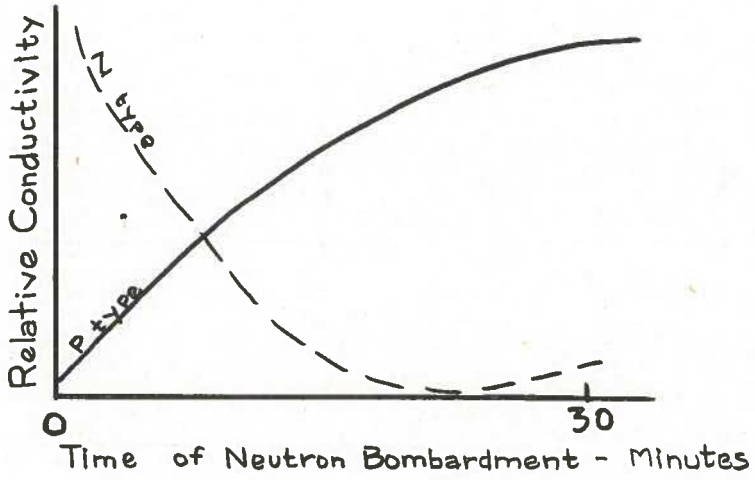
Relative Conductivity
N type
P type
0
30
Time of Neutron Bombardment - Minutes

Fig. 2

Much further work remains in this field. For example, it is not yet understood why the behaviour of germanium differs from that of silicon. The above results hold at room temperature, but some work has been done at dry-ice temperature where the effects are appreciably different.

2. "Low-Frequency Noise in Transistors" -- H. T. Mooers

A new equivalent circuit for the transistor was presented (Fig. 4), electrically equivalent to the old circuit (Fig. 3), but simpler for purposes of calculation. Note that the subscripts e and c refer to emitter and collector respectively. R_{ec} and R_{ce} are then transfer resistances. The equivalent circuit refers, of course, to small alternating-current signals about the operating point.

Noise power over the range ten cycles to ten kilocycles was found to vary inversely with frequency at 3 decibels per octave, with a noise factor of 77 decibels at 10 cycles. Adjustment of operating parameters for maximum gain will also give best signal-to-noise ratio. An indication of the limitation of present transistors for low-level amplifiers can be gained from the following results: with a band of 30 to 15,000 cycles per second, the integrated noise has the same power as a 0.15 millivolt input signal. It was stated that transistor noise has more high peaks than are predicted by a statistical analysis of Johnson noise.

3. "Experimental Examination of Rectifier Theory as Applied to the Selenium Rectifier" -- H. W. Henkels

A vast amount of detailed data was presented on the selenium rectifier, with little correlation with current theory.

4. "Field Effects in Germanium and Their Relation to the Transistor Problem" -- R. Bray

Transistor action is not of course, instantaneous. Considerable insight into the theory of transistors and semi-conductors in general can be gained by studying their action as a function of frequency. Three effects are involved in the operation of a transistor (Fig. 5): (1) injection of holes from the emitter; (2) the passage of holes through the germanium, and (3) collection of holes by the collector. Experiments using the Hall effect indicated that the hole concentration increases with applied electric field. Holes are injected from the positive contact in N-type germanium; electrons are injected from the negative contact in P-type germanium. A typical operating characteristic for a transistor using P-type germanium is shown in Fig. 6.

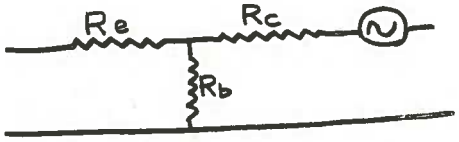

Fig. 3

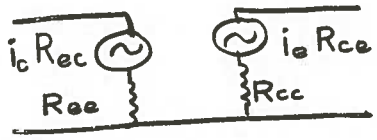

Fig. 4

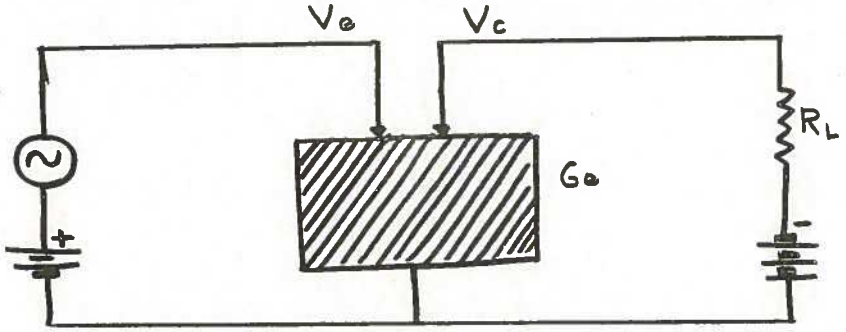

Fig. 5

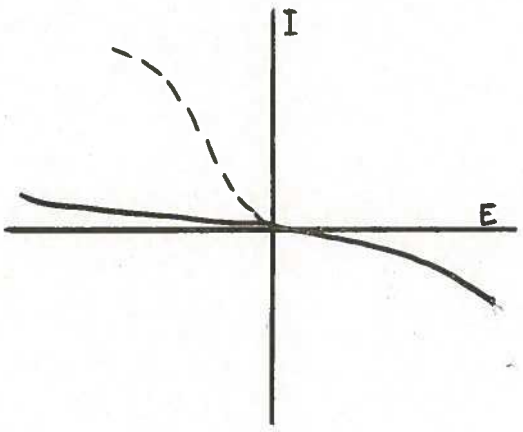

Fig. 6

The application of light to the transistor surface, or the application of a negative bias to the emitter will produce the alteration to the characteristic indicated by a broken line in Fig. 6.

With N-type germanium the electric field has two effects;--it decreases the barrier against injection of holes, and determines the depth to which holes will penetrate. Depth of penetration is determined by the following relation:

$$D = b E \tau \qquad \ldots\ldots\ldots (1)$$

where D is the depth of penetration
b is a constant depending on the mobility of the holes
E is the applied field
τ is the lifetime of the hole

τ is proportional to $\frac{1}{N}$ where N is the electron density per cubic centimetre. N is approximately 10^{15} for a high resistivity material. The number of injected carriers is several times greater than N but no positive space charge is observed, from which it is assumed that there is a compensating increase in the number of electrons in the germanium.

The preceding remarks do not apply to units suitable for ultra-high-frequency mixers. These units employ low resistivity germanium in which injection of carriers and field effects are negligible. It does, however, apply to the high back-voltage type. With these types the back resistance had been reported previously to decrease upon the application of alternating-current signals having a positive cycle. This can be explained simply by the reduced depth of penetration by holes at higher frequencies. The germanium used in transistors is similar to that used in high back-voltage rectifiers.

5. "A Universal-Application Cathode-Ray Sweep Transformer with Ceramic Iron Core" -- C. E. Torsch

Generation of high voltage for the cathode-ray tube in a television receiver from the stored energy in the deflection yoke imposes severe requirements on the yoke-coupling transformer. This paper described detailed circuits which meet these requirements, and employ a transformer which has a ceramic iron core (see Fig. 7). This circuit is for a 50° sweep on a kinescope such as the 10FP4. Regulation of the high voltage output compares favourably with typical radio-frequency supplies. One major advantage over radio-frequency or pulse systems is the absence of any frequency which can cause interference. Universal windings are used on the transformer, and the core is a C-type, having

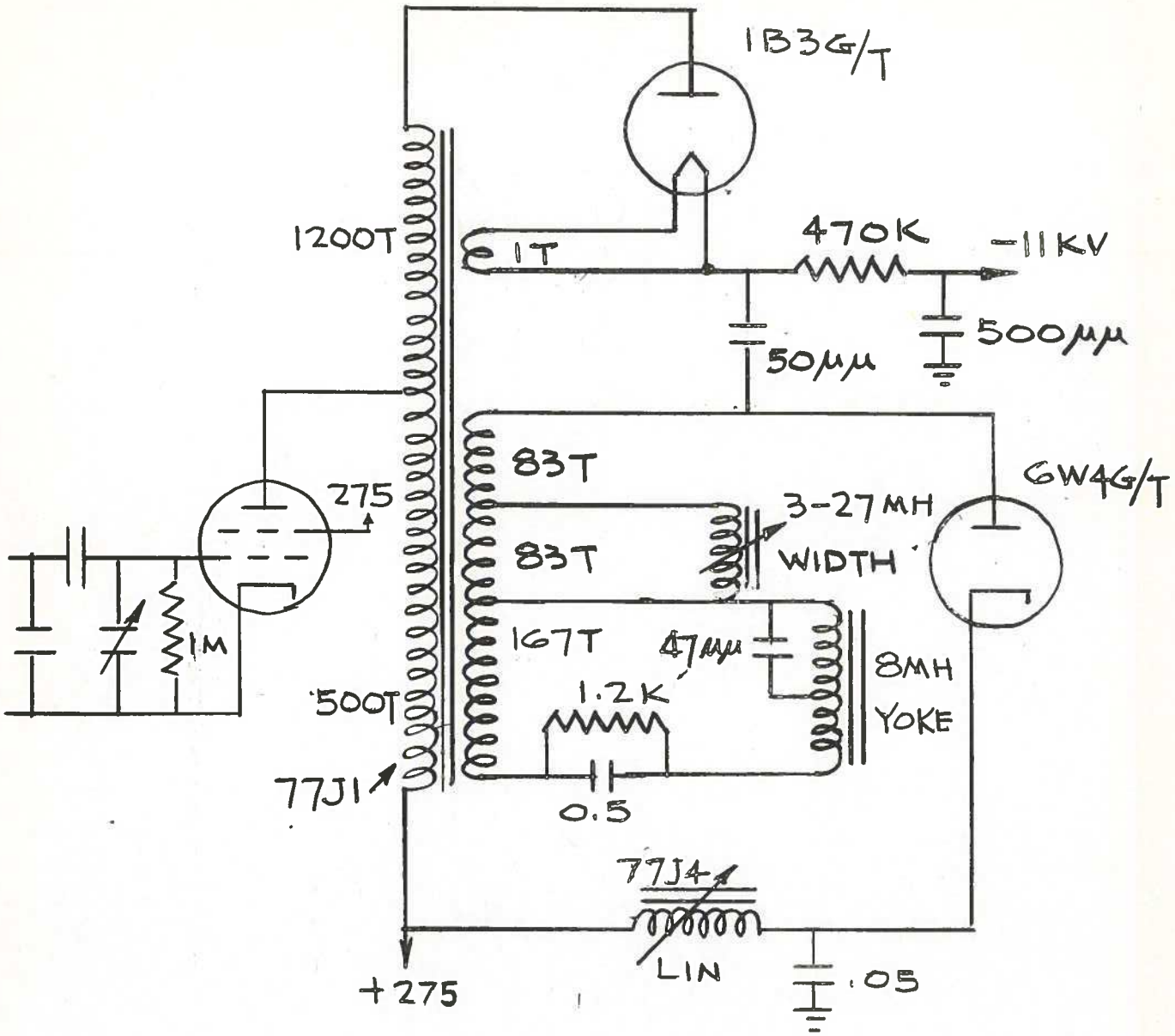
1B3G/T
1200T
1T
470K
-11KV
50μμ
500μμ
83T
6W4G/T
275
3-27MH
83T
WIDTH
1M
167T
47μμ
8MH
500T
1.2K
YOKE
77J1
0.5
77J4
LIN
.05
+275

Fig. 7

two 40-mil gaps. Very close coupling is necessary.

