WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

OCTOBER 1952

VOL. 29 No. 349 THREE SHILLINGS AND SIXPENCE

EDISWAN

SPECIAL PURPOSE

VALVES

Of particular interest

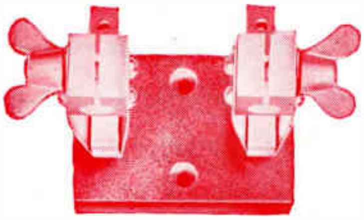
TO THE DESIGNERS OF R.F. HEATING AND DIATHERMY APPARATUS

The ES.833 is a high mu triode particularly suitable for use as an R.F. Power Amplifier, Oscillator or Class B Modulator. It is a direct plug-in replacement for the American type 833A.

The anode and grid connections are brought out at the top and are taken through metal-to-glass seals to heavy current terminals. As a result of this construction the valve is exceptionally efficient at higher radio frequencies, and may be operated under Class 'C' CW conditions at a maximum input of 2 kW at frequencies up to 30 Mcs. At a reduced input rating it is possible to operate the valve as high as 75 Mcs.

RATING		RADIATION COOLED	AIR COOLED
Filament Voltage (volts)	Vf	10.0	
Filament Current (amps)	If	10.0	
Maximum Anode Voltage (volts)	Va (max)	3000	4000
Maximum Anode Dissipation (watts) Radiation cooled	Wa (max)	300	
Maximum Anode Dissipation (watts) Forced Air cooled	Wa		400
Amplification Factor	μ	35	
Maximum Operating Frequency at full rating		30 Mcs.*	

* *Operating frequency at reduced ratings up to 75 Mcs.*



Prices and technical data upon application.

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Left : Type 50-B ‘VARIAC’

Right : Type 100-R ‘VARIAC’

SERIES 200 ‘VARIAC’ TRANSFORMERS

SPECIFICATIONS

Type	Load Rating	Input Voltage	Current		Output Voltage	No-Load Loss	Net Price £ s. d. *
			Rated	Maximum			
200-CM	860 va.	115 v.	5 a.	7.5 a.	0-135 v.	15 watts	7 17 6
200-CU							6 15 0
200-CMH	580 va.	230 v.	2 a.	2.5 a.	0-270 v.	20 watts	9 15 0
200-CUH		115 v.	0.5 a.	2.5 a.	0-270 v.	20 watts	8 5 9

* All ‘VARIAC’ prices plus 20% as from 23rd Feb. 1952

Full details of this and other models in the ‘VARIAC’ range are contained in Catalogue V549, which will gladly be sent on request.

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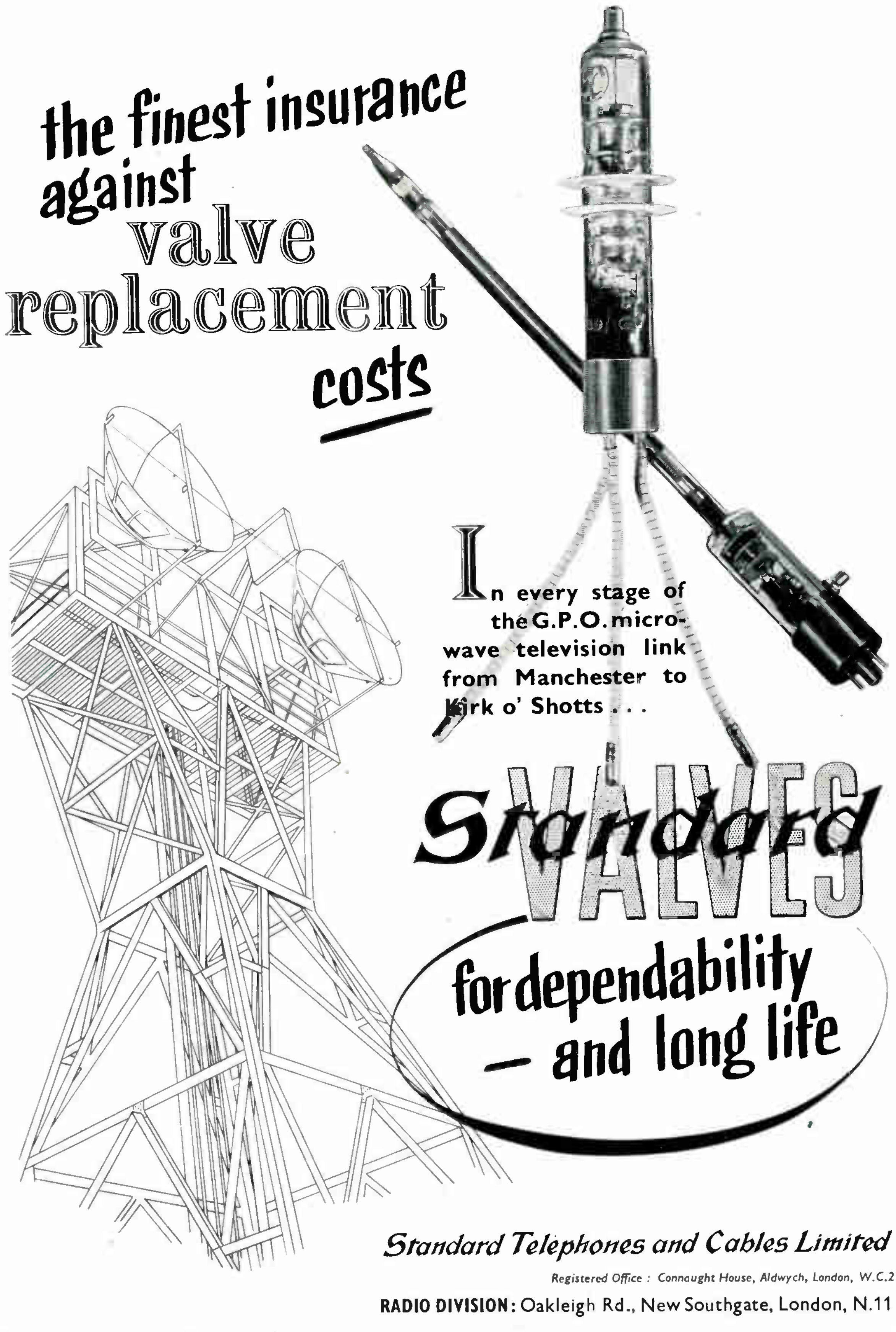

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12-inch, 15-watt, P.M. LOUDSPEAKER

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The very much improved acoustic properties of this, the latest in the famous range of AXIOM High Fidelity Loudspeakers, command the admiration of all those who require quality and value in a speaker.

This high fidelity reproducer gives extremely smooth response in the middle and upper registers, ensuring minimum "scratch" from recordings. On most inputs this shows to advantage no matter what the origin.

In addition the AXIOM 150 Mk II has a wide frequency range and the very low bass resonance ensures faithful reproduction down to the lowest frequency encountered in orchestral reproduction. This new AXIOM is a marked advance on past models and is suitable for use with all good quality amplifiers.

You are invited to write for details of the Axiom 150 Mk II and the special reflex cabinets designed with speaker aperture at optimum listening height.

SPECIFICATION

Frequency Coverage ...	30/15,000 c.p.s.
Overall Diameter ...	12 5/16" (31·3 cms)
Overall Depth ...	6 15/16" (17·6 cms)
Fundamental Resonance ...	35 c.p.s. nominal
Voice Coil Diameter ...	1 3/4" (4·4 cms)
Voice Coil Impedance ...	15 ohms at 400 c.p.s.
Max. Power Capacity ...	15 watts peak A.C.
Flux Density ...	14,000 gauss
Total Flux ...	158,000 maxwells
Net Weight ...	12 lb. 13 ozs.

GOODMANS Goodmans Industries Ltd., Axiom Works, Wembley, Middx. WEMbley 1200

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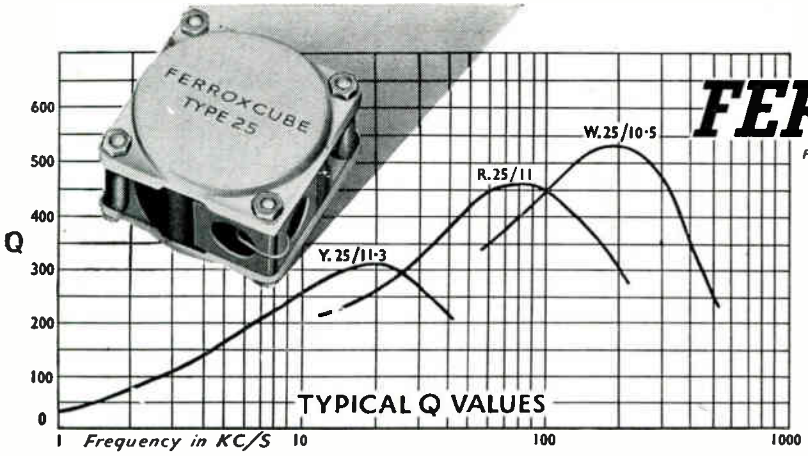
FERROXCUBE TYPE 25
Q
600
500
400
300
200
100
0
W.25/10·5
R.25/11
Y.25/11·3
TYPICAL Q VALUES
1
Frequency in KC/S
10
100
1000


UNIVOX

a New MILLIVOLTMETER by RIVLIN INSTRUMENTS

The Rivlin Millivoltmeter, Model MV.1, is a high quality instrument for measuring A.C. Signal Voltages in eight ranges from 10 mV to 25 V f.s.d. in the frequency range 20 c.p.s. to 500 kc/s. In this instrument a high impedance cathode follower feeds a three-valve amplifier through a range controlling attenuator, the output of the amplifier being connected to the meter through a crystal rectifier bridge. About 20 db negative feedback is applied around the amplifier system resulting in high gain stability and this, together with additional electronic stabilisation, ensures freedom from the effects of normal mains voltage variations.

The degenerative characteristics of the input cathode follower are used to provide a low capacitance input connection at the end of a coaxial cable, thereby dispensing with the need for a bulky probe. Model MV.1 may also be used as a stable amplifier with a maximum gain of 10,000. Output connections at low impedance are provided and in this application the frequency response remains unaltered.

Construction of this Millivoltmeter is to the high standards associated with the products of Rivlin Instruments. Components are of high quality and conservatively rated, and no electrolytic condensers are used in H.T. circuits.

Model MV.1 is supplied in a case for bench use but, if required, the panel can be withdrawn and the instrument mounted into a standard rack without modification. Early delivery can be offered.

Descriptive literature and details available on request to Dept. 7.

RIVLIN INSTRUMENTS, 7A MAITLAND PARK VILLAS, N.W.3

Telephone - GULliver 2960

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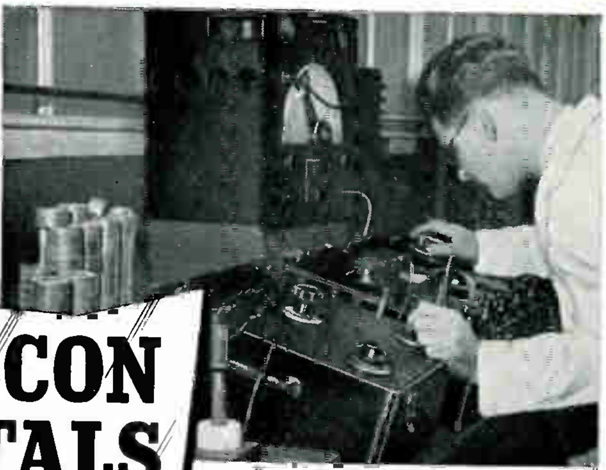
Close technical control of production is an all-important factor in the manufacture of Telcon Metals. Accurate tests and measurements are made at various stages in the course of production and the illustrations show two of the many routine examinations conducted in our well-equipped laboratories.

Routine Factory testing of Mumetal toroidal cores.

TELCON METALS



Precision measurement of magnetic characteristics of toroidal Mumetal cores by the Ferrometer.

MAGNETIC ALLOYS—Mumetal, Radiometal, H.C.R., Rhometal, Permendur, R2799, 36-64, Dust.
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PHASE MEASURING EQUIPMENT

TYPE RX.103

THIS equipment has been developed and manufactured by Airmec from a General Post Office Research Branch design. It was primarily intended for the measurement of the loop-phase-shift and gain of feedback repeaters over the frequency range 50 kc/s—20 Mc/s, but it is equally suitable for the measurement of these quantities in amplifiers, filters, equalisers and other four-terminal networks.

Full details of this or any other Airmec instrument will be forwarded gladly upon request.

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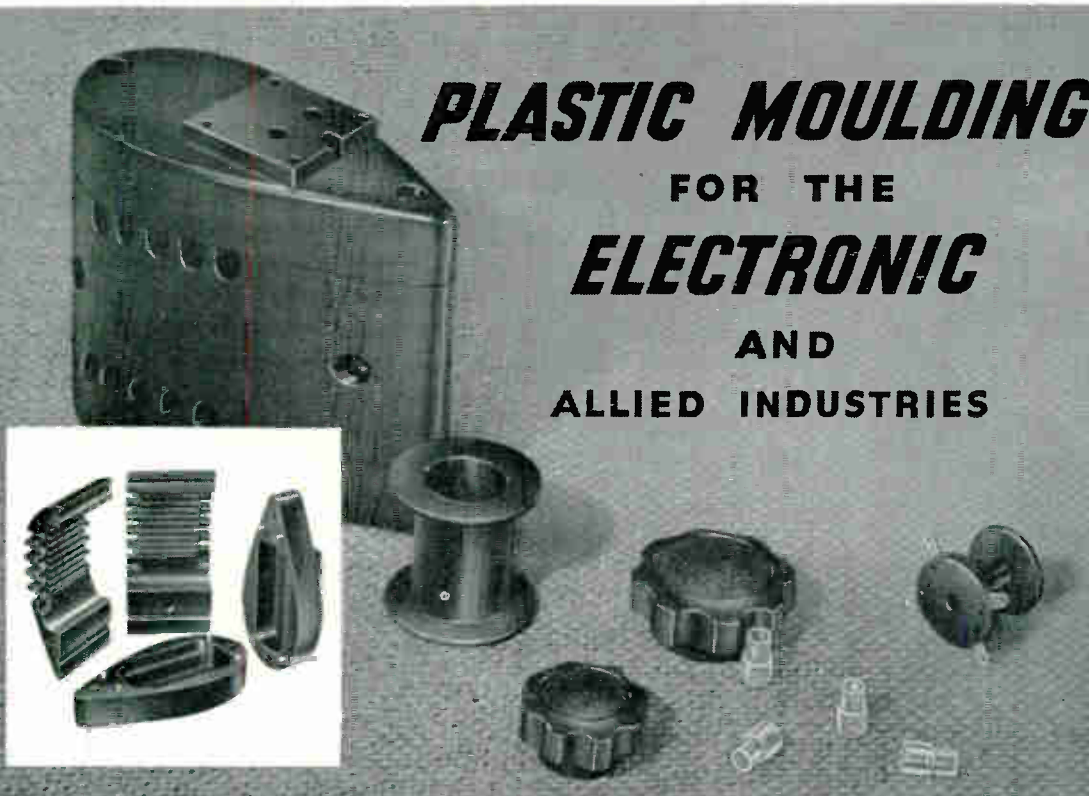

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- AMPLE CAPACITY AVAILABLE FOR ALL COMPRESSION MOULDINGS, UP TO 250 TON PRESSES, AND SMALL PRECISION MOULDINGS IN THERMOPLASTICS.
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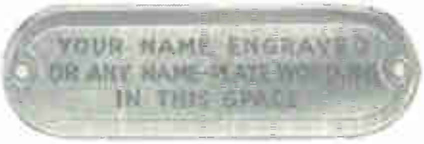

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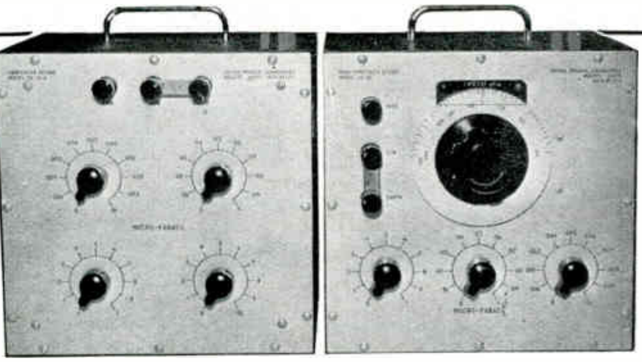
CONDENSER DECADE

Model CD131

B P L



Designed to meet the general requirements of the communications engineer, the B.P.L. Condenser Decade provides a wide range capacitor in a compact size ideally suited for general experimental work. This model can be safely used for low frequency as well as radio frequency work.

ACCURACY. There is a direct reading accuracy of plus or minus 1%. However, a test certificate is provided stating the actual capacity to an accuracy of plus or minus 0.1%. This arrangement meets all requirements experienced in practice. Should a higher degree of accuracy be required, a N.P.L. calibration can be provided at an extra charge.