Little information was given about the ceramic iron, but it was stated that it is a ferrite crystalline structure having few free electrons, and was first reported in 1907 by Hilpert. It has high permeability and low loss due to its high resistivity. The ceramic iron will fail at temperatures above 120°C, as it has a low Curie point.

6. "Two New Image Orthicons" -- James, Johnson and Handel

The RCA Type 5820 image orthicon represents a considerable improvement over the original storage tube, Type 1850-A. Spectral response has been brought into closer agreement with that of the eye. A sharp saturation in output signal at approximately .01 foot-candles (corresponding to an output of 2 microamperes) has been obtained. This allows compression of the whites, producing an improved picture on today's kinescopes, and reduces blooming.

The image side of the target contains a 500 per inch metallic mesh. Fabrication of the mesh was illustrated by slides. A 500 per inch grating is ruled on glass with a diamond point. An undisclosed metal is sputtered on the glass, and the excess removed by hand. This removal is a very skilled operation. Copper or nickel are then plated on, and the mesh is removed from the master, under the surface of the electrolyte.

Wrinkles are removed by hand, and the mesh is mounted in a frame and heat-treated in a hydrogen furnace to degas it, and also to tighten it.

The target itself is of thin blown glass of carefully controlled resistivity. The photo-surface is a commercially secret mixture of bismuth, silver-oxide and caesium. The photo-multiplier is a new design and has a gain of three or four per stage. A considerable improvement in shelf-life expectancy has been realized by reducing evaporation of the bismuth. Memory, or burning, difficulties have also been reduced. The tube is satisfactory for colour television.

7. "Two New Television Tuners" -- M. F. Melvin

The television tuners were not described for reasons involving patents. The successor to the Mallory "inductuner" was described in detail. It consists of ganged sections of a flat spiral inductance having a rotating brush contact with a life of 25,000 complete cycles. It tunes 55 to 215 megacycles with a 10 micromicrofarad capacitor; the Q is about 150. The general principles of using variable inductances to tune television receivers were described, including several ingeneous circuits for use in television receivers.

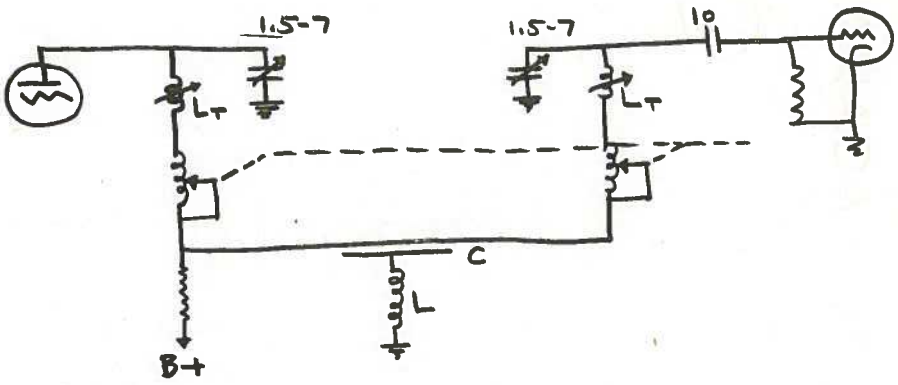

Fig. 8

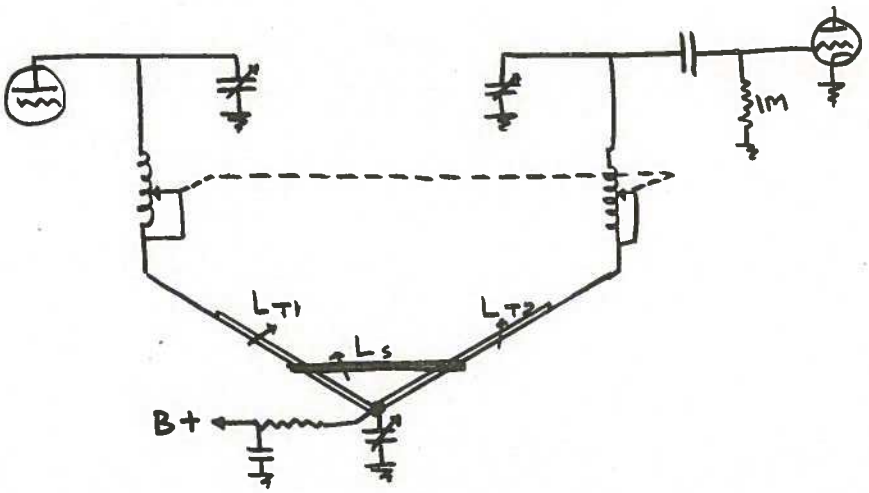

Fig. 9

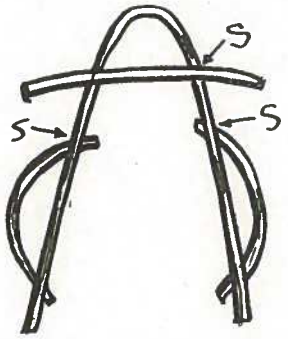

Fig. 10

Fig. 8 is for the present television bands, and Fig. 9 for the proposed UHF band. The ganged element is the main tuner, and the other variable elements are for tracking. Fig. 10 shows one physical form of the elements L_{T1}, L_{T2} and L_S from Fig. 9. It is constructed of tinned copper wire, and has an appearance and cost of production comparable to a safety pin. The points marked "S" are soldered during factory alignment of the circuits.

Examples of best local oscillator tracking obtainable are given in the following table:

Channel	Oscillator Error in Magacycles
2	-0.02
4	+0.25
6	-0.55
7	+0.65
10	+0.85
13	-0.15

8. "Theoretical Limit to Time Difference Measurements" -- D. Richman

This paper treats a problem with application to accurate radar; namely the precision with which the time of arrival of a signal can be determined. It was stated that the carrier of a modulated signal contains more precise information than the envelope; however, there is an ambiguity as to which cycle of the carrier is being measured. A very precise system could be devised if the carrier could be used for measurement, and the modulation envelope used to resolved the ambiguity.

9. "Electronic Contour Mapping" -- R. C. Raymond

It is proposed to print automatically a contour map from information supplied by an airborne scanning radar. It should be appreciated that this system has fundamentally one more dimension than the airborne radar recording altimeter, in that it prints a contour map for a strip four miles in width. Fig. 11 shows the method of scanning; ϕ is varied sinusoidally, θ is fixed. (Note that a pencil beam, not a fan beam is used.) Using the computer shown in the block diagram (Fig. 12), the radar information is converted to a signal

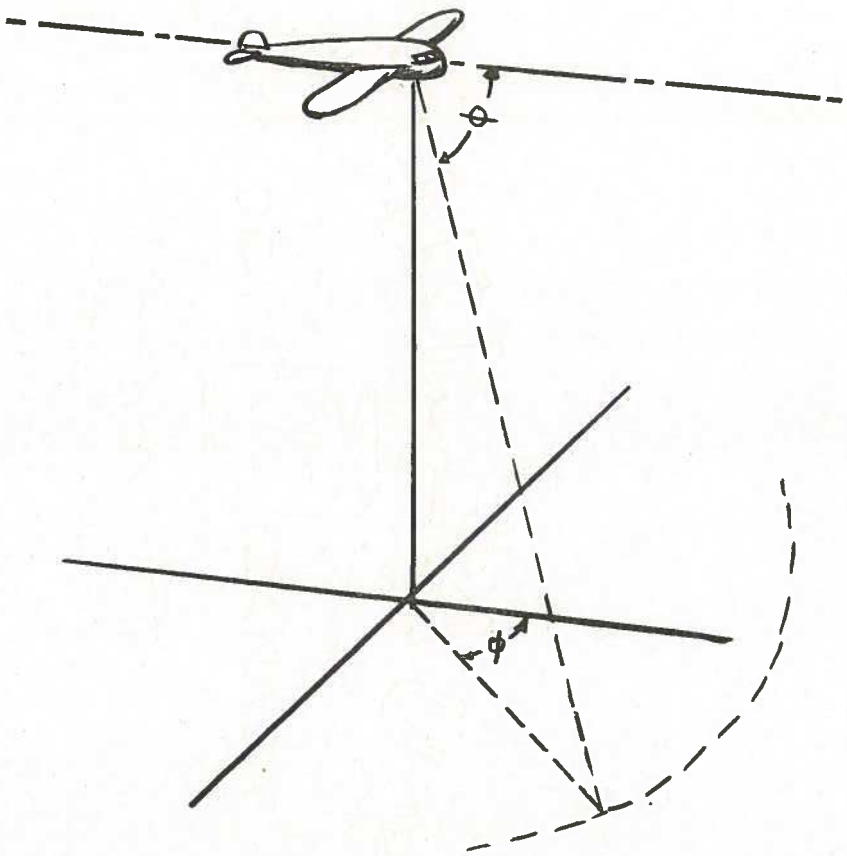
Φ
φ

Fig. 11

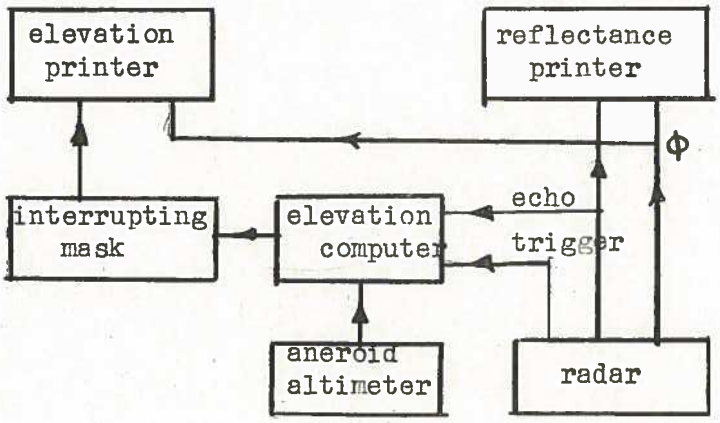
elevation printer
reflectance printer
Φ
interrupting mask
elevation computer
echo
trigger
aneroid altimeter
radar

Fig. 12

proportional to altitude. This signal is converted to a linear position on the cathode-ray tube. The cathode-ray tube image is projected onto a multiplier photocell; an intervening slotted mask interrupts this signal unless it represents certain discrete values of altitude. The signal is then fed to a printer having a moving film synchronized with the forward velocity of the aeroplane, and incorporating a lateral motion of the recording element synchronized with the antenna scan. It can be seen that the mask generates the contour lines. If the mask itself is rotated, and the slots corresponding to certain contour lines are broken, broken lines will be printed on the contour map at, for example, 500-foot intervals. The reference for altitude is an aneroid altimeter.

Provided that the yaw, roll and pitch of the aircraft are held to two or three degrees, appropriate corrections can be computed automatically and applied to the printer. Small angle assumptions are used; the reference directions are established by gyroscopes.

The reflectance printer of Fig. 12 prints a variable density map of the normal radar information. The following constants are proposed for the system:

Scanning speed	120 r.p.m.
Pulse recurrence frequency	720 per second
Contour interval	150 feet
Map width	4 miles
Speed of flight	150 m.p.h.
Antenna aperture	30 inches
Wavelength	1 centimetre

No components of this system have as yet been built.

10. "Wave Guide Attenuation Measurement by a Cavity Decrement Method" -- W. A. Tyrell

The use of short-circuited lengths of over-sized circular wave guide in the TE_{02} mode can result in values of Q in excess of 500,000. The Q can be measured by the method shown in the block diagram, Fig. 13. Ringing of the cavity is indicated by a typical A-scan, as shown in Fig. 14. An attenuation of say 40 decibels is introduced in the intermediate-frequency amplifier, and the shift in apparent ringing time is measured by the precision ranging unit. From this data the Q is easily determined. Various precautions are necessary: for relatively low Q's, blocking of the crystal mixer must be considered; possible degradation of Q due to excitation of other than the desired mode is eliminated by measurements at various cavity lengths. Experimental work was done at a wavelength of 3.2 centimetres using 5-inch I.D. copper wave guide.

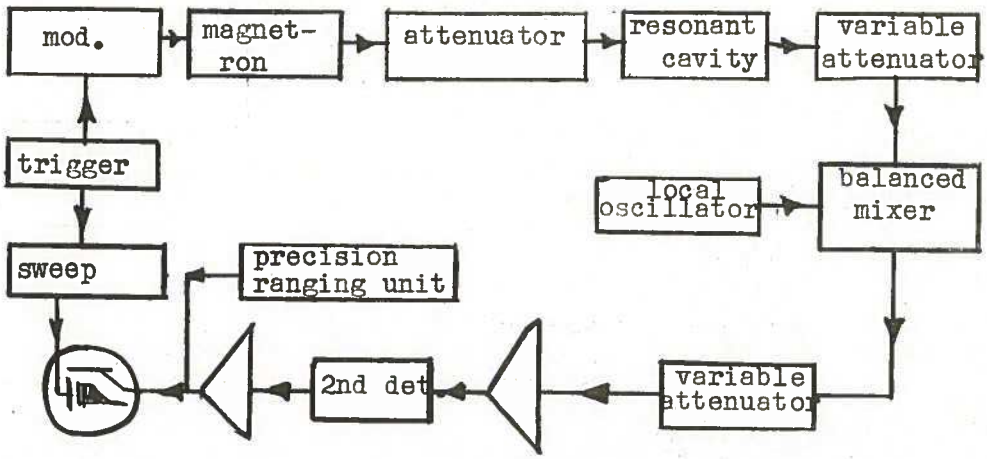
mod.
magnet-
ron
attenuator
resonant
cavity
variable
attenuator
trigger
local
oscillator
balanced
mixer
sweep
precision
ranging unit
2nd det
variable
attenuator

Fig. 13

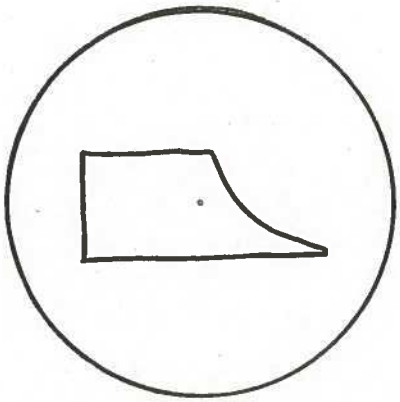

Fig. 14

These constants allow 39 unwanted modes.

Values of attenuation-constant within 2 per cent of the theoretical values have been obtained with carefully polished cavities.

11. "Automatic Calibration of Oscillator Scales" -- W. J. Means and T. Slonczewski

The need for automatic calibration of production variable-frequency -oscillators arose primarily from the tedious nature of hand calibration. In Fig. 15, A is a standard hand-calibrated oscillator carrying its calibration on moving film strip B. This strip is deliberately off-set by 60 cycles. An optical system forms an image of the calibration on the sensitized film strip C in the oscillator which is undergoing calibration. A 60-cycle synchronous motor drives the tuning condenser of this latter oscillator, while the standard oscillator is driven by a similar motor which derives its power from a modulator comparing the output of the two oscillators. The film strips, of course, replace the conventional dial in the completed instrument. Two thousand oscillators have now been calibrated by this method.

A second system has been built which is applicable to higher frequency oscillators. In this system all harmonics of a standard 10-kilocycle signal, up to the two-thousandth, are generated. The oscillator under test is tuned by a motor, and a calibration line is printed on the sensitized film as each harmonic beats with the oscillator frequency.

12. "The Electronically-Driven Ripple-Tank as an Aid to Phase-Front Visualization" -- A. H. Schooley

Information about the performance of various antenna structures is gained from the analogy between electromagnetic propagation and propagation of ripples on the surface of water. The apparatus is shown in Fig. 16. A is a mechanically-driven member simulating an antenna feed; B is a model reflector; the configuration of the ripples is emphasized by illuminating the tank with a light source interrupted at the oscillator frequency. The scaling equation is as follows:

$$\frac{\text{Model dimension}}{\lambda \text{ of ripples}} = \frac{\text{Antenna dimension}}{\lambda}$$

It is obvious that no difficulty is caused by the dependence of velocity of propagation on wavelength in water. Some aspects of antenna behaviour are well illustrated with this system; for example, with large scanning angles of

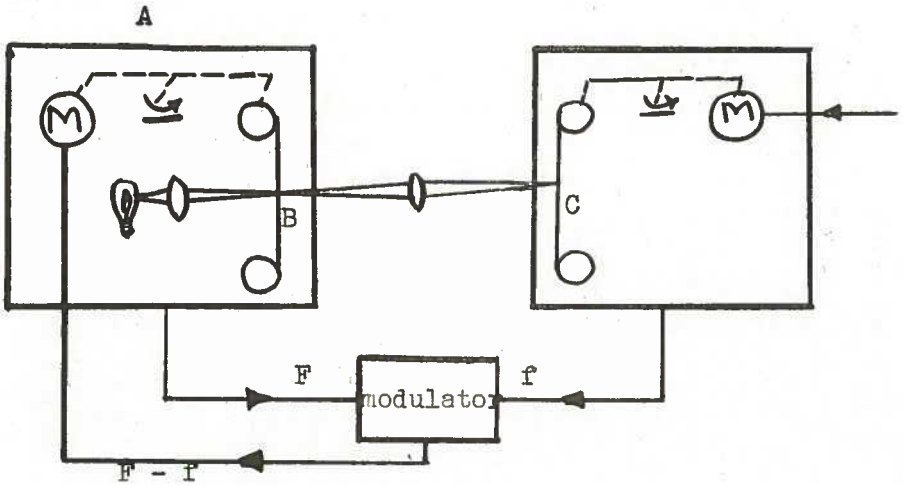
A
M
B
C
M
F
modulator
f
F - f

Fig. 15

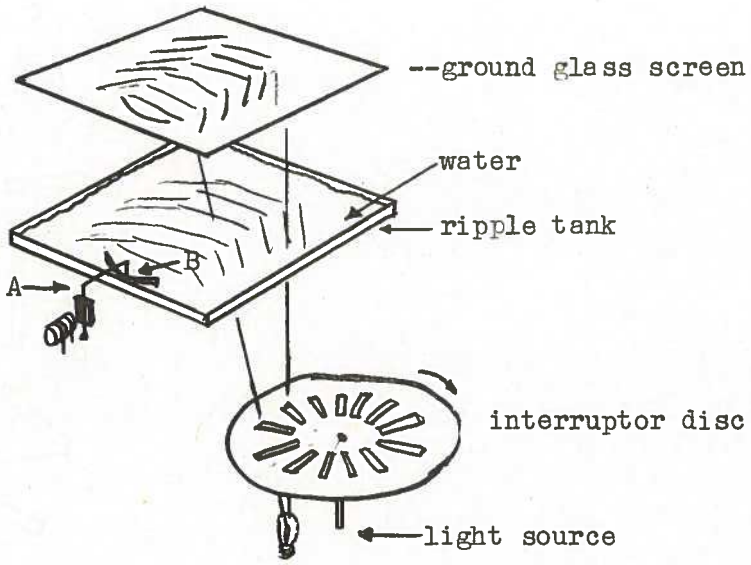
--ground glass screen
water
ripple tank
B
A
interruptor disc
light source

Fig. 16

up to 40 degrees, obtained by moving the feed only, a circular reflector appears much superior to a parabolic reflector.

Wave guide lenses can be simulated; however, the analogy in this case is poor.

Build-up of antenna excitation can be studied qualitatively. This is comparable with the long-line effect in wave guide runs. It is interesting to note that this build-up will become important as the apertures of antennas approach the free-space length of the pulses involved.

It should be emphasized that this technique, applied to electromagnetic propagation studies, is by no means as precise as the rubber-model or plotting-tank methods for investigating electrostatic problems.

13. "Electromagnetic Waves in Circular Wave Guides Containing Two Coaxial Media" -- R. Teasdale and T. J. Higgins

Propagation of electromagnetic energy in a circular metal wave guide containing an inner dielectric wall has been studied. An interesting aspect of this case is that the phase velocity is less than that of light. Values as low as 0.4c can be obtained. For this reason this type of wave guide may be useful in a linear accelerator. The elliptical and parabolic cases have also been studied. The parabolic case was not solved, due to the difficulties of handling Weber's equations. Assistance on this point was requested from the audience, but there were no suggestions.

14. "Small Surface Microwave Diffraction" -- A. Applebaum and P. C. Fritsch

Investigation of Fraunhauffer diffraction for a conducting plane approximately one wavelength in dimension has been carried out. Agreement with theory is good up to 30° incidence, in spite of various approximations in the theory.

15. "The Magnetic Cross Valve" -- H. J. McCreary

Interesting properties are found in a magnetic device having the configuration of Fig. 17 or Fig. 18. The application of 60-cycle voltage to the input coil results in no output voltage, since mutual inductance between the two coils is negligible. However, the addition of a capacitive load on the output circuit produces an output voltage which may be a multiple or a sub-multiple of the input frequency. Super-imposed direct current, added by the rectifier A may be necessary to start the device. Operation is not

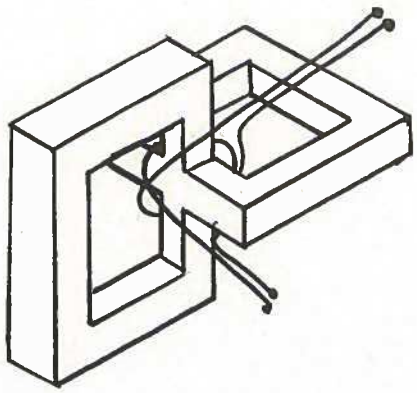

Fig. 17

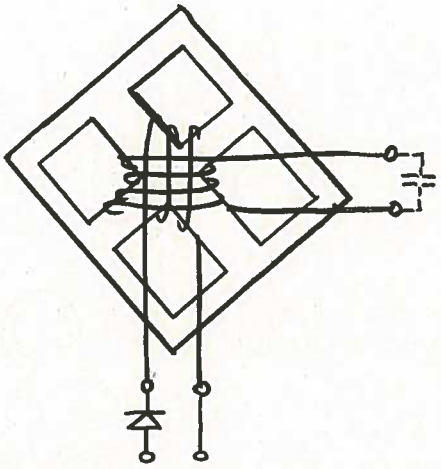

Fig. 18

Fig. 19

Fig. 20

completely understood, and the author welcomes a theoretical analysis. It appears that progressive saturation starting at the edges of the core causes flux linkage between the two coils with a mutual inductance M which itself is a sinusoidal function of frequency.

The locus of the total instantaneous flux vector follows a Lissajous figure; for example Fig. 19 or Fig. 20. It can be seen that the number of flux reversals per second through one coil is integrally related with the number through the other coil.