CAPACITY RANGE: Model CD 131-A, 110 pf. to 1.11 MFD. continuously variable. Air dielectric variable condenser 100 to 1,100 pf., plus 10 × .001, plus 10 × .01, plus 10 × .1 MFD. Model CD 131-B, .001 MFD. to 11.11 MFDS., consisting of four decades: 10 × .001, plus 10 × .01, plus 10 × .01, plus 10 × .1, plus 10 × 1 MFD.

DIELECTRIC: Model CD 131-A, MICA. Model CD 131-B, up to 1 MFD. mica; above that value, paper.

DIMENSIONS: 9 in. x 9in. x 6in. (deep).

WEIGHT: 10½ lb.

Full specification supplied on request.

SENSITIVE	PANEL	MOUNTING	METERS
SIZE	2½"	3½"	5"
RANGE	25μA to 50A	15μA to 50A	15μA to 50A

Prices on application

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There are five important advantages of the new process:

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The new metallising is applied to all the hermetic seals of the standard range (shown in catalogue No. 25, available on request). Special types, including multi-seals, can readily be produced to customer's requirements. Please write to us for further details. We shall be glad to answer any queries on the new metallised ceramics.

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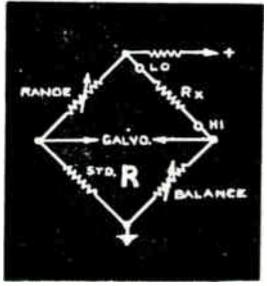
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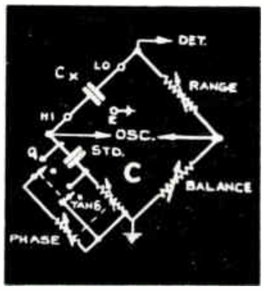
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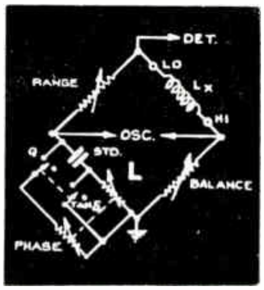
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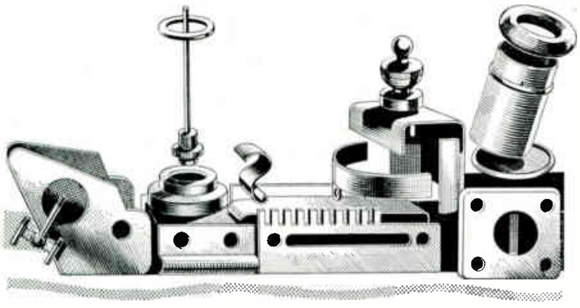

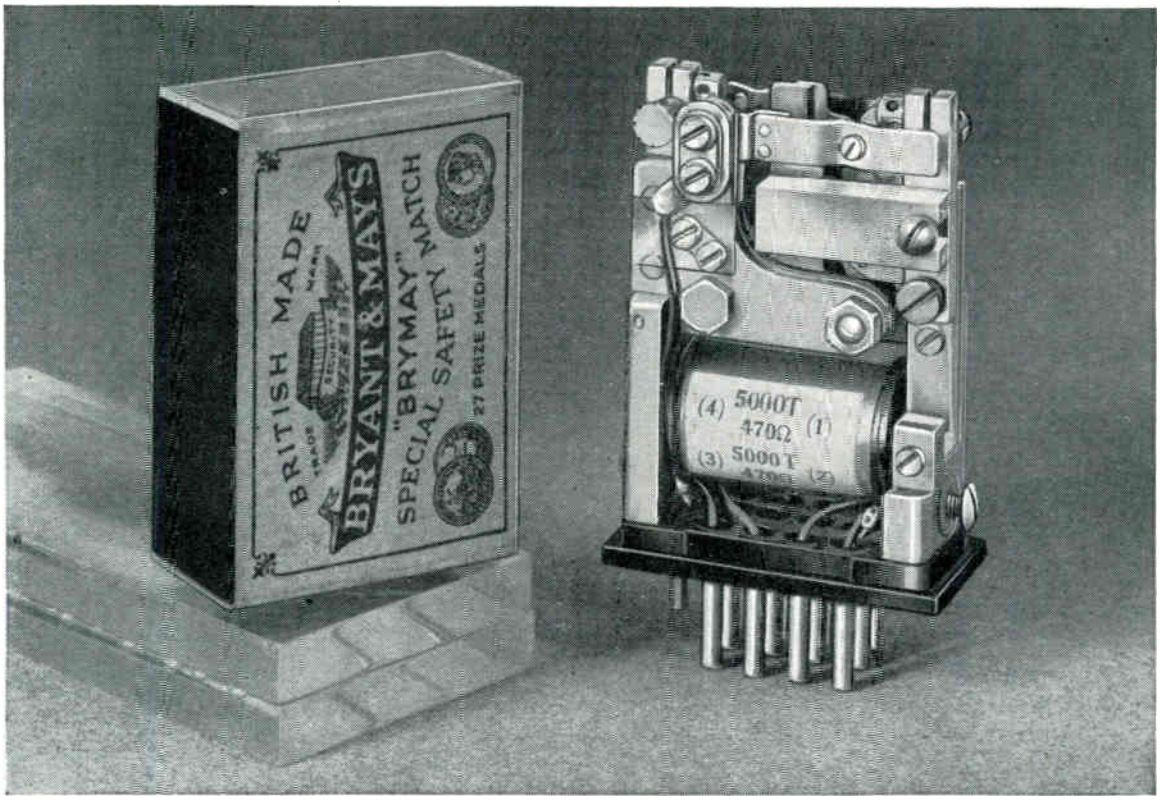

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Considering it is only the size of a matchbox the Type 5 Carpenter Polarized Relay is capable of a surprisingly high performance providing answers to problems in many fields of electrical engineering. Outstanding features of the Type 5 include:

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IMMUNITY FROM POSITIONAL ERROR • GOOD CONTACT PRESSURES
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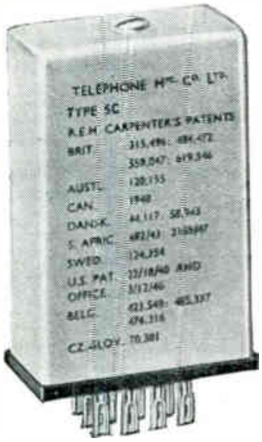
RUGGED DESIGN • EXCEPTIONAL THERMAL STABILITY



Plug or solder tag base optional.

Dimensions—(With cover. Excluding connecting pins.) $2\frac{3}{16}$ *ins. high.* $1\frac{7}{16}$ *ins. wide.* $\frac{3}{4}$ *in. deep. Weight (including socket)* 4.8 *oz.* (137 *gm.*)

Complete specification and further details of the complete range of Carpenter Relays may be had on request.

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CARPENTER POLARIZED RELAY TYPE 5

Manufactured by the Sole Licensees:

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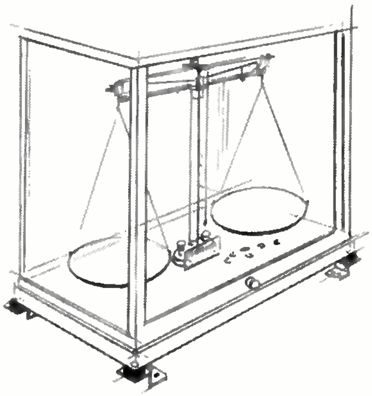


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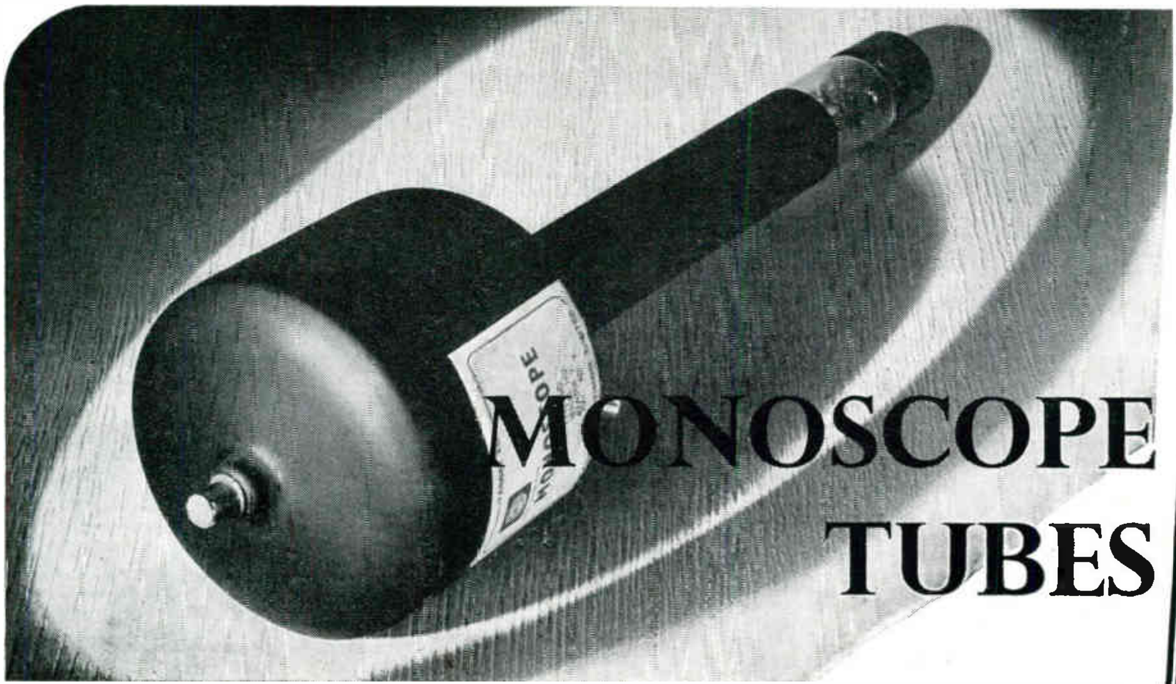

MONOSCOPE TUBES

THE Monoscope is basically a simple caption scanner apparatus capable of providing a video signal derived from a fixed pattern within the tube.

Almost any pattern comprising pure line, halftones or a combination of both can be supplied on receipt of specific requirements, and two standard types are available.

Type J.101 — Test Chart "A"
Type J.201/XI — Test Chart "C"

TYPICAL OPERATING DATA

Deflection	*electromagnetic*
Focus	*electrostatic*
Vh	6·3 *V*
Vg (cut-off)	−50 *V*
Va1	1200 *V*
Va2 (focus)	800/850 *V*
Va3 (wall)	1200 *V*
V target	1160/1200 *V*
I target	5µ*A*

Resolution better than 500 lines
Video Signal 0.5µA peak to peak (min)

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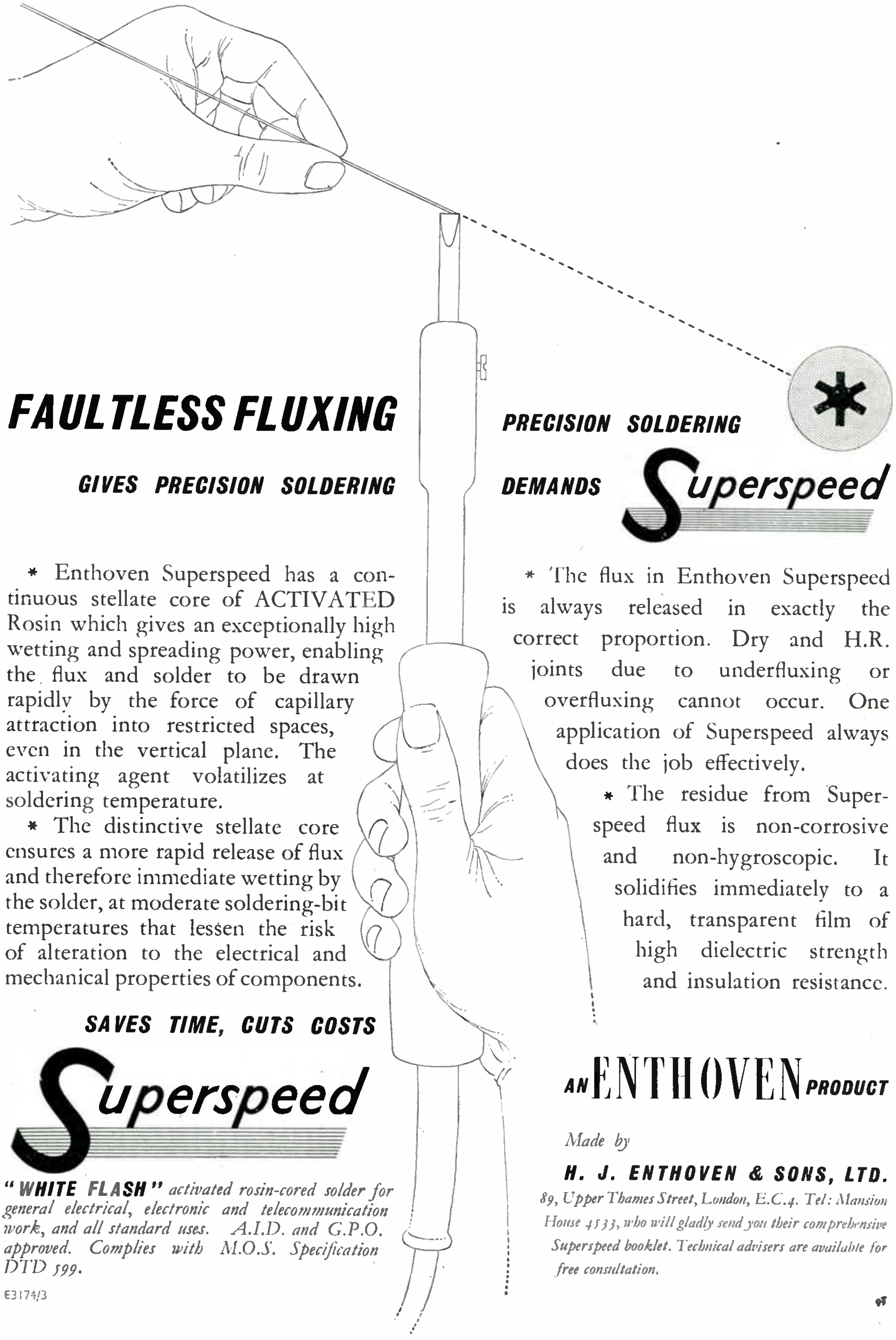

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GIVES PRECISION SOLDERING

* Enthoven Superspeed has a continuous stellate core of ACTIVATED Rosin which gives an exceptionally high wetting and spreading power, enabling the flux and solder to be drawn rapidly by the force of capillary attraction into restricted spaces, even in the vertical plane. The activating agent volatilizes at soldering temperature.

* The distinctive stellate core ensures a more rapid release of flux and therefore immediate wetting by the solder, at moderate soldering-bit temperatures that lessen the risk of alteration to the electrical and mechanical properties of components.

SAVES TIME, CUTS COSTS

Superspeed

"WHITE FLASH" *activated rosin-cored solder for general electrical, electronic and telecommunication work, and all standard uses. A.I.D. and G.P.O. approved. Complies with M.O.S. Specification DTD 599.*

E3174/3

PRECISION SOLDERING DEMANDS Superspeed

* The flux in Enthoven Superspeed is always released in exactly the correct proportion. Dry and H.R. joints due to underfluxing or overfluxing cannot occur. One application of Superspeed always does the job effectively.

* The residue from Superspeed flux is non-corrosive and non-hygroscopic. It solidifies immediately to a hard, transparent film of high dielectric strength and insulation resistance.

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WIRELESS ENGINEER

The Journal of Radio Research and Progress

Managing Editor: HUGH S. POCOCK, M.I.E.E.
Editor: W. T. COCKING, M.I.E.E. Technical Editor: Professor G. W. O. HOWE, D.Sc., LL.D., M.I.E.E.

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CONTENTS

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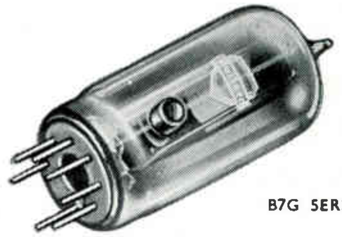
The Mullard range of all-glass photocells for industrial applications


B7G SERIES


B8G SERIES

WIRED-IN SERIES


DEVELOPED on the all-glass technique, Mullard photocells have the outstanding advantages of rigid construction and freedom from microphony, maximum ratio of cathode area to bulb size, high sensitivity and stability and positive location with uniform orientation. They are available on either the B7G or B8G base, with alternative cathode surfaces: caesium-silver oxide (C type cells) with a high sensitivity to red and infra red radiations; and caesium-antimony (A type cells) with a high sensitivity to daylight and radiations of blue predominance.

For applications where savings in space are a prime consideration, as for example, in compact photo-electric equipments, a small wired-in photocell, suitable for end-on incidence of illumination, is also available.

Brief technical details of the Mullard range of photocells are given below. Those who require more comprehensive information, including principles of operation, characteristic curves, and circuit details, are invited to apply for the revised edition of the Mullard publication " Photocells for Industrial Applications ".