Efficiencies of 70 per cent are realized, and the device has practical application as a frequency changer.

16. "An Automatic Built-In Antenna for Television Receivers" -- K. Schlesinger

A production television antenna suitable for mounting within the receiver cabinet was described. Several can be stacked for greater vertical directivity. Good patterns and absence of nulls are obtained on all present television bands. The antenna appears to act as a pair of crossed dipoles on the high-frequency bands, and as a ring radiator on the low-frequency bands.

17. "A Progress Report on Development of the Travelling Wave Tube as a Power Amplifier" -- S. E. Webber

The following are typical operating conditions for the tube under discussion:

Gain	30 db
Bandwidth	20 megacycles
Efficiency	20 per cent
Centre frequency	500 megacycles
Output power	1 kilowatt

The general structure is indicated in Fig. 21. An attenuator is necessary to prevent oscillation. After an exhaustive investigation it was finally decided to use a value of 20 to 30 decibels obtained with an exterior coating of Aquadag.

18. "Coupling between Two Degenerate Cavity Modes through Slots Cut in the Cavity Walls"-- H. C. Hu

In Fig. 22, J_1 and J_2 represent the surface currents associated with two modes of oscillation in a resonant cavity. A slot S in general will cause coupling between the two modes.

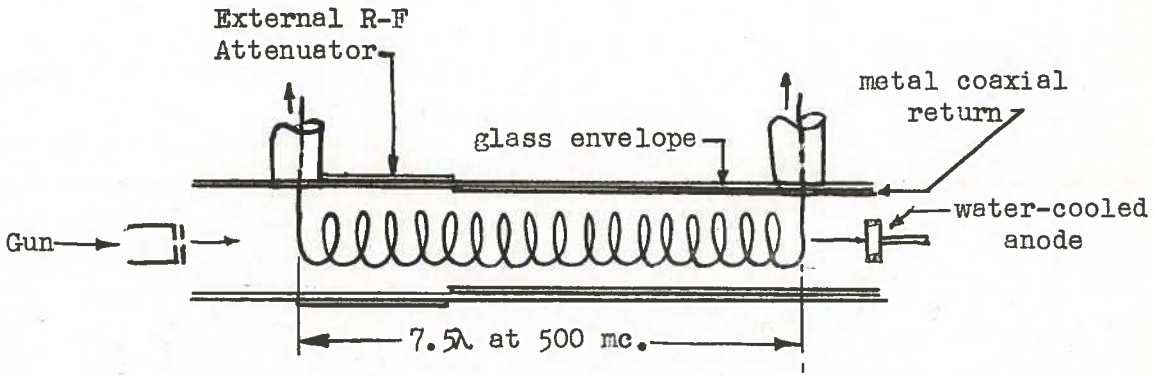
External R-F
Attenuator
metal coaxial
return
glass envelope
water-cooled
anode
Gun
7.5λ at 500 mc.

Fig. 21

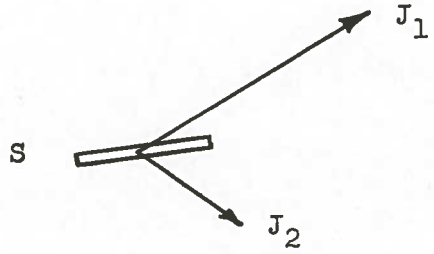
J1
S
J2

Fig. 21

The best orientation for the slot is parallel to the resultant current vactor. To obtain appreciable values of coupling coefficients, slots of considerable length and complexity of shape are required, and fabrication is extremely difficult.

It would appear that the same results could be obtained much more readily using two coupled cavities.

- oOo -

(b) "Radial-Beam, Velocity-Modulated Microwave Tube" by Chester G. Lob and D. F. Holshouser, University of Illinois.

(c) "The 6BN6 Gated Beam Tube" by Robert Adler, Zenith Radio Corporation, and A. P. Haase, General Electric Company.

(d) "Volume Deionization Processes at Ionospheric Pressures" by O. T. Fundingsland and G. E. Austin, Cambridge Field Station, USAF.

2. ELECTROMAGNETICS, North Terrace, Robert E. Beam presiding.

(a) "Electromagnetic Waves in Circular Wave Guides Containing Two Coaxial Media" by Robert Teasdale, Georgia Institute of Technology and Thomas J. Higgins, University of Wisconsin.

(b) "Small Surface Microwave Diffraction" by A. Applebaum and P. C. Fritsch, Naval Ordnance Laboratory.

(c) "The Magnetic Cross Valve" by Harold J. McCreary, Automatic Electric Company.

(d) "Coupling between Two Degenerate Cavity Modes through Slots Cut in the Cavity Walls" by H. C. Hu, University of Illinois.

3. SUPERSONICS, Michigan Room, H. C. Hardy presiding.

(a) "Application of Supersonic Energy to High Speed Electronic Recording" by Homer J. Dana and James L. VanMeter, State College of Washington.

(b) "Supersonic Control of a Lantern Slide Projector" by S. G. Lutz and George Rand, New York University.

(c) "Variable Resonant Frequency Crystal Systems" by William J. Fry and Wayne L. Hall, University of Illinois.

12 NOON LUNCHEON ADDRESS

Alston Rodgers, General Electric Company, Nela Park, Cleveland, Ohio, O. D. Westerberg presiding.

2:00 P. M. TECHNICAL SESSION

1. VACUUM TUBES II, Ballroom, R. M. Bowie presiding.

(a) "A New Rectifier Tube for Extremely High Power and Voltage Levels" by T. H. Rogers, Machlett Laboratories, Inc.

(b) "A Progress Report on Development of the Travelling Wave Tube as a Power Amplifier" by Stanley E. Webber, General Electric Company.

(c) "Efficiency of Reflex Klystrons" by William G. Shepherd, University of Minnesota.

(d) "Design Features and Some Applications of a New Photocell" by J. H. Crow and V. C. Rideout, University of Wisconsin.

2. CIRCUITS, Michigan Room, E. H. Schulz presiding.

(a) "A Versatile Crystal Controlled Source of Angle Modulation" by James F. Gordon, Bendix Aviation Corporation.

(b) "The 'DC Transformer' as a Component in Electronic Circuits" by Otto H. Schmitt, University of Minnesota.

(c) "Transient Response of Filters" by M. S. Corrington, Radio Corporation of America.

3. AUDIO-FREQUENCY, North Terrace, Arthur B. Bronwell presiding.

(a) "Continuously Adjustable Low and High-Pass Filters for Audio Frequencies" by Arnold Peterson, General Radio Company

(b) "A Variable Speed Turntable and Its Use in the Calibration of Disk Reproducing Pickups" by H. E. Haynes and H. E. Roys, Radio Corporation of America.

(c) "Methods and Instruments for the Visual Analysis of Complex Audio Waveforms", by H. R. Foster and E. E. Crump, Kay Electric Company.

(d) "Devices for Speech Analysis and Compression" by Dr. Ing. habil Friedrich Vilbig, Cambridge Field Station, USAF

For details of exhibits, see the special Exhibit Directory available at the Exhibits Registration Desk.

BRIEFS ON TECHNICAL PAPERS

1. ELECTRONIC INSTRUMENTATION I

(a) "RADIO LINK TELEMETERING FOR RECORDING DURING HIGH ACCELERATION PHENOMENA" BY SYDNEY HIMMELSTEIN, NAVAL ORDNANCE LABORATORY.

Radio link telemetering that will work during accelerations of the order of a thousand times gravity require special considerations. Limits of conventional circuits are discussed and conclusions are drawn on the nature of shock resisting circuits. A subminiature pulsed transmitter capable of working during high accelerations is described. One microsecond pulses, either amplitude or frequency modulated, are employed. Work done is in the region from thirty to one hundred megacycles. Details of the associated ground equipment are given. Theoretical and practical considerations of the system are included.

(b) "CLOSED CYCLE RECORDING OSCILLOGRAPHS" BY BEN CISCEL AND ROMAN RUHLAND, MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

Complex systems of electrical mechanical, and aerodynamic components require dynamic analysis for good automatic control. The more intricate the system, the more imperative it becomes that important variables are measured or recorded simultaneously. The recording oscillograph must meet certain obvious requirements such as multiple channels with suitable speed of response. These requirements prove to be starting points in the search for, or development of, a good recorder.

A survey of available equipment led to the design of a motor-driven multichannel recorder writing with ink so that the traces are constantly available for study and system adjustment during flight. Each channel is a complete servo in itself. Later technical demands have resulted in the use of a D'Arsonval movement for faster speed of response. This device was also built up to a closed-cycle system to eliminate drift, maintain dynamic performance, and insure calibration. The feedback is an important feature in its effect on the response characteristics of the recorder.

(c) "D-C AMPLIFIER TECHNIQUES IN OSCILLOGRAPHY" BY M. MARON, ALLEN B. DUMONT LABORATORIES, INC.

There are certain oscillographic applications for which a d-c amplifier is absolutely necessary. These applications are discussed generally. Because of the specialized requirements, the d-c amplifier must meet certain specifications not ordinarily considered in the design of a-c amplifiers. A discussion of these special specifications and design problems is included. To make best use of the d-c amplifier certain special acessory circuits are necessary. These include low frequency sweeps, expanded sweeps, and single sweeps, and in addition high cathode-ray tube accelerating voltage to facilitate use of a long resistance cathode-ray tube screen. A number of typical applications of d-c amplifiers in oscillography are illustrated and demonstrated.

2. SOLID STATE STUDIES I

(a) "NEUTRON IRRADIATED RECTIFIERS" BY K. LARK-HOROVITZ, PURDUE UNIVERSITY; W. E. JOHNSON, WESTINGHOUSE ELECTRIC CO; AND J. C. PIGG, OAK RIDGE NATIONAL LABORATORY.

Using commercial 1N34 and 1N38 rectifiers, the rectifier characteristics have been studied in the Oak Ridge reactor as a function of bombardment. It has been shown that in the range of 2V forward the behavior is the same as to be expected from bulk N-type samples.[1]

In the voltage range below .1S volts in the forward direction, resistivity decreases as it does in the back direction where, in both cases, barrier resistance determines the behavior of the rectifier. In the intermediate voltage range the resistance at first increases and then decreases, indicating that both barrier layer and spreading resistance determine the behavior of the rectifier.

In the case of silicon rectifiers of the commercial type, increase in resistance is observed both in the backward and forward connection in agreement with results obtained upon neutron and deuteron irradiation of silicon bulk samples.

1. Phys. Rev. 74, p. 1235 (1948); AECD Report 2054, June, 1949.

(b) "LOW FREQUENCY NOISE IN TRANSISTORS" BY HOWARD T. MOOERS, UNIVERSITY OF MINNESOTA.

This paper gives the results of an experimental study carried out on a limited number of samples of low frequency noise in transistors. Measurements were over the audio frequency range and extended to a lower frequency limit of less than 10 cycles per second. These studies concerned themselves also with an evaluation of the noise contributions from the emitter and collector. The noise is a function of the operating currents and attempts were made for the limited number of samples to determine the conditions for optimum signal to noise.

(c) "EXPERIMENTAL EXAMINATION OF RECTIFIER THEORY AS APPLIED TO THE SELENIUM RECTIFIER" BY HERBERT W. HENKELS, UNIVERSITY OF PENNSYLVANIA.

Recent work on the correlation of rectifier theory with experiment is examined. The variables in Schottky's theory are treated one by one.

The electrical properties of single crystal as well as microcrystalline specimens are examined in their relation to the selenium rectifier.

(c) "FIELD EFFECTS IN GERMANIUM AND THEIR RELATION TO THE TRANSISTOR PROBLEM" *BY RALPH BRAY, PURDUE UNIVERSITY.

Application of electric field to germanium produces decreases in the resistances which lag behind the applied voltage by several microseconds.[1] Hall effect measurements indicate that the concentration of carriers is increased in the process. Experiments made at the Bell Telephone Laboratories[2] indicate that in the case of N-type Ge. these effects are due to the injection of positive holes from the positive contact; time lags are due to the transit time of the holes as they are drawn into the sample by the electric field. In P-type Ge.[3], it seems that electrons are drawn in from the negative contact. From such experiments conclusions as to the nature of the metal-Ge contact may be drawn, and the mobility and lifetime of the injected carriers may be measured.

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1) R. Bray, Phys. Rev. 74, 1218 (1948).
2) J. Bardeen and W. H. Brattain, Phys. Rev. 75, 1208 (1949).
3) R. Bray, Bull. Amer. Phys. Society, Cambridge Meeting, June, 1949;
*This work assisted by a Signal Corps contract.

3. COMPUTER SESSION I

(a) "THE PHOTOFORMER IN ANACOM CALCULATIONS" BY H. W. SCHULTZ, J. F. CALVERT AND E. L. BUELL, NORTHWESTERN UNIVERSITY.

The word Anacom describes one well known general class of analog or continuous computing machines now employed in the solution of ordinary differential equations and initially described by engineers of the Westinghouse Electric Company. The photoformer produced first by Mr David E. Sunstien of the Philco Corporation is a device for producing continuous single valued functions of an independent variable. Input and output quantities are electrical. The purposes of this paper are (1) to describe a recent version of the photoformer and (2) to show by theory and test its many potential applications as an element in analog computers of the Anacom class.

(b) "LINEAR ELECTRONIC ANALOG COMPUTER DESIGN" BY C. A. MENELEY AND C. D. MORRILL, GOODYEAR AIRCRAFT CORPORATION.

Some of the problems peculiar to the design of a good linear electronic analog computer are defined. Reasons are given for the selection of various component characteristics as being necessary to satisfactory overall performance, the methods of achieving these characteristics are shown. Certain compromises with performance which can be made to attain flexibility, compactness, ease of maintenance, and low cost are discussed. Finally, a complete electronic analog computer with self-contained power supplies housed in a single moveable nineteen inch cabinet is described.

(c) "BONE DENSITY COMPUTING MACHINE" BY WALTER N. BROWN, JR., THE PENNSLVANIA STATE COLLEGE.

A novel computing machine has been developed which computes the mass of a living bone from data contained on a specially prepared X-ray film. When the film is exposed a specially designed step-wedge is placed on the film alongside the bone to be analyzed. The machine performs the functions of densitometering, curve fitting, multiplying, and integrating. Briefly, the machine fits a curve of film blackening versus mass of material penetrated to point data obtained from the wedge image. The function thus found is used to express the blackness of the bone image in terms of the mass of bone penetrated by the X-ray beam.

4. ELECTRONIC INSTRUMENTATION II

(a) "A PULSE LENGTH SORTER AND COUNTER" BY ROBERT J. PARENT AND ROBERT W. SCHUMANN, UNIVERSITY OF WISCONSIN.

This paper describes an electronic pulse length sorter and counter. Pulses of random length and spacing occuring at a rate up to 100,000 per minute can be sorted according to duration into one of 15 duration times differing from each other by equal increments. The sorting is accomplished by biased circuits fed from a step wave circuit driven by a multivibrator gated by the random pulses to be measured. The number of pulses of each length are counted by binary scaling chains following each bias circuit.

(b) "THICKNESS GAGE FOR NON-MAGNETIC MATERIALS" BY IRVING W. ROZIAN AND STEPHEN V. HART, INDUSTRIAL ELECTRONICS INC.

An electronic thickness gage has been designed for the continuous measurement of moving sheets of plate glass. This instrument is applicable to the measurement of thickness of any non-magnetic material within the range of 0.0001 inches to 1 inch and will detect deviations of less than one micro-inch from a standard.

Thickness measurement is accomplished by varying the primary-to-secondary coupling of a split transformer. The output of this transformer is balanced in a bridge circuit against that of a similar unit holding a standard slat. The bridge is energized by a stabilized oscillator. Any deviation from the standard, causes an unbalance voltage to appear at the bridge output which is fed through a phase discriminator and amplifier to a zero-center meter. The deflection of this instrument varies linearly with any change in thickness. Provision is made for recording the output of the instrument and for using this output in automatically adjusting the manufacturing rolls to maintain constant thickness. The circuit and the construction of the instrument will be illustrated by slides.

(c) "MULTIPLE CHANNEL CATHODE RAY INSTRUMENTATION OF NON-ELECTRICAL QUANTITIES" BY J. N. VAN SCOYOC AND G. F. WARNKE, ARMOUR RESEARCH FOUNDATION OF ILLINOIS INSTITUTE OF TECHNOLOGY.

The use of multi-channel cathode ray oscillographic equipment consisting of cathode ray tubes operated at 4000 volt accelerating potential, moving film cameras operating at speeds up to ten feet per second, direct coupled amplifiers with gains of 50,000 with unusual stability and accuracy, automatic sequence controls, unique timing circuits, and piezo gage and strain gage inputs with eight step calibration signals for use in recording transient phenomena such as stress, strain, acceleration, pressure, etc., will be described. This equipment incorporates a number of novel circuits not previously described in the literature.

5. COMPUTER SESSION II

(a) "A COMPUTER FOR SOLVING SECULAR EQUATIONS" BY JOHN F. STORM, UNIVERSITY OF MINNESOTA.

This article describes the theory and design of an analog type computer into which the constants of a secular equation determinant may be inserted directly, and from which the roots may be obtained without expanding the determinant. A third degree equation was studied, but a method is outlined for extending the range of the computer to higher degree equations. The constant terms in the secular equation determinant are restricted to real numbers, but they may be positive or negative. The computer determines only the real roots of the secular equation. The computer will also solve simultaneous linear equations.

(b) "COORDINATE TUBES FOR USE WITH ELECTROSTATIC STORAGE TUBES" BY R. S. JULIAN AND A. L. SAMUEL, UNIVERSITY OF ILLINOIS.

This paper is a report on the program of research and development leading to the design and construction of a memory storage system employing special types of coordinate tubes, which are used to locate information stored in electrostatic memory tubes either of the Haeff or of the Williams types.

The system uses two master tubes which separately control the horizontal and vertical positioning of the electron beams in a bank of slave tubes. This control is by means of servo amplifiers which locate the proper memory positions from their digital address codes in terms of the mechanical positions of target plates contained within the master tubes. The system is such that no particular attention need be paid to the regulation of electronic circuits and power supplies, and good reliability in the location of stored information can be achieved.

Two different types of tubes—one for serial operation and the second for a parallel address system—have been constructed and tested.

(c) "ELECTRONIC ANALOGUE FOR HEATING SYSTEM ANALYSIS" BY RALPH T. SQUIER, BEN CISCEL AND KIMBALL C. CUMMINGS, MINNEAPOLIS-HONEYWELL REGULATOR COMPANY.

The heat supply devices, the building, and the heating controls are here considered as systems which are subject ot the same laws of servo-mechanism analysis which have been applied so successfully to automatic pilots and turret-drive mechanisms.

The heating control system may be thought of as a form of computer which must solve two problems continuously and simultaneously. The first problem has to do with the summation of losses due to structural transmission, infiltration, and radiant effects. The second problem is dynamic in nature and is concerned with the transient characteristics of the heat source, the structure, and the controls.

An electronic analogue is described to demonstrate the effect of such variables as wind, outdoor temperature, furnace size, insulation, etc., on the heating system during transient conditions.

6. TELEVISION

(a) "A UNIVERSAL-APPLICATION CATHODE RAY SWEEP TRANSFORMER WITH CERAMIC IRON CORE" BY CHARLES E. TORSCH, GENERAL ELECTRIC COMPANY.

Public demand for larger television pictures of increased brightness, accompanied by decreased receiver cost, is emphatic. The advent of a universal ratio, ceramic cored sweep and high voltage transformer provides receiver

design engineers with an effective means of meeting this demand. Increased sweep output stage efficiency results from optimized power feedback networks employing inexpensive diode damping in conjunction with the GE Model 77J1 transformer, for directly viewed picture tubes including the 8AP4, and 16AP4. The 8AP4 is swept with inexpensive power tubes at 130 volt "B" supply levels; the 16AP4 is adequately swept and provided with KV anode supply using a single 6BG6G within all rating limits.

(b) "TWO NEW IMAGE ORTHICONS" BY R. B. JANES, R. E. JOHNSON AND R. R. HANDEL, RADIO CORPORATION OF AMERICA.

The incorporation in the image orthicon of a new panchromatic high-sensitivity photosurface permits televising low-level-illuminated scenes with a color rendition approaching black-and-white photographic quality.

This development has led to two new image orthicon tube types: one for either remote pickup or studio use and the other for studio use. The sensitivity and color response of these tubes is described.

Possible sources of illumination are discussed together with changes in the target structure to minimize microphonism and increase life.

(c) "TWO NEW TELEVISION TUNERS" BY MYRON F. MELVIN, P. R. MALLORY AND CO., INC.

Two new television devices are described in this paper. Mechanical and electrical designs and characteristics are given in detail.

The recently released "Spiral" tuner is discussed at length. Transition from the mechanical design of the widely used, continuous type, "Inductuner", is shown. Mechanical simplicity, cost savings, and mechanical improvements are noted. Performance characteristics of various circuits is presented. Data is given on gain, bandwidth, tracking, noise, image rejection, and other necessary points.

A second type tuner is described, and again mechanical and electrical performance data is given. The unit described is felt to be a rather interesting and novel approach to the television tuning problem resulting in good performance with an excellent stability characteristic.

7. ANTENNAS I

(a) "END LOADED AND EXPANDING AXIAL MODE HELICES AS BROADBAND CIRCULARLY POLARIZED RADIATORS" BY PAUL W. SPRINGER, WRIGHT-PATTERSON AIR FORCE BASE.

Circularly polarized antennas are becoming increasingly important for many applications. The simplicity of the axial mode helix makes it particularly well suited to the above use. For applications requiring modified radiation patterns or greater bandwidth, however, it is often necessary to modify the simple helix.

Two of these, the short end loaded helix, and the expanding axial mode helix have proven of particular value where circularly polarized antennas of extreme bandwidth are required.

The theory of operation, impedance curves, polar diagrams, current and phase distribution and radiation efficiency of these antennas are discussed. Practical methods of arraying these radiators are also discussed.

(b) "IMPEDANCE AND RADIATION CHARACTERISTICS OF SLOTTED CYLINDER ANTENNAS" BY ROBERT E. BEAM AND HAROLD D. ROSS, JR., NORTHWESTERN UNIVERSITY.

An approximate theory of the input resistance and radiation patterns of a slotted-cylinder antenna having a narrow slot whose length is equal to or greater than a free space half-wave length and which is fed across the slot at its midpoint by a transmission line is given. The slot is shorted at both ends. The theory is based on the consideration of the antenna as a slot-loaded cylindrical waveguide for purposes of computing the cutoff frequency and the phase constant along the slot in terms of physical dimensions. By the application of Babinet's principle and the assumption that the slot is in a thin, conducting infinite plane, the radiation resistance is computed. In applying Babinet's principle the slot is replaced by a center fed electric dipole whose phase constant is that for the loaded waveguide. The radiation resistance of this electric dipole is computed and inverted with respect to twice the square of half the intrinsic impedance of free space to obtain the input resistance of the slot. Experimental results agree very well with the theory for the cases investigated.