PRINCIPAL CHARACTERISTICS OF MULLARD INDUSTRIAL PHOTOCELLS.

Type	Base	Max. Anode Supply Voltage (V)	Max. Cathode Current (μA)	Max. Dark Current at Max. Anode Supply Voltage (μA)	Sensitivity* (μA/lumen)	Max. Gas Amplification Factor	Projected Cathode Area (sq. cm.)
20CG	B8G	90	5.0	0.1	150	10	6.7
20CV	B8G	150	20	0.05	25 (V_a = 100V)	Vacuum	6.7
58CG	Wire-in	90	1.5	0.1	100	9	1.1
58CV	Wire-in	100	3.0	0.05	20 (V_a = 50V)	Vacuum	1.1
90AG	B7G	90	2.5	0.1	150	7	4.0
90AV	B7G	100	5.0	0.05	45	Vacuum	4.0
90CG	B7G	90	2.0	0.1	125	10	3.1
90CV	B7G	100	10	0.05	20 (V_a = 50V)	Vacuum	3.1

*Sensitivity measured at max. anode supply voltage, with the whole cathode area illuminated by a lamp of colour temperature 2,700°K., and with a series resistor of 1MΩ.

Mullard

MULLARD LTD., COMMUNICATIONS & INDUSTRIAL VALVE DEPT., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2
MVT 125

WIRELESS ENGINEER

Vol. 29 OCTOBER 1952 No. 349

Dr. H. C. Pocklington

WHEN reviewing "Antennas: Theory and Practice," by Schelkunoff and Friis[*] we mentioned that the authors give great credit to Dr. H. C. Pocklington, F.R.S. They say "Half a century ago Pocklington demonstrated that the current and charge on thin perfectly conducting wires are propagated approximately with the velocity of light and that between any two points of monochromatic excitation the current distribution is approximately sinusoidal. Much of practical antenna theory has been based on this fundamental result. The author of this approximation was apparently forgotten. Some radio engineers call it a practical engineering approximation, and some theoreticians once called it a colossal fraud. Engineering books made no effort to present the theory back of it, and it is not surprising that this approximation was sometimes misused. Slender poles have often been placed on the tops of broadcasting towers to increase their effective heights, apparently without the realization that, although the currents in the towers and the poles are approximately sinusoidal, the sinusoids do not constitute one sinusoid, and that some further theorizing would have indicated that the poles are almost ineffective. The importance of phase in deviations of antenna current from the sinusoidal form has sometimes been overlooked, and measured results have been misinterpreted." The authors then say that they devote a whole chapter to this subject.

The paper referred to was entitled "Electrical Oscillations in Wires" and was read by Pocklington before the Cambridge Philosophical Society on Monday, 25th October, 1897, and published in their *Proceedings*, Vol. IX, p. 324. This was only eight years after Hertz's paper in Wiedemann's Annalen to which Pocklington refers. It is unfortunate that in the opening paragraph the fundamental formula is given as $\nabla^2 (P, Q, R) = V^2 d^2(P, Q, R)/dt^2$ where P, Q, R are the components of the electric field and V the velocity of light. Consideration of the dimensions shows at once that V^2 should be $1/V^2$ but fortunately this does not vitiate any of the subsequent results.

The author of this paper was not quite so forgotten as Schelkunoff and Friis imagine, for in the book "Currents in Aerials and High Frequency Networks," by Dr. F. B. Pidduck, published in 1946, Section 4 is entitled "Pocklington's Theory," and the author adopts the somewhat unusual procedure of quoting word for word about a quarter of the paper with slight changes of notation. Without mentioning it he corrects the above mentioned mistake. He then says "In what follows we shall proceed more freely with the development of Pocklington's idea, incorporating the theory of Murray[†] which follows naturally from it." In another book "Advanced Antenna Theory," by Schelkunoff, published within the last few months, great credit is given to Pocklington. It says in the preface "Hertz's analysis of electromagnetic waves excited by an oscillating charge gives automatically the forces existing between two such charges. From this point on, waves in the medium may be ignored. Instead one's attention may be concentrated on the currents in the various sections of the antenna as is usually done in the case of electric networks. Mathematically, Maxwell's equations with various boundary conditions become converted into integral equations. It was by this method that Pocklington obtained

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[*] *Wireless Engineer*, September 1952, p. 253.

[†] *American Journ. Math.*, 1931.

the important sinusoidal approximation to the current in thin antennas, and the natural frequencies and damping constants of circular loops." After referring to the more recent work of Hallén, Stratton and Chu, Schelkunoff says "Many years passed before Hertz's and Pocklington's theoretical results became fully exploited. It may take as many years again for full exploitation of the new results, although even now there is ample evidence that recent theoretical work has not been in vain."

Pocklington sets out clearly in his paper how he proposed to simplify the Hertzian equations; he assumed the wire to be a perfect conductor of small diameter; he then says "The method of solution is to start with the simplest solution of the general equations and by adding an infinite number of such solutions together to obtain one of sufficient generality. The arbitrary function which represents the infinite number of arbitrary constants introduced into this last solution is then found from an equation deduced from the surface condition. The last part of the work is conducted by means of approximations." We do not propose to go into the matter any further; anyone interested can consult either Pocklington's original paper or Pidduck's book.

We regret that this Editorial note is of the nature of a double obituary, for Dr. Pocklington, who was fourth wrangler and Smith's Prizeman in 1892, died on 15th May, aged 82, and Dr. Pidduck, who was for many years a Fellow and Tutor of Corpus Christi College, Oxford, and had retired to Keswick, went out for a walk on 18th June, and was not seen again until his body was found on 1st July, near Scafell Pike; he was 66 years old.

G. W. O. H.

NETWORKS WITH MAXIMALLY-FLAT DELAY

By W. E. Thomson, M.A.

(P.O. Research Station)

SUMMARY—A certain series of systems has the property of having maximally-flat delay.

The impulse responses of the systems provide pulses which can be made more and more symmetrical, and more and more free from overshoot, by increasing the order, n, of the system, which means increasing the complexity of the network which has these properties. For a given number of components, the degree of symmetry achieved is better than with present comparable schemes. The Gaussian (normal error) curve is approached as n increases indefinitely.

Possible applications of these systems are:—

(1) pulse-shaping networks, (2) amplifiers, low-pass or band-pass, with small phase distortion and good waveform response, and (3) amplifiers, low-pass or band-pass, or filter networks, with Gaussian frequency response.

For amplifiers, a gain-bandwidth factor can be achieved which, considering the waveform response achieved, and the complexity of the networks involved, is an improvement on present schemes.

Introduction

A NEED arose for a passive network with a symmetrical and smooth impulse response resembling, say, a sine-squared or a Gaussian pulse. A promising series of networks with maximally-flat delay, and hence 'maximally-symmetric' impulse response was investigated, these being related to a series of all-pass networks with maximally-flat delay, previously investigated by the author.[1] They were found to be satisfactory for the purpose and this application is discussed elsewhere.[2]

Another, and probably more generally useful, application of these systems is to the construction of multi-stage wideband amplifiers (low-pass or band-pass) with small phase distortion, an approximately Gaussian frequency response, and hence also an approximately Gaussian impulse response; it is this application which is stressed in this paper.

The problem studied is, in effect, the same as

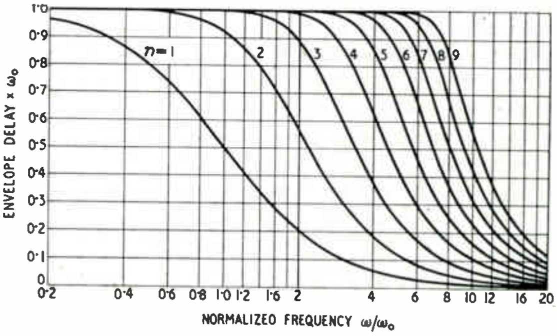

Fig. 1. *Envelope delay of networks.*

MS accepted by the Editor, December 1951.

that studied by Laplume[3,4] who has given solutions for 2-, 3- and 4-stage amplifiers. In this paper a much more general and complete treatment is given.

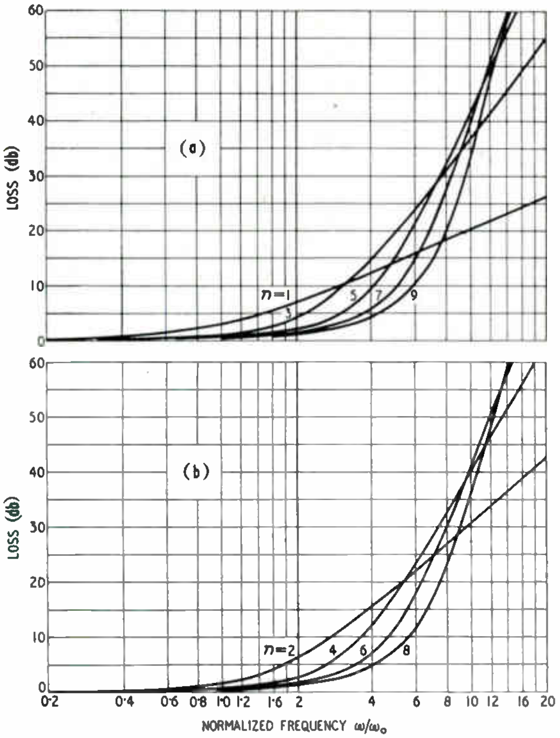

Fig. 2. *Loss of networks.*

Characteristics of the Systems

In this section we describe, with the aid of various curves, those characteristics of the systems which are of interest to the designer. Those interested in the theory will find an outline in the Appendix. The characteristics are dealt with under two headings, first, frequency response, sub-divided into delay/frequency and loss/frequency, and secondly, waveform response. There are, also, two points of view; the systems can be regarded as giving approximations to a delay line, the bandwidth increasing with the parameter n, or to a constant-bandwidth system, in which the delay distortion decreases with increasing n.

Constant-Delay System

If the zero-frequency delay of the system is $1/\omega_0$ sec the families of curves in Figs. 1 and 2 show the effect of increasing n. The delay (Fig. 1) remains practically constant up to a particular frequency (which increases with n) and then falls steadily to zero. This behaviour is associated with the fact that the delay is maximally flat; this is enlarged upon in the appendix. The bandwidth also increases with n and the rate of cut-off becomes steeper; the loss tends to the Gaussian form

$$\frac{10\,(\omega/\omega_0)^2}{(2n-1)\log_e 10}\ \text{db}$$

from which an approximation to the 3-db bandwidth is

$$\omega_0\sqrt{(2n-1)\log_e 2}$$

This and the exact 3-db bandwidth are shown in Fig. 3 which shows that the approximation is reasonably good for $n \geqslant 2$. Fig. 3 also shows the 'delay bandwidth' which has been taken, for simplicity, as the frequency at which the delay has fallen to half its zero-frequency value. This delay bandwidth increases with n much more rapidly than the loss bandwidth, emphasizing the fact that the delay distortion is reduced by increasing n.

For the waveform response we use the response to a unit impulse (delta-function); i.e., a pulse of infinite amplitude and with infinitesimal width but unit area. The unit-step response is the integral of the unit-impulse response. Figs. 4 and

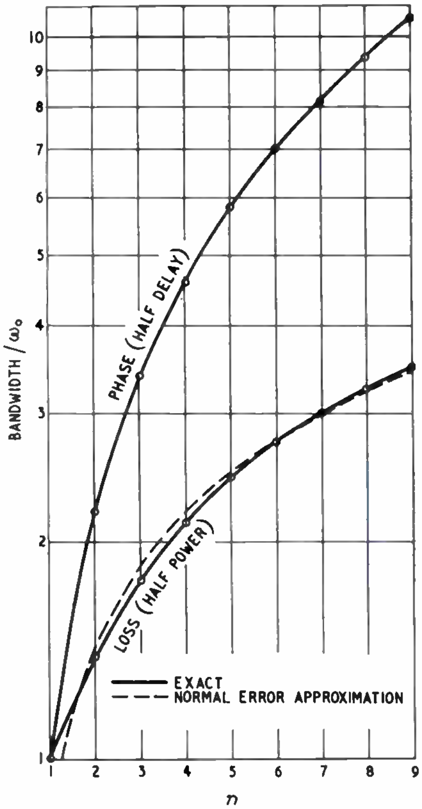

Fig. 3. *Bandwidth of networks.*

5 show the unit-impulse response for $n = 2$, 5 and 9 and illustrate the facts that:

(1) for all values of n the response is centred about $t = 1/\omega_0$

(2) the response has the shape of a rounded pulse which increases in amplitude, decreases in width, and improves in symmetry, as n increases;

(3) there is a small overshoot.

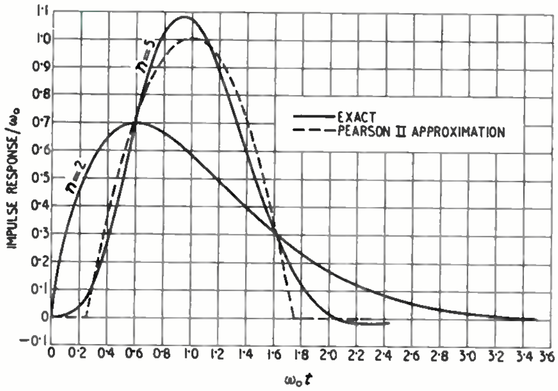

Fig. 4. *Impulse response of networks; orders 2 and 5.*

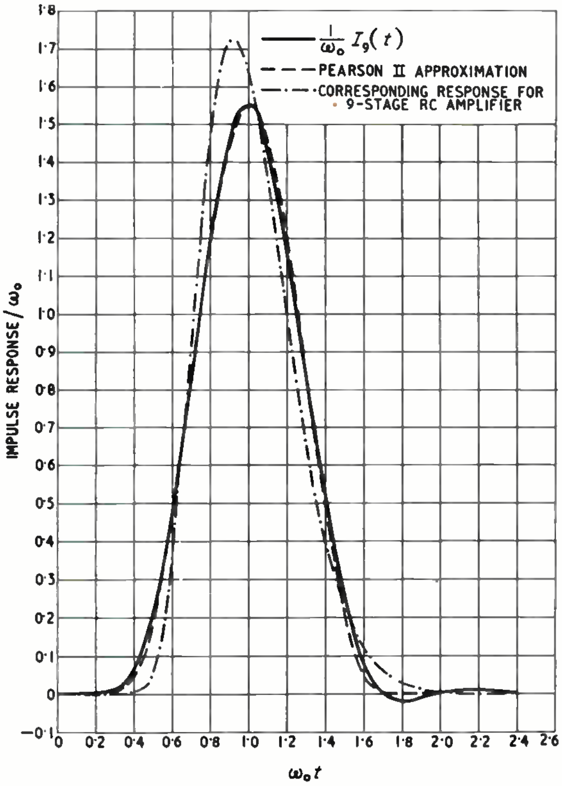

Fig. 5. *Impulse response of network of order 9 with approximation and comparable RC-amplifier response.*

The main facts about the response are summarized by giving its peak amplitude, half-amplitude width, and overshoot and these are shown in Fig. 6. The calculation of the impulse response is a very laborious business and so an approximation has been sought. This is to be found by the technique of fitting "Pearson curves",[5,6] a technique used by statisticians, and the results are shown in Figs. 4 and 5; for n greater than nine the approximation is good enough. As n increases indefinitely the impulse response tends to the Gaussian form

$$\omega_0 \sqrt{\frac{2n-1}{2\pi}} \exp\{-\tfrac{1}{2}(2n-1)(\omega_0 t - 1)^2\}$$

Fig. 7 compares the ninth-order response with a sine-squared and Gaussian pulse having the same peak amplitude and half-amplitude width.

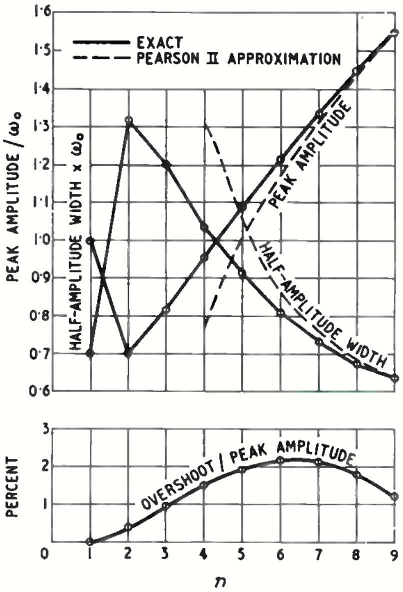

Fig. 6. *Impulse responses; peak amplitude, half-amplitude width and overshoot.*

Constant-Bandwidth Systems

We now consider the systems from another point of view: given a specified bandwidth, in what way do the characteristics vary with n? It was pointed out in the previous section that $\omega_1 = \omega_0 \sqrt{(2n - 1) \log_e 2}$ is a good approximation to the 3-db bandwidth; so we shall now consider a set of characteristics with the same ω_1 and differing n. Instead of a time scale $\omega_0 t$ and frequency scale ω/ω_0, scales $\omega_1 t$ and ω/ω_1 are to be used.