The radiation pattern of the slot in a plane containing the axis of the cylinder is determined in form by that for the complimentary electric dipole. The radiation pattern in a plane perpendicular to the axis of the slot is determined by the method which has previously been used in a report by C. H. Papas and R. King and in a paper by G. Sinclair.

(c) "A COMBINATION SLOT ANTENNA AND RESONANT TANK CIRCUIT" BY NORMAN L. HARVEY, SLYVANIA PRODUCTS, INC.

Slot antennas are notable for their effectiveness over a broad band of frequency. An impedance transforming and coupling network is ordinarily required between the radio unit and the antenna.

This paper describes a means for eliminating impedance coupling network as a distinct structure by utilizing the edges of the slot as the resonant circuit of the radio unit. Such a device is especially suited to broad band use such as in pulse communication and frequency modulation signalling.

(d) "THE CHANNEL GUIDE ANTENNA" BY WALTER ROTMAN, CAMBRIDGE FIELD STATION, USAF.

A theoretical analysis of a waveguide with continuous slot of arbitrary width in a narrow wall is presented. The general condition for radiation from the slot is established in terms of the near field distribution of electromagnetic energy. This near field distribution may be described as a form of single mode transmission in the supporting waveguide, characterized by a complex propagation constant. A method of computing the propagation constant for a variety of channel geometries gives results which are in substantial agreement with experiments conducted at both Ohio State University and this Laboratory. Equivalent circuits, representing the properties of the channel guides, are established. The possibility of mode separation for radiation purposes by means of dielectric loading of the channel is discussed and the propagation of several independent modes is demonstrated. Practical methods of coupling these channel guides to microwave sources are considered. The connection between these modes and the general subject of single surface transmission of energy is brought out.

8. MEASUREMENTS I

(a) "THEORETICAL LIMIT TO TIME DIFFERENCE MEASUREMENTS" BY DONALD RICHMAN, HAZELTINE ELECTRONICS CORPORATION.

The accuracy with which a known signal may be located in time depends on the signal-to-noise ratio, the bandwidth of modulation, the distribution of signal energy within the bandwidth, the duration of the signal, and under certain conditions the carrier frequency on which the signal traverses its transmission path.

The relationships may be summarized in a simple formula. This paper considers in detail the physical reasoning which leads to the derivation of the formula, and the interpretation of the results. Illustrative examples are given.

(b) "ELECTRONIC CONTOUR MAPPING" BY RICHARD C. RAYMOND, HALLER AND BROWN, INC.

A well stabilized aircraft carrying a pencil beam radar set makes several thousand observations per second on the terrain over which it flies. The collected data are used to print a contour map or other map which gives the relative elevations of the terrain points observed. Calculations indicate that an advanced type of equipment, operating at high altitude, could print contour maps at a rate of more than 1,000 square miles per hour. Maps can be produced in standard contour form, in varying density, or in varying color to indicate elevations of the observed areas. Errors due to aircraft instability may be removed in the printing process by a correction system involving the aircraft stabilization system. A simultaneously printed radar reflectance map ties the elevation data to known terrain points.

(c) "WAVEGUIDE ATTENUATION MEASUREMENT BY A CAVITY DECREEMENT METHOD" BY WARREN A. TYRRELL, BELL TELEPHONE LABORATORIES.

A method has been developed for the measurement of extremely low waveguide losses, such as encountered with the TE_{01} mode in oversized circular pipe. This depends upon pulse excitation of a cavity, of which the waveguide is made an integral part, the Q being derived from the rate of decay of the stored energy. Experimental work at 3.2 cm in 12 cm pipe has demonstrated the utility of the method. Losses have been measured for a variety of pipe materials. Discrepancies between calculated and observed values are explained by surface roughness and corrosion. Closer agreement with the expected values has been obtained by improving the inner surface of the guide.

(d) "AUTOMATIC CALIBRATION OF OSCILLATOR SCALES" BY W. J. MEANS AND T. SLONCZEWSKI, BELL TELEPHONE LABORATORIES.

Long frequency scales used in heterodyne oscillators are calibrated by recording photographically on a strip of motion picture film the image of a master scale which continuously indicates the instantaneous frequency of the oscillator. For low frequency applications, the master scale is driven by a circuit which is essentially a duplicate of the oscillator being calibrated together with a synchronizing circuit. For high frequency applications, the master scale is driven through an electronic circuit which measures the frequency in terms of a 10 kilocycle primary standard. The scale is produced in 4.5 minutes, is more accurate and has a better appearance than a hand made product.

9. MAGNETIC DEVICES

(a) "MAGNETIC AMPLIFIER STUDIES ON THE ANALOG COMPUTER" BY E. L. HARDER, W. H. HAMILTON, D. F. ALDRICH, J. T. CARLETON AND F. N. McCLURE, WESTINGHOUSE ELECTRIC CORPORATION.

In an effort to understand more completely the performance of magnetic amplifier circuits, an electrical analog to magnetic circuits has been developed and is described. The non-linear characteristics of the iron are introduced by using a multiple diode non-linear resistance circuit designed to provide the familiar B-H curve in 20 linear steps. The voltage appearing across this resistor is made to be proportional to $N \frac{d I}{dt}$ by using an appropriate integrating amplifier.

Methods of applying the analog to specific design problems as well as studying fundamental magnetic amplifier characteristics are discussed.

The analog provides a powerful tool for convenient studies of magnetic circuits, in general, as well as for magnetic amplifiers.

(b) "ON THE THEORY OF MAGNETIC AMPLIFIERS" BY M. LIWCHITZ-GARIK, E. WEBER AND E. J. SMITH, POLYTECHNIC INSTITUTE OF BROOKLYN.

Magnetic amplifier circuits contain, as basic components, saturable-core reactors, rectifiers and a load which is usually resistive. To date, no closed form analytic solution has been found for the simple circuit containing a series fixed resistance and iron-cored inductor to which a sinusoidal voltage is applied; the prospect of an analytic solution of even the most elementary magnetic amplifier circuit is therefore nil. This paper discusses other methods of steady state analysis which are possible.

The question of best representation of the magnetization characteristic of the core under conditions of asymmetrical magnetization is discussed, and experimental data illustrating the effect of d.c. bias on the a.c. magnetization curve is shown.

The half-wave and full-wave (d.c.) circuits are taken as examples and results computed by a point by point procedure, a power series and a method based on the representation of the magnetization curve by three connected straight lines, are given and compared with experimental results. These methods are direct in that they give results which include the load resistance. An indirect procedure is to first obtain no-load data by computation (which is possible) and then determine actual performance through use of a load line as in the case of vacuum tube computations. The results of various methods are evaluated with respect to accuracy, form, time and labor required, and possibility of leading to design criteria.

(c) "AUDIO TRANSFORMER WITH FREQUENCY RANGE EXTENDING BELOW ONE CYCLE PER SECOND" BY DONALD W. KUESTER, NAVAL ORDNANCE LABORATORY.

In this paper the author discusses some of the problems encountered in the design and construction of transformers having extremely wide band frequency response. The design considerations involved in the design of a particular wide band line to grid transformer are discussed along with the effects of various parameters such as core materials, pie winding, dielectric materials, and interleaving of primary and secondary windings. The particular transformer described is a 72 ohm line to 10,000 ohm grid transformer having a flat frequency response of 0.2 cps to 20 kilocycles per second.

(d) A NEW MAGNETIC RECORD DUPLICATING PROCESS, MARVIN CAMRAS, ARMOUR RESEARCH FOUNDATION OF ILLINOIS INSTITUTE OF TECHNOLOGY.

Magnetic records can be faithfully duplicated at high speed and in large quantities by a contact printing process. The program is first recorded on a master tape of high magnetic properties. This master is then held against a blank magnetic tape while the two are subjected to a "transfer field". When the copy tape is separated from the master, it retains an accurate reproduction of the magnetic recording from the master. This new method promises to be widely used for magnetic record releases.

DUPLICATION OF MAGNETIC TAPE RECORDINGS BY CONTACT PRINTING, ROBERT HERR, MINNESOTA MINING AND MANUFACTURING COMPANY.

A new method is described for copying magnetic recordings without electrical transcription. Unrecorded tape is subjected to a controlled alternating magnetic field while in contact with recorded tape, and thereby magnetized directly, in a manner analogous to the pressing of discs. When optimum master and print media are used the recording is nearly if not quite as good as can be obtained by playback and re-recording. Because of the simplicity of the operation and the speed with which it may be carried out it is expected to make the large scale production of pre-recorded program material practical from an economic viewpoint.

10. RESEARCH MANAGEMENT

(a) FOR THE GOVERNMENT, R. D. BENNETT, NAVAL ORDNANCE LABORATORY.

Research organizations have expanded in size and in number in recent years, and this is true in government as well as in industry. The expansion in the armed services has been much greater than in many other areas, and their total investment in plant for research is now very large. The effective operation of these establishments is vital, both from the point of view of cost, and the importance of their products to the preservation of national security. Therefore, it is essential that, in these establishments, not only the ordinary problems of research management be solved, but also that, in addition, those peculiar to research in the armed services be solved as well. The speaker will identify some of these problems and indicate approaches which have been made to their solution, with particular reference to methods used at the Naval Ordnance Laboratory.

(b) FOR THE RESEARCH FOUNDATION, H. A. LEEDY, ARMOUR RESEARCH FOUNDATION OF ILLINOIS INSTITUTE OF TECHNOLOGY.

Research today, although a subject of national importance, is still by no means universally accepted by industry. Of the 17,000 largest industries in the United States, only 15 per cent have a research laboratory, one of the principal reasons being the failure of many industrial executives to appreciate the value of research. For industries large or small which are cognizant of the importance of research to their survival, organizations like Armour Research Foundation of Illinois Institute of Technology are rendering a valuable service in solving many of their important and difficult research and development problems. The general plan of organization and operation of such a research foundation will be discussed.

(c) FOR THE UNIVERSITIES, F. A. ROHRMAN, UNIVERSITY OF COLORADO.

The educational institutions of our country offer important contributions of our nation's research. The management of this institutional research differs from the management of corporation and non-profit foundation research in many ways, because of the differences in needs and results. The educational institution must relegate research to a secondary role — that as a supplement to good teaching and training. Research of basic and fundamental concepts must also be emphasized rather than the applied or commercial-value research.

The management of research in the educational institutions has many more problems than that of corporations and non-profit foundations. The personnel engaged in such research is composed of the widest extremes in ability and temperament; the research fields are more extensive; the administrational and financial problems more complex.

(d) FOR INDUSTRY, DUDLEY E. CHAMBERS, GENERAL ELECTRIC COMPANY.

Management action depends, in part, upon a sure appreciation of the steps from exploratory research through manufacture and upon an ability to judge the status of a project through these steps. Further, the technical organization depends upon the company's fields and scope of operations. This paper briefly outlines one concept of the steps from exploratory research through manufacture, describes the common types of industrial research organization and, finally, discusses a few of the principles of the philosophy of operation of a true research department.