The loss curves require no change of vertical scale; each curve has the same shape as in Fig. 2 but the curves must be laterally displaced and will

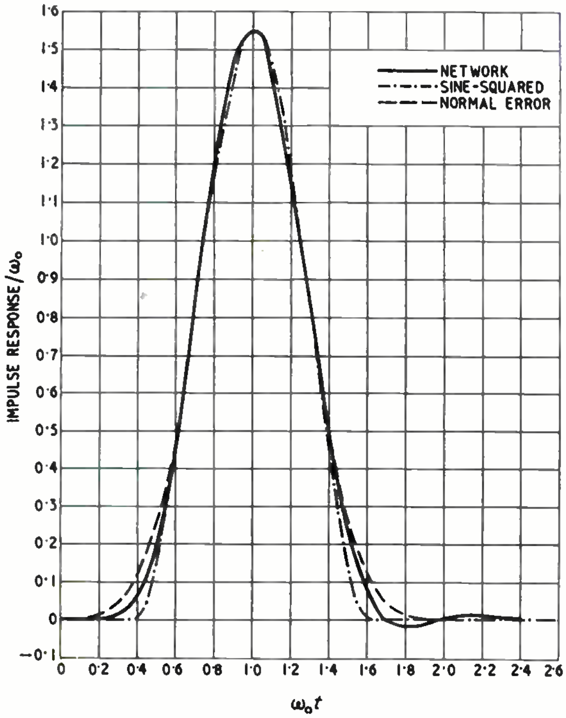

Fig. 7. *Impulse response of 9th order network and sine-squared and normal-error pulses of same amplitude and half-amplitude width.*

all have a loss of approximately 3 db at $\omega/\omega_1 = 1$. The rate of cut-off becomes greater with increasing n as before, and the loss tends to the Gaussian form

$$10(\omega/\omega_1)^2 \log_{10} 2 \text{ db}$$

as n increases; this expression is fairly accurate in the passband even for small values of n.

The delay curves require alteration of both scales. In practical applications, however, it is most likely that the variation of delay rather than the absolute delay would be of interest; a set of curves has been prepared, Fig. 8, showing the change of delay with frequency, taking the zero-frequency delay as a datum; the time-unit is $1/\omega_1$. The values of ω/ω_1 at which the loss is 0·1, 0·5, 1, 2, or 3 db have also been indicated. These curves are based on an approximation which is discussed in the Appendix. The curves of impulse response also require changes of both scales. The resultant curves (which are not given) would have approximately the same width and height, regardless of n, but the position of the centre would be at $\omega_1 t = \sqrt{(2n - 1) \log_e 2}$. The improvement in symmetry and overshoot would be as before.

Examples of Design

(1) Choose a system to have a delay of 0·1 μsec, and constant loss, up to 3 Mc/s.

Since $1/\omega_0 = 0{\cdot}1\ \mu$sec, $\omega_0 = 10$ Mr/s. For $f = 3$ Mc/s, $\omega = 6\pi$ Mr/s and $\omega/\omega_0 = 0{\cdot}6\pi \approx 1{\cdot}9$. The curves of Fig. 2 show that for $n = 7$ the loss would be about 1 db at 3 Mc/s and Fig. 1 shows that the delay would not have dropped appreciably at this frequency.*

(2) A system is to have a 3-db bandwidth of 3 Mc/s. How will the drop of envelope delay at that frequency vary with n?

Fig. 8 is used; with $\omega_1 = 2\pi \times 3$ Mr/s, unity on the delay scale is $1/(2\pi \times 3) \approx 0{\cdot}05\ \mu$sec, so the drop in delay is, approximately, 0·02, 0·01, 0·002 μsec, etc., for $n = 1, 2, 3$, etc.

Applications and Realization

In this section we touch on some applications of the systems described in the first part. We must emphasize that the designing of a network to have a given transfer function is a distinct problem from that of finding a transfer function suitable for given requirements. The systems which have the properties described in the first part lend themselves to convenient realization by known methods, one or two of which are discussed here.

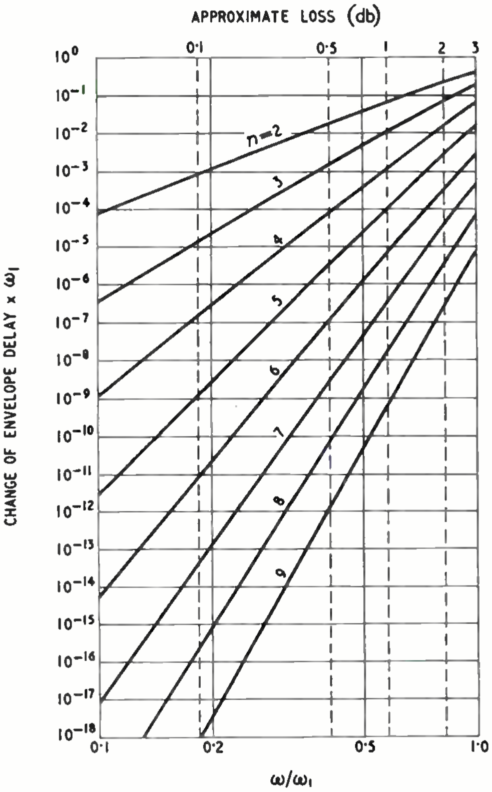

Fig. 8. *Variation of change of envelope delay with n.*

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* Mr/s = megaradians per second.

In the first part there was no occasion to give the explicit form of the transfer function. It was sufficient to show how to determine the two parameters, ω_0 and n, (or ω_1 and n) which specify it. Here we go on to point out that the transfer function (input/output) is an nth degree polynomial in $j\omega$; the precise form is given in the Appendix. Such a polynomial can be specified by its n zeros, some of which may be complex. These are given in Table 1 for n up to nine; there is no exact formula for these zeros, which have had to be determined by numerical factorization of the polynomials. For some purposes the factors themselves are more useful; they are given in Table 2.

Passive Network

A ladder network of series inductors and shunt capacitors, working between resistors, the total number of components being n, can be designed by Darlington's method[7] to have nth-order maximally-flat delay. The method, however, is not simple and is not discussed here.

Such a network, when stimulated by a sufficiently narrow pulse, will give an output of the appropriate shape, such as those shown in Figs. 4 and 5. The network then forms a convenient way of defining the pulse shape. This possibility is discussed elsewhere.[2]

Low-Pass Amplifier

A multi-stage amplifier may be designed to have a transfer function of the type discussed earlier, multiplied, of course, by a constant, the gain of the amplifier; the response may be changed at the low-frequency end by coupling and decoupling capacitors. One method has been discussed by the author,[8] in which the number of stages is n and the valves have two-terminal coupling networks.

More recently, an improved method has been devised by Reeves,[9] in which four-terminal networks are used, allowing a better response and

TABLE 1

(*a*) The following coefficients are to be multiplied by ω_0 to give the zeros of $T_n(\omega)$.

$n = 1$	$n = 2$	$n = 3$	$n = 4$	$n = 5$	$n = 6$	$n = 7$	$n = 8$	$n = 9$
−1		−2·3222		−3·6467		−4·9718		−6·2970
	−1·5 ±*j*0·8660	−1·8389 ±*j*1·7544	−2·8962 ±*j*0·8672	−3·3520 ±1·7427	−4·2484 ±*j*0·8675	−4·7583 ±*j*1·7393	−5·5879 ±*j*0·8676	−6·1294 ±*j*1·7378
			−2·1038 ±*j*2·6574	−2·3247 ±*j*3·5710	−3·7344 ±*j*2·6266	−4·0701 ±*j*3·5172	−5·2048 ±*j*2·6162	−5·6044 ±*j*3·4982
					−2·5172 ±*j*4·4921	−2·6857 ±*j*5·4207	−4·3683 ±*j*4·4150	−4·6384 ±*j*5·3173
							−2·8390 ±*j*6·3539	−2·9793 ±*j*7·2915

(*b*) The following coefficients are to be multiplied by ω_1 to give the zeros of $T_n(\omega)$.

$n = 2$	$n = 3$	$n = 4$	$n = 5$	$n = 6$	$n = 7$	$n = 8$	$n = 9$
	−1·2474		−1·4600		−1·6563		−1·8344
−1·0402 ±*j*0·6005	−0·9878 ±*j*0·9424	−1·3148 ±*j*0·3937	−1·3421 ±*j*0·6977	−1·5386 ±*j*0·3142	−1·5851 ±*j*0·5794	−1·7330 ±*j*0·2691	−1·7856 ±*j*0·5062
		−0·9551 ±*j*1·2064	−0·9308 ±*j*1·4297	−1·3524 ±*j*0·9512	−1·3559 ±*j*1·1717	−1·6142 ±*j*0·8114	−1·6326 ±*j*1·0191
				−0·9116 ±*j*1·6268	−0·8947 ±*j*1·8058	−1·3547 ±*j*1·3692	−1·3512 ±*j*1·5490
						−0·8805 ±*j*1·9705	−0·8679 ±*j*2·1241

more gain to be obtained from a given number of stages. The coupling network and the relation of the components to the transfer function of the stage are shown in Fig. 9; the terminating shunt capacitances do not need to have any particular ratio and the gain is inversely proportional to their sum.

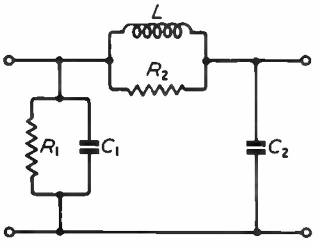

Fig. 9. Four-terminal coupling network to give transfer function (input/output) proportional to $(j\omega/\omega_0)^2 + (j\omega/\omega_0)a + b$.

$$R_1 = \frac{a}{b\omega_0(C_1 + C_2)};$$

$$R_2 = \frac{C_1 + C_2}{a\omega_0 C_1 C_2};$$

$$L = \frac{1}{b\omega_0^2 C_2}; \text{ zero-frequency gain} = \frac{g_m}{\omega_0(C_1 + C_2)} \cdot \frac{a}{b}.$$

Stages of this type can be used for the quadratic factors of $T_n(\omega)$, given in Table 2; if n is odd there is one linear factor $(j\omega/\omega_0) + a$, which can be realized by a stage with a two-terminal load consisting of a resistor $1/a\omega_0 C$ in parallel with the shunt capacitance C. For such an amplifier the gain per stage, as a voltage ratio, can be obtained by multiplying the gain-bandwidth of Table 3 by $g_m/\omega_1 C_m$ where g_m is the geometric mean conductance of the valves used and C_m the geometric mean of the total shunt capacitances; i.e., $C_1 + C_2$, in the stages.

Example:—Find component values for an amplifier with a 3-db bandwidth of 3 Mc/s and $n = 4$; the valves have a mutual conductance of 8 mA/V and $C_1 = C_2 = 10$ pF for each stage.

Gain per stage

$$= \frac{8 \times 10^{-3}}{2\pi \times 3 \times 10^6 \times 20 \times 10^{-12}} \times 1{\cdot}062$$
$$= 22{\cdot}5\text{; i.e., 27 db}$$

$$\omega_0 = \frac{2\pi \times 3 \times 10^6}{\sqrt{7 \log_e 2}} = 8{\cdot}55 \times 10^6$$

$$\frac{1}{\omega_0(C_1 + C_2)} = 5850\,\Omega;$$

$$\frac{C_1 + C_2}{\omega_0 C_1 C_2} = 23{,}400\,\Omega; \qquad \frac{1}{\omega_0^2 C_2} = 1368\,\mu\text{H}$$

Thus the components are:

Stage 1	Stage 2
$R_1 = 5850 \times \frac{5{\cdot}7924}{9{\cdot}1401}$	$R_1 = 5850 \times \frac{4{\cdot}2076}{11{\cdot}4878}$
$= 3710\,\Omega$	$= 2140\,\Omega$
$R_2 = \frac{23400}{5{\cdot}7924}$	$R_2 = \frac{23400}{4{\cdot}2076}$
$= 4040\,\Omega$	$= 5570\,\Omega$
$L = \frac{1368}{9{\cdot}1401}$	$L = \frac{1368}{11{\cdot}4878}$
$= 150\,\mu\text{H}$	$= 119\,\mu\text{H}$

TABLE 3

Gain-Bandwidth Factor for Low-Pass Amplifier Realized by Reeves Method

Number of stages	Value of n	Gain-bandwidth factor
1	2	1·442
2	3	0·921
2	4	1·062
3	5	0·801
3	6	0·866
4	7	0·710
4	8	0·746
5	9	0·636

TABLE 2

FACTORS OF $T_n(\omega)$

$n = 1$	2	3	4	5	6	7	8	9
1				3·6467		4·9718		6·2970
		2·3222	5·7924 9·1401	6·7039 14·2725	8·4967 18·8011	9·5166 25·6663	11·1758 31·9772	12·2587 40·5893
	3 3	3·6778 6·4594	4·2076 11·4878	4·6493 18·1563	7·4688 20·8453	8·1403 28·9365	10·4097 33·9347	11·2088 43·6466
					5·0345 26·5152	5·3714 36·5969	8·7366 38·5743	9·2769 49·7885
							5·6780 48·4320	5·9585 62·0414

The top row gives the coefficient a of factors $(j\omega/\omega_0) + a$; The remaining rows give the coefficients a and b of factors $(j\omega/\omega_0)^2 + a(j\omega/\omega_0) + b$, the a being uppermost.

Band-Pass Amplifier

If the pass-band is small compared with the midband frequency, it is possible to make an amplifier in which the gain and delay characteristics are symmetrical about the midband frequency, as is well known. Each half could have the shape of Figs. 1 and 2, the lower half being reversed, of course, and the midband corresponding to zero frequency. The response to a short pulse of the midband frequency has an envelope proportional to impulse responses such as those shown in Figs. 4, 5 and 6.

There are various ways of achieving this: the simplest is by stagger-tuning. For the *n*th-order response *n* stages are required, each stage having a two-terminal load consisting of a parallel combination of resistor $R = 1/2c\omega_1 C$, inductor $L = 1/\omega_m{}^2 C$ or $1/(\omega_m \pm d\omega_1)^2 C$, and the shunt capacitance C; ω_m is the midband frequency and $-c$, or $-c \pm jd$ are the numbers given in Table 2. For such amplifiers the gain-bandwidth factor of Table 4 applies.

TABLE 4

Gain-Bandwidth Factor for Maximally-Flat Delay Amplifier

(1) Low-pass amplifier realized by author's method.
(2) Band-pass amplifier realized by stagger tuning.
The gain-bandwidth factor for an *n*-stage synchronous tuned band-pass amplifier (which is also valid for an RC-coupled low-pass amplifier) is included for comparison.

Number of stages (= *n*)	Gain-bandwidth factor: maximally-flat delay	Gain-bandwidth factor: synchronous tuned
2	0·833	0·589
3	0·756	0·482
4	0·690	0·417
5	0·635	0·373
6	0·592	0·340
7	0·555	0·315
8	0·525	0·295
9	0·499	0·278

Example.—Design a 6-stage amplifier with midband 30 Mc/s and 3-db bandwidth 3 Mc/s; i.e., the gain is to be 3 db down at 28·5 and 31·5 Mc/s. The mutual conductance of the valves used is 8 mA/V and the shunt capacitance is 25 pF.

We have $\omega_m = 60\pi \times 10^6$; $\omega_1 = 3\pi \times 10^6$. Gain per stage

$$= \frac{8 \times 10^{-3}}{2 \times 3\pi \times 10^6 \times 25 \times 10^{-12}} \times 0{\cdot}592$$

$$= 10 \text{ approx.; i.e., } 20 \text{ db}$$

$$\frac{1}{2\omega_1 C} = \frac{1}{2 \times 1{\cdot}5 \times 2\pi \times 10^6 \times 25 \times 10^{-12}} = 2122$$

Details of the stages are:

Tune frequency (Mc/s)	Inductor (μH)	Resistor (Ω)
$30 - 1{\cdot}5 \times 1{\cdot}6268 = 27{\cdot}56$	0·97	$2122/0{\cdot}9116 = 2328$
$30 - 1{\cdot}5 \times 0{\cdot}9512 = 28{\cdot}57$	1·03	$2122/1{\cdot}3524 = 1568$
$30 - 1{\cdot}5 \times 0{\cdot}3142 = 29{\cdot}53$	1·09	$2122/1{\cdot}5386 = 1378$
$30 + 1{\cdot}5 \times 0{\cdot}3142 = 30{\cdot}47$	1·16	1378
$30 + 1{\cdot}5 \times 0{\cdot}9512 = 31{\cdot}43$	1·24	1568
$30 + 1{\cdot}5 \times 1{\cdot}6268 = 32{\cdot}44$	1·34	2328

The maximum Q is about 12.

Acknowledgments

The author is indebted to the Engineer-in-Chief, General Post Office, and to the Controller, H.M.S.O., for permission to publish this paper.

APPENDIX

Transfer Function. The transfer function of the *n*th-order system (input/output) is

$$T_n(\omega) = \sum_{r=0}^{n} \frac{2^r.{}^nC_r}{{}^{2n}C_r} . \frac{(j\omega/\omega_0)^r}{r!}$$

where ${}^nC_r$ is the number of combinations of *n* things *r* at a time. As $n \rightarrow \infty$, $2^r.{}^nC_r/{}^{2n}C_r \rightarrow 1$, so that

$$\lim_{n \to \infty} T_n(\omega) = \exp(j\omega/\omega_0)$$

i.e., as *n* increases the system tends to the distortionless form with zero loss and constant delay $1/\omega_0$.

For practical numerical work it is more convenient to express $T_n(\omega)$ in the form

$$T_n(\omega) = \frac{L_n(z)}{(2n-1)!!}$$

where $z = j\omega/\omega_0$ and $(2n-1)!! = 1.3.5.7\ldots(2n-1)$. The polynomials $L_n(z)$ have integral coefficients and are most easily determined from the recurrence relation

$$L_n(z) = (2n-1)L_{n-1}(z) + z^2 L_{n-2}(z)$$

with $L_0(z) = 1$ and $L_1(z) = z + 1$

Delay. The delay, like the delay of any physical system, can be expressed as a power series

$$t_0(1 + a_2\omega^2 + a_4\omega^4 + \ldots .)$$

where t_0 is the zero-frequency delay, equal to $1/\omega_0$ in this case, and the *a* terms are constants. Maximal flatness implies that as many as possible of the *a* terms from a_2 upward, are zero. In this case

$$a_2 = a_4 = \ldots = a_{2n-2} = 0$$

In effect, of the $n + 1$ constants required to specify an *n*th degree polynomial, $n - 1$ of them are used in getting maximal flatness of delay, one is left for the bandwidth, specified by ω_0, and one for the gain; the gain is actually unity for $T_n(\omega)$, but this may be multiplied by a constant in any practical realization.

A proof of the maximally-flat delay property can be obtained from a previous paper,[1] which discussed systems with transfer function $T_n(\omega)/T(-\omega)$, although the notation was different. Such systems are all-pass, and have delay exactly twice that for $T_n(\omega)$ alone: the behaviour with frequency and in particular the maximal flatness is thus the same. The envelope delay is

$$\frac{1}{\omega_0}\left[1 - \frac{(\omega/\omega_0)^{2n}}{\{(2n-1)!!\}^2|T_n(\omega)|^2}\right]$$

An expression for $|T_n(\omega)|^2$ is given in the next section of the appendix. In Fig. 8 an approximate form for $|T_n(\omega)|_2$ is used and the approximate expression for the departure from zero-frequency delay is

$$\frac{1}{\omega_1}\cdot\frac{\{(2n-1)\log_e 2\}^{n+\frac{1}{2}}(\omega/\omega_1)^{2n}}{\{(2n-1)!!\}^2\exp\{(\omega/\omega_1)^2\log_e 2\}}$$

Loss. The loss for the nth-order system is

$$10\log\{|T_n(\omega)|^2\}\,\text{db}$$

and an expression for $|T_n(\omega)|^2$ is

$$|T_n(\omega)|^2 = \sum_{r=0}^{n}\frac{2^{2r}.{}^nC_r{}^nC_r}{{}^{2n}C_r{}^{2n}C_{2r}}\cdot\frac{(\omega/\omega_0)^{2r}}{(2r)!}$$

$$= \exp\{u^2/(2n-1)\}\left[1 + \frac{1}{2(2n-3)}\cdot\frac{u^4}{(2n-1)^2}\right.$$

$$\left.+\frac{2}{3(2n-3)(2n-5)}\cdot\frac{u^6}{(2n-1)^3}+\dots\right]$$

where $u = \omega/\omega_0$. The exponential factor gives the Gaussian approximation to the loss and the series does not make much difference for $\omega < \omega_1$, even for small values of n.

Impulse Response—Pearson II Approximation. For this we need the first four moments of the impulse response about its mean μ_1'; i.e., we need

$$\mu_r = \int_0^\infty (t-\mu_1')^r I_n(t)dt$$

for $r = 2, 3, 4$; $I_n(t)$ is the nth-order impulse response, and μ_1' is always equal to the zero-frequency delay, in this case $1/\omega_0$. These moments can, however, be found without finding $I_n(t)$: they can be found from

$$\frac{\exp(j\omega/\omega_0)}{T_n(\omega)} = \sum_{r=0}^{\infty}\frac{(-)^r}{r!}\mu_r(j\omega)^r$$

whence

$$\mu_2 = \frac{1}{(2n-1)\omega_0^2};\quad \mu_4 = \frac{3(2n-5)}{(2n-1)^2(2n-3)\omega_0^4}$$

and it can also be shown that

$$\mu_3 = \mu_5 = \mu_7 = \dots = \mu_{2n-1} = 0$$

which is a direct consequence of the maximally-flat delay characteristics and also shows how the impulse response approaches symmetry, for a perfectly symmetrical pulse would have all its odd moments zero.

The Pearson Type II approximation is, for $n > 4$

$$I_n(t) \approx \omega_0\sqrt{\frac{2n-1}{2n-5}}\cdot\frac{(2n-7)!!}{2^{n-3}(n-4)!}\times\left[1-\frac{(2n-1)(\omega_0 t-1)^2}{2n-5}\right]^{n-4}$$

$$|\omega_0 t - 1| < \sqrt{\frac{2n-5}{2n-1}}$$

$$\approx 0,\ \text{elsewhere}$$

and from this, approximations to the peak amplitude and half-amplitude width are

Peak amplitude $\quad\omega_0\sqrt{\dfrac{2n-1}{2n-5}}\cdot\dfrac{(2n-7)!!}{2^{n-3}(n-4)!}$

Half-amplitude width

$$\frac{2}{\omega_0}\sqrt{\frac{2n-1}{2n-5}\left[1-\frac{1}{2^{1/(n-4)}}\right]}$$

Comparison with basic system. One of the best known systems for getting good phase characteristics and impulse response free from overshoot is that with transfer function

$$(1 + j\omega/\omega_2)^n$$

Such a system can be realized by an n-stage amplifier with identical stages—the 'RC-coupled amplifier,' the band-pass equivalent being the 'synchronous-tuned' amplifier. The impulse response for $n = 9$ is shown in Fig. 5, ω_2 being chosen so that the 3-db bandwidths are approximately the same. The great improvement in symmetry of the maximally-flat delay system is evident. Table 4 includes the gain-bandwidth factor for such a system; again the maximally-flat delay system is superior.

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CASCADE LCR PHASE-SHIFT OSCILLATORS

By F. Butler, B.Sc., M.I.E.E., M.Brit.I.R.E.

SUMMARY.—Several types of phase-shift oscillator are described, in each of which a valve amplifier is coupled to a passive ladder network in which inductance, capacitance and resistance are so proportioned as to give the requisite phase shift and voltage transformation ratio to generate continuous oscillations. In certain cases, the oscillation frequency may be controlled by the use of piezo-electric elements. A simplified theory of the mode of operation is given. The circuits are primarily designed to work at audio or at low radio frequencies, some of them being suitable for use with crystal triodes or transistors.

1. Introduction

Most phase-shift oscillators employ passive RC circuits arranged in a bridge or equivalent twin-T form, or they make use of a ladder network which is necessarily of high attenuation when it is arranged to give the desired phase displacement between the input and output voltages. By including inductive elements in the phase-shift network the energy dissipation may be reduced and the complex voltage transformation ratio of the network may be made suitable for the production of sustained oscillations in a system which includes the network and a suitable power amplifier. A number of single-valve oscillators will be described, some of which may be frequency-controlled by quartz plates or bars. All the circuits are best employed at audio or at low radio frequencies, the performance at high frequencies being adversely affected by wiring or valve capacitance.

2. Circuit Theory

All the networks to be discussed are simple variants of the arrangement given in Fig. 1. Using the symbols shown on this diagram, the network equations are:—

$$e = Z_1 i_1 + Z_2 (i_1 - i_2), \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$0 = Z_2 (i_2 - i_1) + (Z_3 + Z_4) i_2, \quad \ldots \quad (2)$$

$$E = Z_4 i_2. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

From these equations it is easy to write down expressions for the voltage transformation ratio E/e, the phase shift, the input impedance e/i_1, the forward transfer impedance e/i_2 and the reverse transfer impedance E/i_1 of the network. The results are:—

$$E/e = \frac{Z_2 Z_4}{Z_1 Z_2 + (Z_1 + Z_2)(Z_3 + Z_4)}, \quad \ldots \quad (4)$$

$$Z_i = \text{input impedance } e/i_1,$$

$$= \frac{Z_1 Z_2 + (Z_1 + Z_2)(Z_3 + Z_4)}{Z_2 + Z_3 + Z_4}, \quad \ldots \quad (5)$$

$$E/i_1 = \frac{Z_2 Z_4}{Z_2 + Z_3 + Z_4}, \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

$$e/i_2 = Z_1 + \left(1 + \frac{Z_1}{Z_2}\right)\left(Z_3 + Z_4\right). \quad \ldots \quad (7)$$

In any practical oscillator circuit it must be arranged that the amplifier power gain exceeds the network attenuation and that there is zero phase shift round the loop which includes the network and the associated amplifier. Attention is drawn to a paper by G. G. Gouriet.[1] in which the requirements to be satisfied in the design of valve oscillators are clearly described.

Before the generalized network in Fig. 1 can be reduced to a form suitable for use in an oscillator circuit it is necessary to consider some properties of the associated amplifier stage. When used with a resistive load, an earthed-cathode amplifier delivers an output voltage that is reversed in phase as compared with the input voltage. To convert such an amplifier into an oscillator thus requires the use of a phase-reversing network.

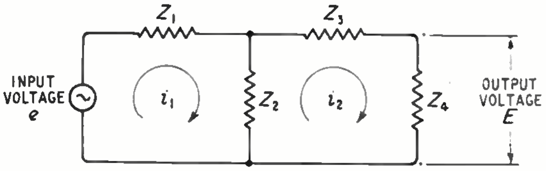

Fig. 1. *Generalized coupling network.*

By contrast, an earthed-grid amplifier and a cathode follower each deliver an output which is in phase with the driving voltage and to convert either of these amplifiers into an oscillator requires zero phase shift between the input and output voltages of the four-terminal coupling network. Some networks having the desired gain and phase characteristics will now be discussed. In all cases it will be assumed that the amplifier and network elements are linear, that the valve grid current is zero, that the amplifier voltage gain is a constant m, and that the output resistance of the amplifier can be included as a component part of the impedance of one of the network elements.

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Fig. 2 represents a network which corresponds to the generalized arrangement of Fig. 1 if:—

$$Z_1 = r + j\omega L\,; \quad Z_2 = \frac{1}{j\omega C_1}\,; \qquad e = mE;$$

$$Z_3 = \frac{1}{j\omega C_2}\,; \qquad Z_4 = \frac{R/j\omega C_3}{R + 1/j\omega C_3}\,.$$

Substituting these values for Z_1, Z_2, Z_3 and Z_4 in equation (4) and separating the real and imaginary parts of the resulting equation, the following expressions are derived:—

$$\omega^2 L\,(C_1C_2 + C_1C_3 + C_2C_3) = \frac{r}{R}\cdot C_1 + \left(1 - m + \frac{r}{R}\right) C_2 + C_3 \qquad \cdots \quad (8)$$

$$\frac{1}{\omega^2} = L\,(C_1 + C_2) + rR(C_1C_2 + C_1C_3 + C_2C_3) \quad (9)$$

The oscillation frequency is given in terms of the network constants by equation (9) and the maintenance condition is derived by eliminating ω between equations (8) and (9).

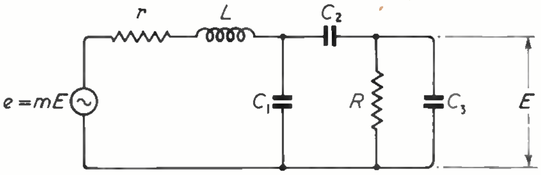


Fig. 2. *Series-inductance, shunt-capacitance network.*

In the particular case when $C_3 = 0$, the frequency of oscillation is given by:—

$$\frac{1}{\omega^2} = L\,(C_1 + C_2) + rR\,C_1C_2 \qquad \cdots \qquad \cdots \quad (10)$$

Fig. 3 shows another suitable coupling network. It is equivalent to Fig. 1 if:—

$$Z_1 = r_1 + \frac{1}{j\omega C_1}\,; \quad Z_2 = r_2 + j\omega L\,; \quad Z_3 = R_1\,;$$

$$Z_4 = \frac{R_2/j\omega C_2}{R_2 + 1/j\omega C_2}\,; \quad E/e = E/mE = \frac{1}{m}\,.$$

Again substituting for Z_1, Z_2, Z_3 and Z_4 in equation (4), the real and imaginary parts of the resulting expression become:—

$$\frac{R_1 + R_2 + r_2}{\omega C_1\,\omega C_2} = \frac{L}{C_1}\cdot R_2 + \frac{L}{C_2}\{R_1 + r_1 + (1-m)R_2\} + R_2\,\{R_1r_2 + r_1\,(R_1 + r_2)\} \quad \cdots \ (11)$$

$$\omega L\,R_2\,(R_1 + r_1) = \frac{1}{\omega C_1}\left\{R_2\,(R_1 + r_2) + \frac{L}{C_2}\right\} + \frac{1}{\omega C_2}\,\{r_1\,(R_1 + R_2 + r_2) + r_2\,[R_1 + (1-m)\,R_2]\} \qquad \cdots \qquad \cdots \quad (12)$$

In practice, R_2 is a grid leak of extremely high resistance or is absent from the circuit and in this case equations (11) and (12) reduce to:—

$$R_1r_2 + (R_1 + r_2)\,r_1 + L\left\{\frac{1}{C_1} + \frac{1-m}{C_2}\right\} = \frac{1}{\omega C_1\,\omega C_2} \qquad \cdots \qquad \cdots \qquad \cdots \quad (13)$$

$$\omega^2 L\,(R_1 + r_1) = \frac{R_1 + r_2}{C_1} + \frac{r_1 + (1-m)r_2}{C_2} \ \cdots \ (14)$$

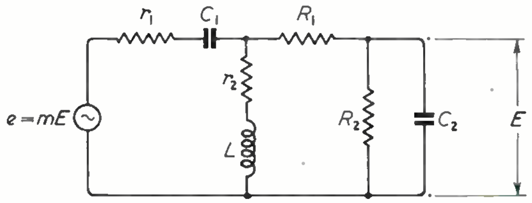


Fig. 3. *Series-capacitance, shunt-inductance network.*

Equations (13) and (14) give the oscillation frequency and maintenance conditions. Their significance is best understood by setting $r_1 = r_2 = 0$, so that the valve amplifier has zero internal resistance and there is no energy dissipation in the coupling coil. The above equations then become:—

$$\frac{1}{\omega^2} = L\,\{C_2 + (1 - m)\,C_1\} \qquad \cdots \qquad \cdots \quad (15)$$

$$\frac{1}{\omega^2} = L\,C_1 \qquad \cdots \qquad \cdots \qquad \cdots \qquad \cdots \quad (16)$$

The requisite amplifier gain is then

$$m = \frac{C_2}{C_1} \qquad \cdots \qquad \cdots \qquad \cdots \qquad \cdots \qquad \cdots \quad (17)$$

Although the analysis of an idealized circuit leads to results which are not accurately borne out by experiments, the process is useful because it suggests reasonable values for the various circuit elements to be used as a starting point in practical oscillator design.

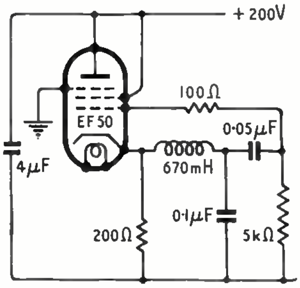


Fig. 4. *Audio-frequency oscillator using series-L, shunt-C circuit.*

3. Typical Oscillator Circuits

An audio-frequency oscillator employing the network of Fig. 2 (C_3 being omitted) is shown in Fig. 4. Using the circuit constants indicated on the diagram, the oscillation frequency is about 500 c/s. Output may be taken from the cathode of the valve or from the grid end of the network. Low impedance loads may be connected between cathode and earth, preferably through a blocking capacitor. High impedance loads may be joined directly across the network-terminating resistor. Reducing the value of this resistor causes a corresponding reduction of the amplitude of oscillation and reduces harmonic distortion in the output. The waveform of the voltage across the shunt capacitor is extremely good, but it is not permissible to connect any appreciable load at this point.

Inspection of equations (8) and (9) shows that when r is zero, the oscillation frequency and maintenance conditions are independent of the value of the terminating resistance R. In practice, a very low value of r can be achieved by using a high Q coil, a valve of large mutual conductance and a low value of cathode-bias resistance. The valve is a cathode-follower amplifier of which the cathode load is formed by the parallel combination of the bias resistance and the input impedance of the network. For such an amplifier, the voltage gain m is given by $m = \frac{\mu}{\mu + 1} \cdot \frac{Z}{Z + r_a/(\mu + 1)}$ where

Z = cathode load impedance,
μ = valve amplification factor,
r_a = anode slope resistance of valve.