11. ANTENNAS II

(a) "AN AUTOMATIC BUILT-IN ANTENNA FOR TELEVISION RECEIVERS" BY K. SCHLESINGER, MOTOROLA INC.

Fundamental problems of small built-in antennas are outlined. First among these are low-band efficiency and directivity.

Networks are presented to obtain uniform frequency coverage and maximum power transfer both for dipoles and loops. The overall response is shown by oscillogram

A special type of VHF-loop antenna is shown. It covers all TV-channels without tuning and is omni-directional by design.

Considerable power gain is obtained by stacking two or three of these horizontal loops within a TV-receiver console. It is shown how to check by an oscilloscope the current distribution in the elements of the array.

Receivers employing built-in antennas of this type are demonstrated.

(b) "THE ELECTRONICALLY DRIVEN RIPPLE-TANK AS AN AID TO PHASE-FRONT VISUALIZATION" BY ALLEN H. SCHOOLEY, NAVAL RESEARCH LABORATORY.

The use of water-ripples to qualitatively and semi-quantitatively study phase-fronts near two-dimensional models of antenna structures deserves consideration by the electronics engineer. For this purpose electronically driven probe vibrators are used to excite the water surface of a glass ripple-tank. Synchronously chopped light is directed through the tank to a ground glass screen where the phase-fronts appear stationary. Using simple equipment it is possible to rapidly visualize the changes in phase-front pattern brought about by changes in feed point position, reflector configuration, and by changes of as much as several hundred percent in exciting frequency. A considerable part of the paper will consist of a motion picture film showing such phase-front patterns.

(c) "THE ELECTROMAGNETIC FIELD IN THE VICINITY OF A LINEAR CONDUCTOR" BY PAUL H. NELSON, UNIVERSITY OF FLORIDA.

The interference pattern set up in the vicinity of a linear conductor immersed in a plane electromagnetic wave is considered by reducing the problem from three to two dimensions, solving Maxwell's equations and introducing suitable theoretical development shows very good agreement between the measured and calculated points. Graphical representation and three-dimensional models are presented as aids in visualizing the resultant field pattern. The investigation is of interest because of its close relationship to slot-type and linear radiators of electromagnetic waves.

(d) "CORRECTION OF SPHERICAL ABERRATION BY A PHASED LINE SOURCE" BY ROY C. SPENCER, CARL J. SLETTEN, AND JOHN E. WALSH, CAMBRIDGE FIELD STATION, USAF.

Parallel rays incident on a concave spherical reflector cross the axis after reflection. An axial line source has been phased so as to correct for the spherical aberration thus allowing aberrationless scanning of a pencil beam over at least $\pm$ 30° in any direction. The phasing of the source varies from endfire through broadside along the source. Tests made using feeds such as open waveguide, horn, polyrod and corrected slotted line source support the theory

12. THEORY OF COMMUNICATIONS

(a) "APPLICATION OF STATISTICAL THEORY IN COMMUNICATIONS" BY JEROME B. WIESNER, MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

In this paper the difficulties arising in the analysis of communication systems on a sinusoidal basis are pointed out, and a statistical method of providing a measure of information content of messages, and a measure of system transmission capacity developed by Norbert Wiener are described. The use of this new approach to the analysis of communication networks is illustrated. Methods for obtaining necessary statistical data on which designs must be predicated are explained and the use of these concepts to provide a new kind of filtering in the time domain is described. Finally, brief mention is made of the application of the information theory concepts in the design of sensory replacement devices.

(b) "STATISTICAL PREDICTION OF NOISE" BY Y. W. LEE, C. A. STUTT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

A simple form of Wiener's statistical prediction theory is given, and a demonstration of the theory using filtered noise as the random time function is de-

scribed. The noise source is a 6D4 gas tube; its output spectrum is shaped by a simple tuned circuit. This source is connected to the predictor which is designed for three prediction times. In order to determine the quality of prediction, the input and output of the predictor are recorded with the aid of a two-beam oscilloscope on a strip of continuously moving film. Close agreement is obtained between experimental results and theoretical calculations.

(c) "TRAFFIC HANDLING CAPACITY OF PAIRED-PULSE CODING FOR 100 CHANNEL DISTANCE MEASURING EQUIPMENT (DME)" BY CHARLES J. HIRSCH, HAZELTINE ELECTRONICS CORPORATION.

Distance Measuring Equipment (DME) has been adopted as a primary navigational aid by the International Civil Aviation Organization (ICAO). It is secondary radar system having 100 distinct operating channels to supply aircraft with the distance to 100 ground transponder beacons. To create 100 distinct interrogation channels, 10 interrogation frequencies are combined with 10 paired-pulse codes. Likewise, 100 distinct reply channels are created. A paired-pulse code consists of two consecutive pulses whose time separation is a characteristic of the signal. Circuits which receive only paired pulses having a specified time separation are described. The paper analyzes the extent that traffic is apparently increased by the chance combination of unwanted pulses which create acceptable spacings. Charts, experimental data, and photographs of actual equipment to support the analysis are presented. It concludes that DME is well able to support all aircraft traffic which is contemplated for the next fifteen years.

13. VACUUM TUBES I

(a) "THE HIGH FREQUENCY RESPONSE OF CYLINDRICAL DIODES" BY EDWARD H. GAMBLE, CURTISS-WRIGHT CORPORATION.

This paper includes the results of an investigation into the response of cylindrical diodes to the application of voltages which contain high frequency components. In particular the response to large signals has been determined. the term "large signal" refers to the condition that the amplitudes of the time-varying components are comparable to that of the polarizing voltage.

The approach to the problem is identical to that employed for the determination of the basic equations for the response of the planar diode which is described in a companion paper, "The Current Build-Up in a Planar Diode," by the author.

(b) "RADIAL-BEAM, VELOCITY-MODULATED MICROWAVE TUBE" BY CHESTER G. LOB AND DON F. HOLSHOUSER, UNIVERSITY OF ILLINOIS.

The status of the development of a radial-beam velocity-modulated electron tube for broadband local oscillator applications is discussed. The drift region of this tube is a hollow cylinder into which electrons are radially injected. The analysis of the potential distribution within this region is described and results are discussed. Experimental results of the tube are included.

(c) "THE 6BN6 GATED BEAM TUBE" BY ROBERT ADLER, ZENITH RADIO CORPORATION, AND A. P. HAASE, GENERAL ELECTRIC COMPANY.

I. The Laboratory Prototype and Its Circuit Applications

When an electron beam is focused upon a grid through a narrow slot in a positive accelerator, a grid control characteristic results which is useful for limiting purposes. Two such electrode systems in cascade can serve as limiter-discriminator. Prior work along related lines is reviewed and the development of the gated beam tube summarized. Typical circuits for intercarrier sound and for FM receivers are described in detail and other applications discussed.

II. The Commercial Realization of Type 6BN6

The use of sharply focused beams in grid-controlled receiving tubes represents a new departure in tube design which entails many unusual problems. Mechanical and electrical considerations in the production design are reviewed. The transfer characteristics of the 6BN6 are given and experience to date with this type, as well as plans for future types, are briefly discussed.

(d) "VOLUME DEIONIZATION PROCESSES AT IONOSPHERIC PRESSURES" BY O. T. FUNDINGSLAND AND G. E. AUSTIN, CAMBRIDGE FIELD STATION, USAF.

Methods are proposed for extending laboratory studies of electron and ion removal processes to ionospheric pressures. In order to subordinate recombination at the tube walls, diffusion of the charged particles to the walls is retarded by employing a toroidal electrodeless discharge tube with a co-annular magnetic field. A first order theory indicates that radio-frequency gyromagnetic resonance absorption can be employed to determine the relative concentrations of the various ions, and hence to compare their removal rates during the discharge afterglow. When the toroid is designed as a microwave resonant cavity, electron removal rates can be determined by measuring the frequency shift of the cavity as a function of time, after the manner of Biondi and Brown at Massachusetts Institute of Technology.

14. ELECTROMAGNETICS

(a) "ELECTROMAGNETIC WAVES IN CIRCULAR WAVE GUIDES CONTAINING TWO COAXIAL MEDIA" BY ROBERT TEASDALE, GEORGIA INSTITUTE OF TECHNOLOGY; AND THOMAS J. HIGGINS, UNIVERSITY OF WISCONSIN.

The general problem of wave propagation in a circular wave guide containing two different coaxial media is treated in detail. A conditional equation governing propagation is derived. The two conditions for which simple E or H waves can propagate are determined and discussed. Curves relating phase

velocity to design parameters are plotted for the E^0 wave. Several examples are discussed for which this general solution reduces to special solutions found by other authors. The content of this paper is applicable to the design of linear accelerators for charged particles.

(b) "SMALL SURFACE MICROWAVE DIFFRACTION" BY A. APPLEBAUM AND P. C. FRITSCH, NAVAL ORDNANCE LABORATORY.

The Huygens-Schelkunoff approach to the diffraction of electromagnetic waves is applied to a claculation of the energy diffracted back along the direction of incidence. Previous publications have dealt only with the case of normal or near normal incidence. The present paper presents the results for oblique incidence on conducting surfaces approximately a wave-length squared in area.

The simple first approximation of boundary conditions is modified by a correction factor. Graphical comparison shows the resulting correction to be significant, particularly at the "skirts" of the diffraction pattern.

Microwave techniques are applied to an experimental determination of diffraction patterns of a variety of small metal plates. A novel technique utilizing a magic Tee impedance bridge separates the background reflections from the desired pattern, thus permitting indoor "fields" measurements. Graphs are presented which demonstrate close agreement of theoretical and experimental results.

(c) "THE MAGNETIC CROSS VALVE" BY HAROLD J. McCREARY, AUTOMATIC ELECTRIC COMPANY.

This is the discussion of a basically new electromagnetic device in which two stationary coils with no mutual inductance to each other in the ordinary definition of the term, transfer energy from one coil at one frequency to the other coil at a second frequency through the medium of a vector of field of flux which follows a lissajous locus or mode of motion. It is compared to rotary electromagnetic devices in which the more simple lissajous mode of motion or circle is used and to the transformer which has but one degree of freedom.

Working models and lantern slides of characteristics will be shown.

(d) "COUPLING BETWEEN TWO DEGENERATE CAVITY MODES THROUGH SLOTS CUT IN THE CAVITY WALLS" BY H. C. HU, UNIVERSITY OF ILLINOIS.

When a slot is opened up in the cavity wall and the impedance looking into the slot is high, a boundary is imposed that the surface current in the direction perpendicular to the slot be small. Thus slots can be utilized to promote the coupling between two modes if in the direction normal to the slot the surface currents of the two modes are equal and opposite. Clearly the direction of cancellation will depend upon the relative amplitudes of the two modes, and consequently by varying the direction of such slots the degree of coupling can be made to have any desired value. An illustration of this method is a cylindrical cavity with diameter 4.74 cm and length 3.41 cm in which the TE_{113} and TE_{311} modes are degenerate i.e. both resonant at $\lambda = 3.14$ cm. Methods to determine the direction of slots will be described and diagrams of such slots in the end cap of the cylindrical cavity will be shown for $\frac{U_1}{U_2}$ equal to 2, 1 and ½; where U_1 and U_2 stand for the energy storage of TE_{113} and TE_{311} respectively. These three diagrams are indicative of the relation between the slot directions and the relative excitation of the two modes.

There are perhaps a number of applications of this scheme; one thing that is particularly obvious is its employment toward the cavity used as a microwave band pass filter, wherein the variation of coupling is a control upon the desired bandwith of transmission.