A slight rearrangement of the network elements makes it possible to convert the circuit of Fig. 4 into the earthed-grid version shown in Fig. 5, where the network terminating resistance is the parallel combination of the valve output resistance and its anode load resistance.

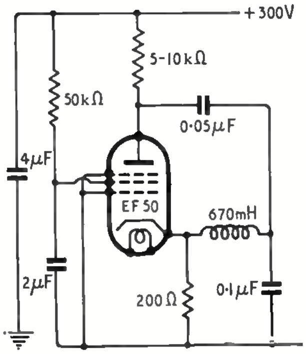


Fig. 5. *Earthed-grid version of Fig. 3.*

Fig. 6 shows a crystal-controlled oscillator derived from Fig. 4. It can be made to work satisfactorily over the range 50 kc/s to 1 Mc/s, but some care must be taken over the choice of component values, since the circuit tends to operate in the Colpitts mode shown in Fig. 7. The modified Colpitts circuit, originally proposed by Gouriet[1] and also developed by Clapp[2] is a far more active oscillator when used with high-frequency crystals, and its stability is also extremely good.[3] For these reasons the arrangement shown in Fig. 6 is not particularly recommended except for use at low frequencies. Inspection of Fig. 6 shows that if the coil is short-circuited and the capacitor in parallel with the quartz crystal removed, then the circuit becomes identical with Fig. 7.

A practical audio-frequency oscillator circuit based on Fig. 3 is given in Fig. 8. Its performance is very similar to that of the arrangement shown in Fig. 4. A crystal-controlled version, with component values suitable for operation at 500 kc/s, is illustrated in Fig. 9. It is far more satisfactory than the arrangement of Fig. 6, and it shows no tendency to oscillate in any undesired mode.

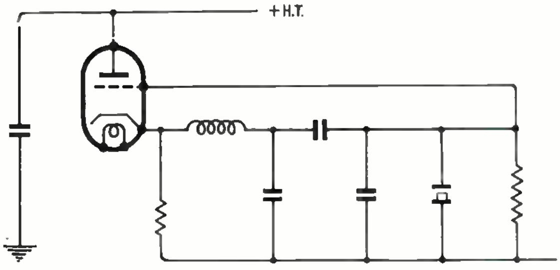


Fig. 6. *Crystal-controlled oscillator derived from Fig. 3.*

4. Transistor Circuits

When operating at audio or low radio frequencies under class A conditions with negative grid bias and with a non-reactive anode load a conventional triode valve has a very high input impedance, a relatively low output impedance and the amplified output voltage is reversed in phase as compared with the input signal voltage. By contrast a crystal-triode or transistor amplifier has a low input impedance, a high output impedance and there is no phase displacement between the input and the amplified output voltages. In some respects a transistor thus resembles an earthed-grid triode amplifier and to convert such an amplifier into an oscillator requires the inclusion of a zero phase shift network between the input and output terminals of the amplifier. The gain in the amplifier must exceed the network loss in order to produce sustained oscillations.

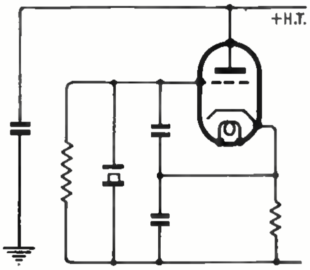


Fig. 7. *Modified Colpitts circuit due to Gouriet and Clapp.*

Some circuits have been devised, suitable for use with a range of crystal triodes, Type CGT—1, developed by the B.T-H. Company. Characteristics of three typical specimens are listed in Table 1.

It will be noticed from the table that the exciter or emitter characteristics are widely different in the three cases but, in general, this electrode will require a small positive bias. Specimen No. 2 is considered to show the nearest approach to a normal characteristic and was therefore selected for the initial experiments.

Fig. 10 shows a transistor-oscillator circuit derived from the earthed-grid arrangement given in Fig. 5. With the component values indicated on the diagram the working frequency is approximately 800 c/s.

Crystal control can be achieved by including a quartz plate Q in the feedback circuit as shown in Fig. 11. Oscillation then occurs at the series-resonant frequency of the crystal, at which its impedance degenerates to a very low resistance. This circuit operates well from a power supply capable of delivering 1 mA at 50 V, the maximum safe input being 5 mA at 250 V. In both the above circuits the positive emitter bias is derived from the voltage drop across a resistor connected in the lead from the base of the crystal triode. A by-pass capacitor is shunted across the resistor.

Fig. 12 shows a 50-kc/s crystal-controlled oscillator coupled to a locked oscillator operating at 10 kc/s. If desired, a third oscillator, operating at 1 kc/s, can be synchronized to the 10-kc/s source so that the assembly forms a very compact secondary standard of frequency. The locking arrangement shown is not very satisfactory or reliable, particularly if the 10-kc/s or 1-kc/s oscillators are required to supply an appreciable output power. If a large output is required it is essential to provide buffer amplifiers or to use some form of multivibrator divider.

The B.T-H transistors referred to above are of the point-contact type. More recently, junction transistors have been developed both in this country and in America[4] although they have not yet reached the production stage.

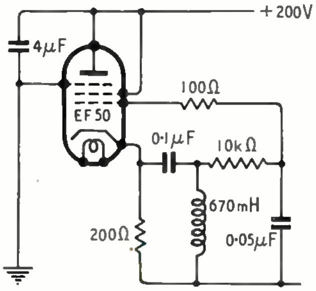
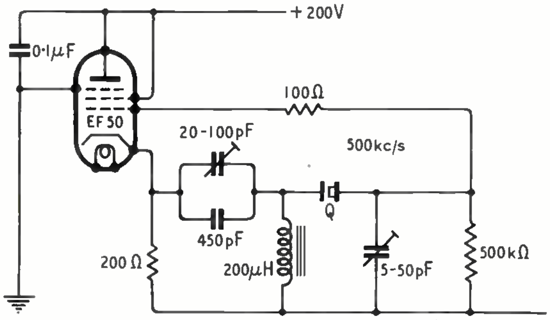


Fig. 8 (left). *Audio-frequency oscillator circuit based on Fig. 3.*

Fig. 9 (below). 500-*kc/s crystal oscillator derived from Fig. 8.*



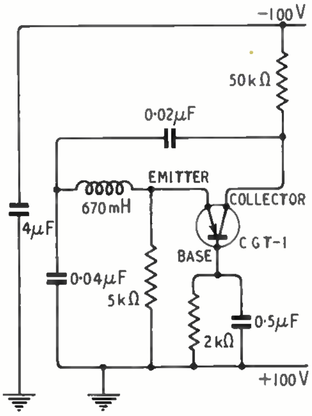


Fig. 10 (above). *Audio-frequency oscillator using B.T-H crystal triode Type CGT-1.*

Fig. 11 (right). *Crystal-controlled 50-kc/s oscillator employing crystal triode.*

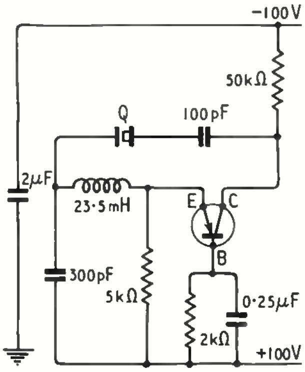


TABLE 1

Serial Number	Emitter or Exciter Voltage	Collector Voltage (Negative)	Input Impedance (ohms)	Output Impedance (ohms)
1	– 0·2 to + 0·2	20 to 70	300	30 000
2	0 to + 0·3	20 to 70	350	50 000
3	– 0·3 to 0	20 to 60	350	50 000

There are considerable differences between the characteristics of point-contact and junction transistors. In particular, the collector output impedance of the junction type is higher and it is almost independent of the collector voltage. The characteristic curves showing the relationship between collector voltage and current are almost ideally linear down to extremely low levels. The *n-p-n* junction transistor Type M.1752 developed in the Bell Telephone Laboratories is exceptional as regards its capabilities for efficient low-level operation. Junction transistors are much superior to the point-contact units as regards the generation of internal noise, and the sole disadvantage of the former type appears to be that they are incapable of operation at high radio frequencies.

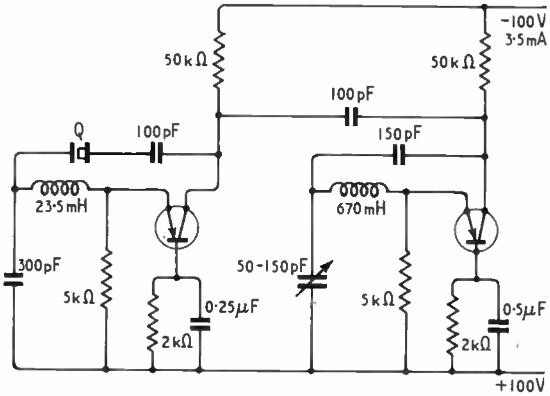


Fig. 12 (left). *Crystal-controlled 50-kc/s oscillator and 10-kc/s locked oscillator.*

A few experiments made with a single specimen of the M.1752 transistor show that its performance is entirely satisfactory in the oscillator circuits already described. Fig. 13 shows one suitable arrangement. With the component values shown, the operating frequency is 450 c/s. For efficient operation the negative emitter voltage should be about three-quarters of the positive collector supply. If these proportions are retained, reliable oscillation still takes place with collector potentials as low as one volt.

5. Conclusions

The oscillator circuits described above are economical in components and they work very well at audio and moderate radio frequencies. At the same time it is doubtful if they show any marked advantages over the many types of circuit already in use. A feature of the audio-frequency oscillators is that the amplitude of oscillation can be smoothly controlled by variation of the resistance element in the coupling network. When this resistance is reduced to the point at which oscillations are barely sustained, the waveform is extremely good.

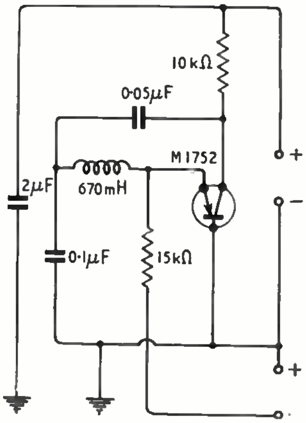


Fig. 13 (right). *Audio-frequency oscillator using n-p-n junction transistor Type M.1752.*

When employed with low-frequency piezo-electric crystals, it has been found that reliable oscillation takes place, even when using quartz bars of low activity.

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ELECTRICAL PROPERTIES OF SEA WATER

Reflection and Attenuation Characteristics at V.H.F.

By J. A. Saxton, Ph.D., B.Sc., A.M.I.E.E., and J. A. Lane, B.Sc.

(Radio Division, National Physical Laboratory.)

SUMMARY.—The results of recent measurements by the authors of the dielectric properties of aqueous sodium chloride solutions at radio frequencies between 9,400 Mc/s and 48,000 Mc/s are summarized, and then applied to the calculation of the electrical properties of sea water at various temperatures and any radio frequency. The results indicate that sea water has a static dielectric constant of about 75 and 69 at 0°C and 20°C respectively, compared with values of 88 and 80 for pure water at these temperatures. The reflection coefficient of sea water is given as a function of the angle of incidence at frequencies between 30 Mc/s and 30,000 Mc/s, and it is shown how the dipolar and ionic conductivities govern the attenuation of pure, fresh and sea water at radio frequencies.

1. Introduction

IN the study of the propagation of radio waves it is often necessary to know the magnitude of the reflection and absorption effects produced by the various media of the earth's surface and atmosphere. In general, there are two techniques available by means of which these can be estimated. In some cases, direct measurements of reflection and absorption effects are possible, and this was the procedure adopted, for example, by McPetrie and Saxton,[1] and Ford and Oliver[2] in their measurements on the properties of various types of soil at wavelengths between 5 m and 9 cm. Alternatively, the results of laboratory measurements on specimen constituents of the earth's surface can be used to calculate theoretically the reflection and absorption effects likely to occur in actual transmission. This technique has been used by one of the authors[3] to estimate the reflection coefficient of snow and ice layers for high radio frequencies: in the present paper it is shown how the results of measurements of the dielectric properties of aqueous sodium chloride solutions may be used to calculate the attenuation and reflection characteristics of sea water for radio waves of any frequency, and some specific examples are given.

The variation of the dielectric properties of pure water with frequency and temperature is now well established. As a consequence of the polar nature of the water molecule a region of dispersion exists between the frequencies of 3,000 and 300,000 Mc/s (wavelengths of 10 cm and 1 mm), and at room temperatures the associated absorption coefficient reaches a maximum at a frequency of about 30,000 Mc/s (wavelength of 1 cm). This dispersion and its effect on the electrical properties of water at very high frequencies were discussed in an earlier paper.[4] Now in the case of a solution of an electrolyte such as sodium chloride in water, the dielectric properties appropriate to the pure solvent at a given temperature and frequency are modified by an amount depending on the concentration of the electrolyte. The precise nature and extent of this modification has been investigated by various workers from time to time, but until recently at radio frequencies much lower than those used by the authors. Accurate dielectric measurements are, however, exceedingly difficult at low frequencies even with quite dilute solutions of an electrolyte owing to the large loss angle, δ. [δ is given by the relation $\tan \delta = 2\sigma/\epsilon' f$, where σ(e.s.u.) = total conductivity of solution, ϵ' = dielectric constant, and f = frequency of incident radiation.] Many of the earlier results are, in fact, inconsistent. For frequencies of about 10,000 Mc/s and above this difficulty is largely absent, and the authors have recently made determinations of the dielectric properties of various liquids and electrolytic solutions at frequencies between 9,350 and 48,200 Mc/s (wavelengths of 3·21 cm and 0·62 cm) and at temperatures between 0°C and 40°C. The results are described in detail elsewhere,[5,6] but those on aqueous sodium chloride solutions are directly related to the properties of sea water, and they are discussed in this connection below.

2. Dielectric Properties of Aqueous Sodium Chloride Solutious

The dielectric properties of any lossy medium can be expressed in terms of several parameters which may be summarized thus:—

$$\left.\begin{aligned} \epsilon &= \epsilon' - j\epsilon'' \\ &= \epsilon' - 2j\sigma/f \\ &= (n - j\kappa)^2 \end{aligned}\right\} \qquad \cdots \qquad \cdots \qquad (1)$$

where ϵ = complex dielectric constant, σ = total conductivity in e.s.u., n = refractive index, and κ = absorption coefficient. The experimental procedure was essentially the same at each frequency (9,350, 24,100 and 48,200 Mc/s) and involved direct measurement of the absorption coefficient, κ, of the solutions contained in a cir-

MS accepted by the Editor, January 1952

cular waveguide. Details of the apparatus and theoretical analysis are given in the papers referred to above and will only be discussed briefly here. It is perhaps worth pointing out again here, however, that in the case of an electrolytic solution in a polar solvent like water the total conductivity, σ, is partly an effective conductivity due to the polar molecules of the solvent and partly the normal ionic conductivity of the solute ions. Their relative contributions to the term ϵ'' depend on the salt concentration and the frequency of the incident radiation.

2.1. *Theoretical Basis of Calculations*

The variation of dielectric properties of pure water with frequency and temperature can be represented, to a close approximation by the equations:—

$$\epsilon' = \frac{\epsilon_s - \epsilon_0}{1 + x^2} + \epsilon_0 \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

$$\epsilon'' = \frac{(\epsilon_s - \epsilon_0)x}{1 + x^2} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

with $x = \omega\tau$; where ϵ_s = static dielectric constant, ϵ_0 = dielectric constant representing the sum of electronic and atomic polarizations, τ = a relaxation time characteristic of a particular temperature, and ω = angular frequency.

Also, from equation (1):—

$$2n^2 = (\epsilon'^2 + \epsilon''^2)^{\frac{1}{2}} + \epsilon' \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

$$2\kappa^2 = (\epsilon'^2 + \epsilon''^2)^{\frac{1}{2}} - \epsilon' \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

$$n\kappa = \sigma/f = \epsilon''/2 \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

By means of equations (2), (3) and (5) it was found possible to explain the observed values of κ for the NaCl solutions in terms of a constant value of ϵ_0 of 4.9, equal to that of pure water, and values of ϵ_s and τ depending on the temperature and salt concentration. This procedure is in line with arguments previously advanced by one of the authors[7] and further developed by Hasted, Ritson and Collie[8] in their work on the dielectric properties of aqueous ionic solutions. It is always necessary in this treatment to allow for the ionic conductivity of the solute by adding a term $2\sigma_i/f$ to the expression for ϵ'' in equation (3) before calculating κ from equation (5) (σ_i = ionic conductivity in e.s.u.). The values of σ_i used are those given in the International Critical Tables for low frequencies, and the increase in ionic conductivity at very high frequencies which is predicted by the Debye-Falkenhagen theory of electrolytes is apparently not significant under the conditions discussed here. The values of ϵ_s and τ found to satisfy equations (2) and (3) (after correcting for ionic conductivity), give the measured value of absorption coefficient, and may be regarded as representing another polar dielectric derived from water by structural changes consequent upon the addition of the electrolyte.