15. SUPERSONICS

(a) "APPLICATION OF SUPERSONIC ENERGY TO HIGH SPEED ELECTRONIC RECORDING" BY HOMER J. DANA AND JAMES L. VANMETER, STATE COLLEGE OF WASHINGTON.

In connection with a Navy sponsored research project on Facsimile conducted at the State College of Washington, it was necessary to develop a supersonic generator powerful enough to inscribe a new type of recording paper without touching it. For this purpose a magneto-striction oscillator was designed to operate over the range of 15 to 28 KC. A nickel alloy tube, used as the vibrating element was provided with a concave reflector in one end to focus the sound energy to a point. Using a 200 watt triode the oscillator delivers an estimated 20 watts in sound energy, part of which is available at the point of focus.

(b) "SUPERSONIC CONTROL OF A LANTERN SLIDE PROJECTOR" BY S. G. LUTZ AND GEORGE RAND, NEW YORK UNIVERSITY.

Simple electronic equipment has been developed with which a lecturer can activate an automatic lantern slide projector by means of a supersonic whistle. The whistle is attached to a small rubber bulb and is concealed in the speaker's hip pocket. The 25 kc tone is picked up by a crystal microphone and activates the projector mechanism through a relay, after amplification and rectification. Use of this device eliminates the services of a projectionist, frees the lecturer from dragging a control cable, and creates the impression of operation by "mental telepathy." The equipment will be demonstrated in projecting the slides for the paper.

(c) "VARIABLE RESONANT FREQUENCY CRYSTAL SYSTEMS" BY WILLIAM J. FRY AND WAYNE L. HALL, UNIVERSITY OF ILLINOIS.

A discussion of the problems involved in the design of a variable resonant frequency crystal system for use as a generator for ultrasonic radiation in liquid media will be presented.

The characteristics of an operating instrument will be indicated.

16. VACUUM TUBES II

(a) "A NEW RECTIFIER TUBE FOR EXTREMELY HIGH POWER AND VOLTAGE LEVELS" BY T. H. ROGERS, MACHLETT LABORATORIES, INC.

Rectifier tubes capable of operation at very high inverse voltages (50 to 150 kilovolts) have heretofore been limited to relatively low current and power. The rise of new applications for rectified current at much higher power levels in the high-voltage range (for smoke precipitation, isotope separation, long-range radar, etc.) has led to the development of a new type of high-vacuum rectifier tube, with design features to provide lower anode power loss, higher anode power dissipation capacity and higher peak emission. Such tubes can handle a peak current of 10 amperes and an inverse voltage of 110 kilovolts. A three-phase power supply unit employing such tubes can deliver 360 KW of power at 100,000 volts, d.c.

(b) "A PROGRESS REPORT ON DEVELOPMENT OF THE TRAVELLING WAVE TUBE AS A POWER AMPLIFIER" BY STANLEY E. WEBBER, GENERAL ELECTRIC COMPANY.

This paper describes the experimental observations made while investigating the use of the travelling wave principle to make a wide band power amplifier. A tube will be described which, using a conventional helix type of wave guide, has been operated at a power output in excess of 500 watts, at a frequency of 500 megacycles per second. The power gain is of the order of 25 and the efficiency about 20 percent or more. It has been found that the most important factor governing operation of the travelling wave tube as a power amplifier has been the location and amount of the attenuation used to suppress oscillations. Results of this work on attenuation will be discussed.

(c) "EFFICIENCY OF REFLEX KLYSTRONS" BY WILLIAM G. SHEPHERD, UNIVERSITY OF MINNESOTA.

It has been proposed that the efficiency of a reflex klystron might be increased by having the electrons on their first transit of the gap interact weakly with the resonator field while on the return transit they interact strongly. The paper is concerned with a theoretical analysis of this problem. The results indicate that there is little to be gained by this method except for very short drift angles. Even in this case the gain is limited by electrons unable to retraverse the resonator gap.

(d) "DESIGN FEATURES AND SOME APPLICATIONS OF A NEW PHOTOCELL" BY J. H. CROW AND V. C. RIDEOUT, UNIVERSITY OF WISCONSIN.

A new vacuum photocell with a photo-emissive cathode and two anodes has been designed for use in circuits where the photocell transfer constant must be rapidly altered. The large but linear variation in gain with voltage on the added electrode will allow many applications in addition to that for which it was originally designed.

17. CIRCUITS

(a) "A VERSATILE CRYSTAL CONTROLLED SOURCE OF ANGLE MODULATION" BY JAMES F. GORDON, BENDIX AVIATION CORPORATION.

A crystal controlled source of angle modulation is described wherein relatively large deviations are accomplished without sacrificing stability.

Peculiar to the circuit is high angle modulation sensitivity plus negligible amplitude modulation as a result of the modulating voltage.

Modulation is very linear and for practical deviations is superior to that usually accomplished with modulated crystal circuits.

The simplicity of the circuit plus the small number of vacuum tubes used provides a means of simplifying many existing FM communications transmitters.

(b) "THE 'DC TRANSFORMER' AS A COMPONENT IN ELECTRONIC CIRCUITS" BY OTTO H. SCHMITT, UNIVERSITY OF MINNESOTA.

It has been found possible to construct a circuit consisting of a linear oscillator, an efficient r.f. transformer, and a linear varistor demodulator in a compact inexpensive form such that the entire assembly can be treated as a component in a circuit design. The component acts like a transformer, can be designed with various ratios and taps, has wide band frequency response, a fair efficiency and can handle considerable power yet is better isolated than a conventional transformer and handles DC as well as AC signal. Applications to modulators, amplifiers, voltage regulators, stimulators, measuring bridges and isolated power supplies will be described.

(c) "TRANSIENT RESPONSE OF FILTERS" BY M. S. CORRINGTON, RADIO CORPORATION OF AMERICA.

The ideal low-pass filter is defined as one which is perfectly flat for frequencies from zero to cutoff and attenuates at a fixed number of decibels per decade beyond. The transient response of such a filter has been computed and it is shown that such a characteristic is not necessarily desirable when the time of rise and amount of overshoot are important. From this basic transient response it is possible to derive many solutions for selectivity curves composed of straight line segments. These can be used for comparative purposes when designing practical circuits.

There are often simple relations between the transient response of a low-pass filter and that of the corresponding high-pass filter. Many curves are given to show these responses, as well as the effect of peaking and rolloff near cutoff.

18. AUDIO-FREQUENCY

(a) "CONTINUOUSLY ADJUSTABLE LOW AND HIGH-PASS FILTERS FOR AUDIO FREQUENCIES" BY ARNOLD PETERSON, GENERAL RADIO COMPANY.

Filter circuits with continuously adjustable cut-off frequencies have been developed for audio frequencies. Each filter section uses two capacitors, one low-Q coil and a twin-triode variable reactance circuit. By proper proportioning of the filter elements, the variable reactance circuit produces a smooth variation in cut-off frequency over a 3:1 frequency range without serious change in the nature of the pass-band response. A single potentiometer controls the cut-off frequency over this 3:1 range, and the range may be extended in steps by switching the coil and the two capacitors. Beyond cut-off the low and high-pass filter sections have an attenuation of about 18 db per octave. The discussion will include an explanation of the filter design and the circuit details which achieve the above characteristics even though very few elements are used.

(b) "A VARIABLE SPEED TURNTABLE AND ITS USE IN THE CALIBRATION OF DISK REPRODUCING PICKUPS" BY H. E. HAYNES AND H. E. ROYS, RADIO CORPORATION OF AMERICA.

The frequency response of a disk reproducing pickup, when measured by means of a conventional variable-frequency test disk, is a function of the dimensional and physical properties of the disk, as well as of the pickup itself. This is because the effects of elastic deformation of the record material and of finite stylus tip size vary with the physical wavelength of the undulations of the recorded groove, and hence with frequency. If variations of test frequency are instead produced by variations of the rotational speed of a constant frequency disk, the above mentioned effects are constant and do not affect the response characteristic of the pickup. A test procedure embodying this latter method is discussed, along with experimental results which have been obtained.

A variable speed turntable well suited to this method of calibration is described in considerable detail. It covers a very wide continuous range of speeds, with excellent speed stability and low flutter.

(c) "METHODS AND INSTRUMENTS FOR THE VISUAL ANALYSIS OF COMPLEX AUDIO WAVEFORMS" BY H. R. FOSTER AND E. E. CRUMP, KAY ELECTRIC COMPANY.

Recently developed methods and instruments for the visible speech work initiated at the Bell Telephone Laboratories are now being applied to a wide variety of uses in the audio and supersonic field. Common to these new instruments is the three-dimensional display of time-frequency and amplitude. A description and demonstration will be given of at least three new instruments. The Sona-Graph is a sound spectrograph which produces written records on facsimile paper of the time-frequency-level of audio sounds up to 8000 cps. The Sonalator is a 29-channel instantaneous speech translator which employs 29 separate crystal filters and a rotary beam switching tube to give a visible speech display on a cathode ray tube. The Sonactor is an instantaneously-acting pitch extractor. Other instruments now under development will be shown if complete by September.

(d) "DEVICES FOR SPEECH ANALYSIS AND COMPRESSION" BY DR. ING. HABIL FRIEDRICH VILBIG, CAMBRIDGE FIELD STATION.

1. Vibrating String Filter. A filter, consisting of many steel strings, will be excited into mechanical vibrations by means of an exciting coil. The vibrating strings which are used to excite an electrostatic pick-up device are tuned in such a manner that their resonance curves are packed closely together. Since the resonance curve of such a vibrating string is very narrow (1 to 2 cycles) the whole system will be immersed in damping liquids, to obtain bandwidths between 30 and 40 cycles for each string. Since an electromagnetically excited system of this sort is a non-linear device, it is possible to pick off the fundamental vibration from a string which is excited in a harmonic. With such a device it might be possible to frequency-divide and, with special pick-ups, to frequency-multiply a desired frequency band. It is further intended to investigate the transient properties of such a filter. If, through a suitable device, interfering frequencies are wobbulated with respect to desired frequencies, then an effective elimination of the interference is perhaps possible since the desired frequency will pass through the string filters while the wobbulated interfering frequencies due to transient phenomena in the filter will appear at the output only as background noise. String filters of any desired characteristics could be devised merely by on-and-off switching of the string.

2. Frequency Analysis and Frequency-Band Division. Wave forms of speech or other types of vibration are electro-mechanically recorded on a film. Using diffraction-grating techniques, a diffraction spectrum is produced by optical means from the film pattern. Through a rotating prism, this spectrum is then projected onto a stationary spiral split. Light passing through the slit is transformed bya photocell into current variations. With this combination of rotating prism and spiral slit, a point-by-point scanning of the diffraction pattern is made possible. The current variation produced by the photocell will be proportional to the intensity of the spectral line and will be used to control the vertical deflection of a cathode-ray tube. If the horizontal time deflection is synchronized with the rotation of the prism then the amplitude distribution of the spectrum can be displayed on the cathode-ray tube. Instead of a spiral slit, a disc with a special type pattern has been printed onto the disc with the above apparatus may be used. Each individual spectral line will excite in the photocell a frequency (or a special signal) which will depend on the type of pattern on the disc. Thus it is possible to arrange that the photocell will pick up frequencies which are related to the speech frequency or to the frequencies in the speech spectrum in any desired speech frequency ratio. A speech band comprising 300 to 3000 cycles might thus be changed into a band of 100 to 200 cycles, etc.