The values of ϵ_s and τ resulting from this analysis for sodium chloride solutions for concentrations up to 3 Normal and temperatures from 0°C to 40°C are given in Table 1, with the corresponding values of σ_i, the ionic conductivity.

These values can be used with equations (2) and (3), with $\epsilon_0 = 4{\cdot}9$, to calculate the dielectric properties of any sodium chloride solution at any frequency and any temperature between 0°C and 40°C. The total value of ϵ'' must be obtained, as mentioned above, by adding the appropriate value of $2\sigma_i/f$ to the expression for ϵ'' given in equation (3). These parameters agree, throughout the concentration and temperature ranges investigated, with the authors' experimental observations to an accuracy of about 2%, and it is of interest, before applying these results to the practical case of sea water, to compare experimental observations at other frequencies with values calculated on the basis outlined above.

2.2. *Comparison with Other Experimental Data*

There are very few existing measurements of the dielectric properties of concentrated electrolytic solutions owing to the difficulties associated

TABLE 1

Dielectric Properties of Aqueous NaCl Solutions
Units of $\tau = 10^{-12}$ sec
Units of $\sigma = 10^{11}$ e.s.u.

	0°C			10°C			20°C			30°C			40°C		
	ϵ_s	τ	σ_i	ϵ_s	τ	σ_i	ϵ_s	τ	σ_i	ϵ_s	τ	σ_i	ϵ_s	τ	σ_i
0	88	18·7	0	84	13·6	0	80	10·1	0	77	7·5	0	73	5·9	0
0·5N	77	17·1	0·22	74	12·2	0·31	71	9·2	0·40	68	7·2	0·47	65	5·7	0·56
1·0N	69	16·4	0·43	66	11·8	0·56	63	9·0	0·69	60	7·1	0·83	58	5·6	0·97
1·5N	62	15·3	0·55	60	11·3	0·78	57	8·7	0·97	55	6·9	1·17	52	5·5	1·36
2·0N	56	14·4	0·74	54	10·9	0·98	51	8·3	1·24	49	6·7	1·48	47	5·4	1·72
2·5N	51	13·6	0·86	48	10·6	1·15	46	7·9	1·46	44	6·4	1·74	42	5·3	2·00
3·0N	46	13·0	0·98	43	10·3	1·28	41	7·6	1·60	39	6·2	1·93	37	5·2	2·26

with dielectric measurements in media of high conductivity. The only recent observations, making use of very high-frequency radiation and including a determination of both components of the complex dielectric constant are those of

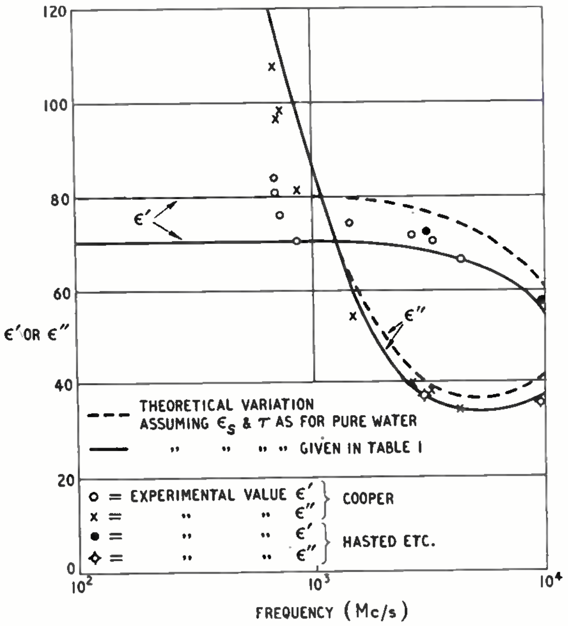

Fig. 1. *Theoretical and experimental values of* ϵ' *and* ϵ'' *for* 3% (0·51 *N*) *NaCl solution; temperature* = 21° *C.*

Cooper,[9] and Hasted, Ritson and Collie.[8] In interpreting his results, Cooper has suggested that the ionic conductivity of the solute should be added directly to the effective conductivity of the pure solvent with no other change in the dielectric properties. This is equivalent to saying that ϵ_s and τ remain unchanged by the addition of sodium chloride to water, and that the properties of the solution at any particular temperature and frequency can be specified by finding ϵ and ϵ'' for water and simply adding to the latter term the quantity $2\sigma_i/f$, where σ_i is the appropriate ionic conductivity in e.s.u. For dilute solutions this is approximately true, but for concentrated solutions the change produced in ϵ_s and τ must be taken into account and this is beginning to be appreciable for the salt concentration normally present in sea water (about 3 to 4%). The magnitude of the change is illustrated in Fig. 1, where Cooper's experimental values for ϵ' and ϵ'' at several frequencies at 21°C for a 3% (0·51 N) solution of sodium chloride in water are compared with the calculated variations with frequency using (1) values of ϵ_s and τ appropriate to pure water, and (2) the modified values of ϵ_s and τ given in Table 1. The experimental observations quoted by Hasted, Ritson and Collie for a 0·5 N solution are also shown. Cooper's observations at frequencies below 1 000 Mc/s appear somewhat inconsistent, but the experimental points in general agree rather better with the authors' calculated variation based on the modified values of ϵ_s and τ than they do with the calculated variation assuming a direct addition of conductivities. At this concentration the changes in ϵ_s and τ are about 11 and 4% respectively, somewhat larger changes being predicted by Table 1 for the more concentrated solutions. For example, a 2 N solution at 20°C has a static dielectric constant of about 51, compared with a value of 80 for the pure solvent. The results of Hasted, Ritson and Collie indicate a value of about 59 for the same conditions, and their values of ϵ_s and τ are in general agreement with those given above, except that their ϵ_s is somewhat higher throughout the range of concentration investigated.

It would appear, therefore, that the modified dielectric constants and relaxation times form a reasonable explanation of the electrical properties of salt solutions; and, moreover, they enable an estimate to be made of the electrical properties of sea water at any radio frequency.

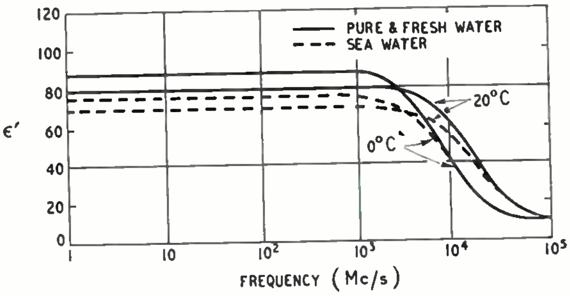

Fig. 2. *Dielectric properties of pure, fresh and sea water.*

3. Dielectric Properties of Sea Water

3.1. *Composition of Sea Water*

According to Dorsey,[10] the composition of sea water varies somewhat from place to place and from time to time; and in the surface layers of the oceans the total salinity varies from 3·1% to 3·7% depending upon the latitude, being rather greater in the southern hemisphere than at the corresponding latitude in the northern one. Our knowledge of the distribution of salt throughout the depth of the oceans is very imperfect, but if the average figure of 3·5% given by Dorsey is combined with that of 3·8% given by Smith-Rose[11] for sea water from the English Channel, then a salt concentration of 3·6% would appear to be a reasonable mean figure for the purposes of the present paper. Now the results of Hasted, Ritson and Collie already mentioned suggest that the electrolytes present in sea water, other than sodium chloride, will also produce a reduction in the values of ϵ_s and τ roughly in proportion to their concentration, and of a magnitude at least equal to that produced by the same amount of sodium chloride. The dielectric properties of sea water will therefore be, to a close approximation, the same as those of a 3·6% (0·62 N) solution of sodium chloride in water, and this is the figure used in the discussion below.

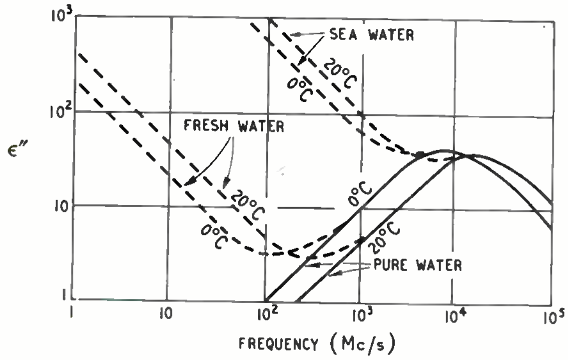

Fig. 3. *Dielectric properties of pure, fresh and sea water.*

3.2. *Variation of Dielectric Properties with Temperature and Frequency*

A limited and not completely rigorous discussion of the variation of the dielectric properties of sea water, as a function of frequency at a fixed temperature of 20°C, has been given by one of the authors in an earlier paper,[4] assuming a direct addition of dipolar and ionic conductivities with no change in the static dielectric constant and relaxation time. While no great error results from this procedure in the case of sea water, the more comprehensive calculations given in this section have been based on the modified values of ϵ_s and τ and, in view of the agreement with experimental data given above, they lead to more accurate results for the dielectric properties of sea water.

The calculated variation of ϵ' and ϵ'' for sea water over the frequency range 1 to 10^5 Mc/s for temperatures of 0°C and 20°C is shown in Figs. 2 and 3, with the corresponding values for pure and fresh water added for purposes of comparison. It is at once obvious that the dielectric properties of pure, fresh and sea water are identical for frequencies above about 2×10^4 Mc/s.

The small concentration of dissolved salts normally present in fresh water is insufficient to produce any change in the value of ϵ' for pure water at any frequency. In the case of sea water, however, a gradually increasing reduction in ϵ' is apparent for all frequencies less than 2×10^4 Mc/s, until the limiting low-frequency values, equal to ϵ_s, are reached at about 10^3 Mc/s. These are approximately 75 and 69 at temperatures of 0°C and 20°C respectively.

The total value of ϵ'' at any frequency is the sum of the dipolar and ionic conductivity terms, and the magnitude of the latter contribution is such that, instead of a symmetrical loss function with a single maximum at a given temperature as for pure water, there is a steadily increasing value of ϵ'', inversely proportional to frequency, at frequencies less than about 10^3 Mc/s and 10^2 Mc/s for sea and fresh water respectively. The temperature variation of ϵ'' for pure water is, of course, that associated with dipolar dispersion, and the maximum value of ϵ'' occurs at lower frequencies as the temperature is reduced. The added ionic conductivity present in fresh and sea water (about 10^8 and 4×10^{10} e.s.u. respectively) results, however, in ϵ'' ultimately assuming a temperature dependence associated with ionic dissociation at frequencies below about 10^2 and 3×10^3 Mc/s respectively. In the case of the concentration and temperature range of interest here the specific ionic conductivity increases with temperature, and consequently in this region the higher the temperature the greater is the value of ϵ''.

Figs. 2 and 3 also illustrate the features established in the earlier paper;[4] namely, that sea water never behaves as a dielectric at any point in the radio-frequency spectrum, and that fresh water only behaves approximately so over quite a limited range of frequencies, say from 50 to 10^3 Mc/s.

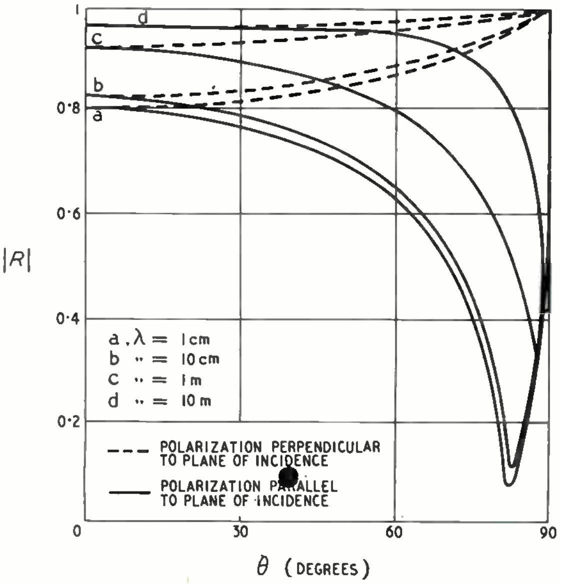

Fig. 4. *Modulus of reflection coefficient* $|R|$ *of sea water for various wavelengths as a function of angle of incidence* (θ)*; temperature* = 10° *C.*

4. Reflection Attenuation Characteristics of Sea Water

As far as the authors are aware, there is no existing summary of the reflection and absorption characteristics of sea water over a range of frequencies, and in this section these are calculated from the values of ϵ' and ϵ'' already given.

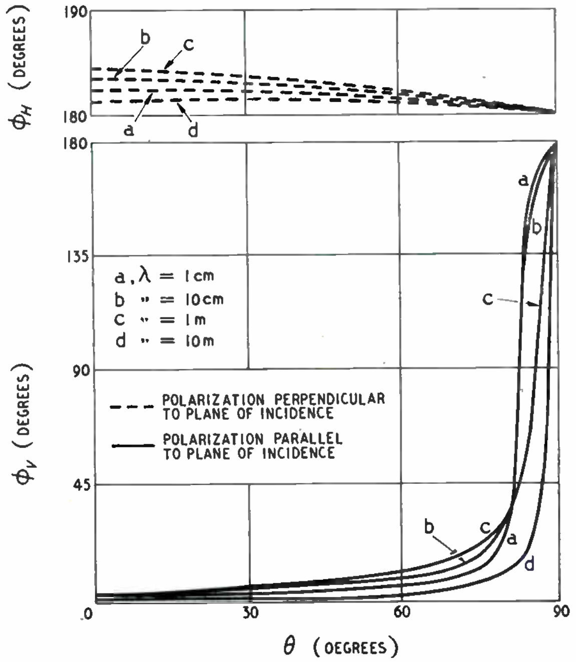

Fig. 5. *Phase retardation ϕ on reflection at a sea-water surface; temperature = 10° C.*

4.1. *Reflection Coefficient*

The properties of the reflection coefficient of a plane sea-water surface for plane-polarized radiation are shown in Figs. 4 and 5, where the modulus of the reflection coefficient, $|R|$, and the phase retardation, ϕ, occurring on reflection are given as a function of angle of incidence, θ, for various wavelengths between 1 cm and 10 m. They have been calculated for radiation polarized parallel to, and perpendicular to, the plane of incidence using the Fresnel reflection coefficients in the form given by McPetrie.[12] A temperature of 10°C was chosen as representing a mean annual temperature for British coastal waters. At wavelengths of 1 cm and below, the values of ϵ' and ϵ'', and hence of $|R|$ and ϕ, for sea water are indistinguishable from those for pure and fresh water, as can be seen from Figs. 2 and 3. It may be noted that $|R|$ at normal incidence is never less than 0·8 for wavelengths of 1 cm and above, and that the total variation in ϕ_H, for radiation polarized perpendicular to the plane of incidence, occurs between $\theta_H = 180°$ and $\phi_H = 185°$. As in the case of fresh water, ϕ_v passes through a value of $\pi/2$ as $|R_v|$ passes through a minimum value at a 'pseudo' Brewster angle. The actual value of this minimum value of $|R_v|$ increases with increasing wavelength. Since in many problems on radio-wave propagation it is angles near to grazing incidence which are of particular importance, expanded plots of Figs. 4, and 5 for angles of incidence between 80° and 90° are shown in Figs. 6 and 7.

It should be remembered that these values of reflection coefficient apply to the idealized case of plane-polarized waves incident upon a plane sea-water surface. In actual transmission, of course, the reflected radiation will be subject to a certain amount of scattering (i.e., the reflection tends to become non-specular), and this effect, for a given wavelength, will increase as the surface irregularities increase; in addition, the effect of the latter irregularities becomes more important as the angle of incidence, θ, decreases from $\pi/2$; i.e., as conditions depart from those of grazing incidence.

4.2. *Attenuation Characteristics*

The attenuation of sea water can also be calculated from the values of ϵ' and ϵ'' given in Figs. 2 and 3 using equation (5). The attenuation in practical units of decibels per metre can be found directly from the relation:

$$\text{Attenuation in db/m} = 8{\cdot}69 \times 2\pi\kappa/\lambda = 54{\cdot}6\ \kappa/\lambda \quad .. \quad (7)$$

where λ is in metres.

The attenuation is shown as a function of frequency in Fig. 8, for temperatures of 0°C and

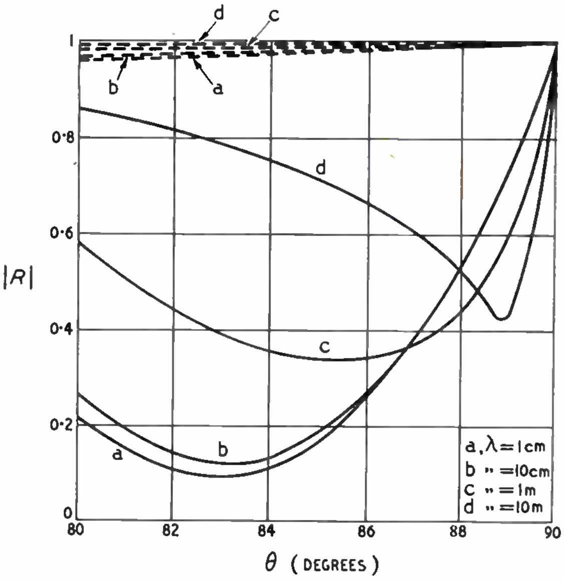

Fig. 6. *Expanded plot of Fig. 4 for angles of incidence between 80° and 90°.*

20°C, which represent the approximate limits likely to occur in practice. The corresponding attenuation values for pure and fresh water were not given in the earlier paper[4] and are included for purposes of comparison.

The attenuation characteristics are dependent upon the dipolar and ionic conductivities and their relative contributions to ϵ'', and may be inspected from this point of view. The ionic conductivity can be assumed to be constant and independent of frequency, but the total conductivity varies with frequency as well as with the terms n and κ, as shown by equation (6). The attenuation of sea water decreases with decreasing frequency over the whole of the frequency range 1 to 10^5 Mc/s, and the values for pure, fresh and sea water are identical for frequencies above 2×10^4 Mc/s. At lower frequencies the curves given can be interpreted as follows:—

(a) *Pure Water*

As the frequency decreases, the term $x(= \omega\tau)$ in equation (3) decreases, and ultimately the condition is reached where $x^2 \ll 1$. In this case, $\epsilon'' \propto f$ at a given temperature. Now $\epsilon'' = 2n\kappa$, and n is practically constant for all frequencies less than 10^3 Mc/s, so that in this region $\kappa \propto f$, or the attenuation (db/m) $\propto f^2$.

(b) *Fresh Water*

The normal amount of ionic conductivity associated with fresh water is about 10^8 e.s.u. and this is greater than the dipolar conductivity for all frequencies less than about 10^2 Mc/s, but over a limited range of frequencies, say from 2 to 10^2 Mc/s, the relative magnitudes of ϵ' and ϵ'' are such that the attenuation is very nearly constant. At frequencies below 1 Mc/s, however, where the ionic conductivity is even greater still compared with the dipolar conductivity (i.e., $\epsilon'' \approx 2\sigma_i/f$) we have the condition $\epsilon''^2 \gg \epsilon'^2$. Consequently, from equation (5), the attenuation (db/m) $\propto f^{\frac{1}{2}}$.

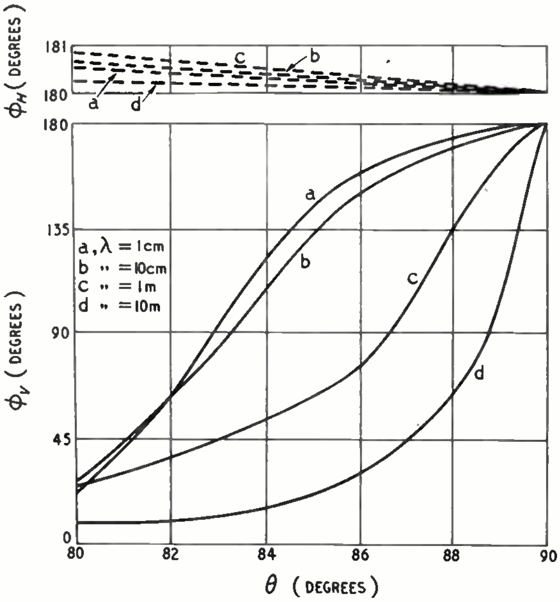

Fig. 7. *Expanded plot of Fig. 5 for angles of incidence between 80° and 90°.*

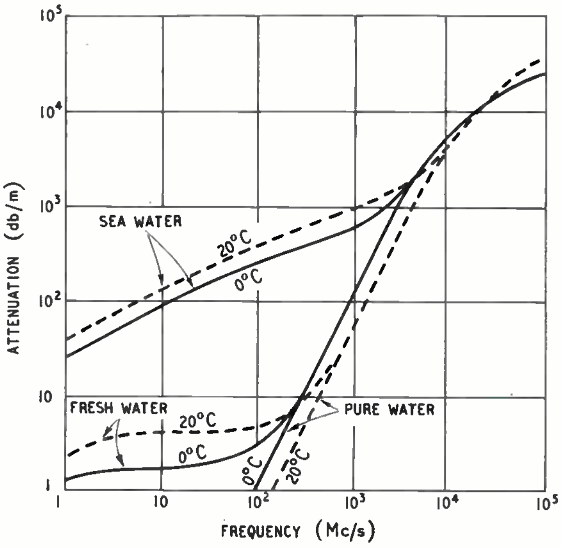

Fig. 8. *Attenuation of pure, fresh and sea water as a function of frequency.*

(c) *Sea Water*

Here the ionic conductivity is greater than the dipolar conductivity for all frequencies below about 4×10^3 Mc/s, and the former term already predominates at a frequency of 60 Mc/s. The magnitude of the ionic conductivity is such, moreover, that for frequencies below this value we again have the condition that $\epsilon''^2 \gg \epsilon'^2$, with the attenuation (db/m) $\propto f^{\frac{1}{2}}$.

5. Conclusion

An examination of the measured dielectric properties of aqueous sodium chloride solutions shows that the influence of the electrolyte on the dielectric properties of pure water is beginning to be appreciable for the salt concentration present in sea water. For example, on interpreting the results in terms of the Debye equations of dipolar dispersion, the static dielectric constant is reduced from 80 to about 69 at 20°C, and from 88 to about 75 at 0°C, with similar reductions in the dipolar relaxation time from $10{\cdot}1 \times 10^{-12}$ sec to $9{\cdot}2 \times 10^{-12}$ sec, and from $18{\cdot}7 \times 10^{-12}$ sec to $17{\cdot}0 \times 10^{-12}$ sec, respectively. The reflection and absorption coefficients of sea water can be calculated for any frequency and temperature, and it is shown how the attenuation of sea water increases with frequency from a value of about 40 db/m at 1 Mc/s (wavelength 300 m) to about 3×10^4 db/m at 10^5 Mc/s (wavelength 0·3 cm) for a temperature of 20°C.

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19TH NATIONAL RADIO EXHIBITION

State of Development in Television and Sound Receivers

THIS year's exhibition was held at Earl's Court from 26th August to 6th September, and was predominantly a television exhibition. Sound broadcast receivers were there in numbers, it is true, together with a small amount of non-broadcasting apparatus, components and test gear, but television was undoubtedly the major interest.

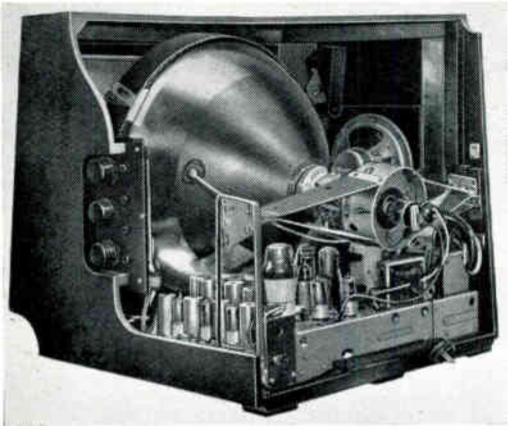
The present trend in television is unquestionably towards larger pictures and they are usually obtained by the use of larger cathode-ray tubes. The picture of 9-in. diagonal (9-in. tube) is apparently becoming a thing of the past. A very few years ago it was the most popular size, but in this year's exhibition it was represented by two models only. The 12-in. picture is now the commonest and accounted for some 53% of the models shown. The larger sizes, 14-in., 15-in., 16-in., 17-in., and 21-in. were individually much fewer in numbers, but together accounted for some 45% of the direct-viewing television sets exhibited.

Table models now give pictures as large as 17 in. and are not much bigger than the 12-in. sets of a few years ago, for this increase of picture size has been obtained without a corresponding increase of cabinet size. It comes about partly through the use of a large deflection angle in the c.r. tube; the angle is about 70° and makes the tube appreciably shorter than the older types. It is also partly a result of the introduction of the rectangular tube for this saves a good deal of space at top and bottom.

The circular tube is still widely used, however, even in the larger sizes, and the so-called metal tube is now by no means rare. In this only the truncated cone is of metal and forms the final anode, the screen and neck being glass. It requires a highly insulating mounting.

Most tubes over 12 in. are operated at around 12–14 kV, while the 12-in. types work at a little lower voltage—often at about 10 kV. Aluminized screens and/or ion traps are used, and very bright pictures are secured. The brightness obtainable is now usually greater than is necessary and advantage of this is taken to fit a so-called neutral filter. This improves the contrast when the picture must be viewed in considerable ambient lighting. It does this because any external light reflected from the face of the tube must pass twice through the filter whereas the light of the picture itself passes through it once only.

Some 55% of modern sets now have such a filter and the hue varies from a light grey to a dark purple. The majority are quite light, however, and in one or two models (Murphy Radio), the filter is removable and need not be used unless the ambient lighting is sufficient to render it desirable. This is a good point, for an initially brighter picture is needed with the filter than without and both the cathode loading of the tube and the spot size tend to increase with brightness.

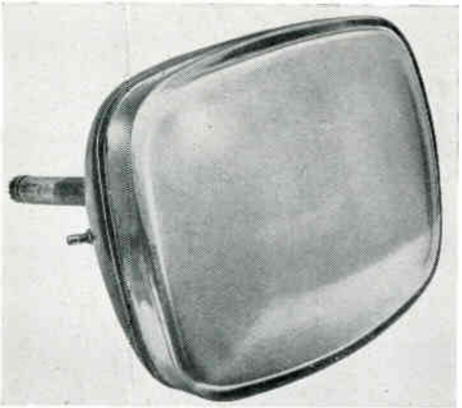


Murphy V204 with part of cabinet cut away. The controls are on one side of the cabinet with the loudspeaker on the other.

The detachable filter can hardly be considered a trend of development, however. In fact, the trend is the other way and some makers do not use a separate filter but employ a tube having its face of tinted glass, so that the tube and filter are combined.

There are plenty of sets without any filter, however, but all have an implosion guard. This serves to protect the tube against knocks and to protect the viewer against tube implosion. It is sometimes a sheet of safety glass in front of the tube, but very often it is a moulded plastic shaped to fit the end of the tube. It is this implosion guard which is usually tinted to form the light filter, although in those few sets in which the filter is detachable a clear implosion guard is used as well.

Projection sets are still available and are basically of the same types as in previous years using the Mullard tube and optical system; a 2½-in. c.r. tube operating at 25 kV is employed with a Schmidt optical system. The picture sizes vary from about 19-in. diagonal to about 5 ft. Most domestic types employ back projection with a viewing screen which is given very marked directional properties in the vertical plane and some directionality in the horizontal. Because of this the picture is affected remarkably little by ambient lighting. One of the smallest projection pictures is that of the Ferranti T1625, which gives a picture of 15 in. by 11¼ in.



Ediswan 17-*in. rectangular c.r. tube, CRM*171.

For the larger pictures front projection is used—the viewing screen being separate from the set and hung on the wall. Viewing must then take place in almost total darkness; in fact, under conditions akin to those of the cinema. These sets are not intended for normal domestic conditions so much as those of the club, the hotel and so on.

On the electrical side the details are very largely independent of the picture size. Projection sets differ from direct viewing in that the set must provide rather more signal drive to modulate the electron beam, and safety circuits must be provided to protect the tube in the event of a time-base failure. In addition, a separate unit is included to develop the 25-kV e.h.t. supply by the ringing-choke method. In directly-viewed sets the e.h.t. is almost invariably obtained as a by-product of the line scan by rectifying stepped-up voltage pulses which occur during the fly-back. Up to 14 kV can be obtained in this way.

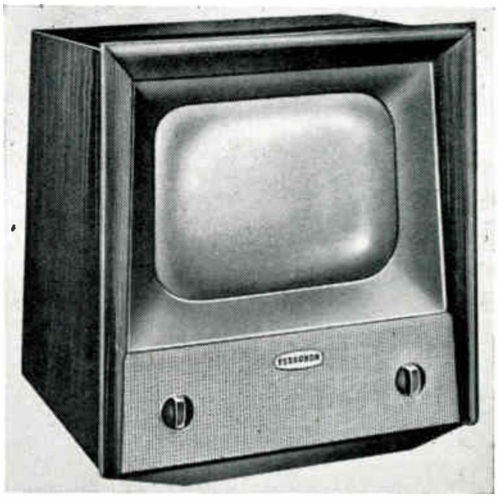
The wide-angle tubes now used, together with the high final anode voltage, make a large number of volt-amps necessary for deflection. It is around three times as much as a couple of years ago! That this is obtained with no increase of input power, and often with a reduction, is good evidence of the improvement in the efficiency of line-scanning circuits. This improvement is not a new thing this year. These highly efficient circuits were well to the fore last year and were briefly discussed in the review of last year's exhibition;[1] what is new is their almost universal adoption.

Most of these circuits use a pentode valve fed from an h.t. line of some 170-200 V and draw perhaps 70-100 mA from it. A low-loss auto-transformer couples the valve to the deflection coil and an overwind on the primary steps up the fly-back pulse to some 10–14 kV. A diode control valve is used and enables an h.t. boost of some 100–200 V to be obtained. The valves and circuits control large circulating volt-amperes but dissipate comparatively little power.

There are variations between different designers in the methods of controlling the circuit to obtain a linear scan and there are also variations in the driving methods. Some sets have a separate saw-tooth voltage generator which is quite often a two-valve multivibrator, others adopt a pulse drive for the pentode, or something intermediate between the two. This is particularly the case when the anode-circuit conditions are such that the pentode can be driven below the knee of its anode-volts–anode-current characteristic.

Quite often there is no driver stage and the pentode itself provides its own drive by feedback. Two methods are in use. In one of them the control grid is fed, sometimes through a shaping network, from a winding on the output transformer, as in the Baird P1815 receiver. In the other the feedback, which is always positive, is from the screen to the control grid.[2] This form of circuit probably results in less interaction between the various controls.

With very few exceptions the line-scan generator is synchronized by feeding to it differentiated line sync pulses. It is synchronized line by line. The fly-wheel methods so widely used in the U.S.A. have hitherto had little place in this country. For some years English Electric have adopted the method for fringe areas only. These sets have been, and still are, designed to operate with normal synchronizing methods for ordinary conditions but, by means of a plug-in unit, a fly-wheel circuit can be introduced where this is advisable. The merit of this type of synchronizing is that it is only the aggregate effect of many sync pulses that counts and the system is less susceptible to noise.



Ferguson 14-*in. table model measuring* 17 *in. wide by* 18¾ *in. high by* 16½ *in. deep.*

plate. In some of the portable types, which at one time relied entirely on the internal aerial, provision is now made for the use of an outdoor aerial. This has come about because of the number of people who have been found attempting to use them inside a steel-panelled caravan!

For the power supply both a.c./d.c. and a.c. techniques are used. Many sets are available in both categories and are identical save for the power supply. Then there are the mains/battery types in which operation from internal batteries or the mains is provided; obviously they are ideal where the same receiver must be used at times as a portable set, but mainly as the permanent home set.

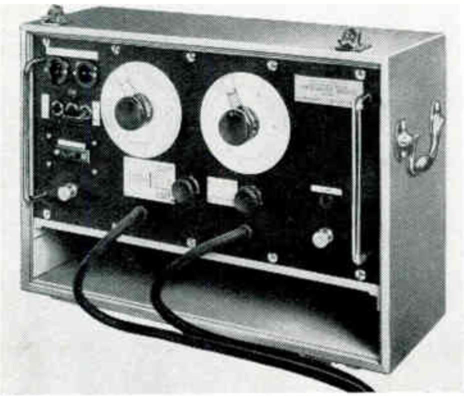
Radio-gramophones now often include three-speed record-changers, for 78, 45 and 33⅓ r.p.m. These have been available for some time now, but largely for export requirements, for the 45 r.p.m. record has only just been introduced here. Record-changers themselves are available separately and Collaro, Garrard and H.M.V. exhibited a range of types. As an example of their capabilities, the H.M.V. 2125 can handle up to eight 10-in. or 12-in. 78 r.p.m. records mixed, and up to ten 10-in. or 12-in. 33⅓ r.p.m. With a special centre-post up to eight 7-in. 45 r.p.m. discs can be handled.

One unusual radio-gramophone is the Alba Seven-0-Seven portable. It has a spring motor and a 4-valve receiver for a.c./d.c./battery operation and measures only 17 in. by 14 in. by 6½ in. when closed into its suit-case form.

In the table-models there is a tendency to make cabinets of larger frontal area but of much reduced depth. The object is to improve the reproduction by providing a better baffle for the loudspeaker and reducing box resonances.

Export types, of which many are now made, differ from home models largely in being built to withstand tropical conditions. Components are designed for operation at higher temperatures and metal parts are treated to resist corrosion. Many models are designed for operation from a car battery with the aid of a vibrator for the h.t. supply.

Although the exhibition was mainly of domestic apparatus a certain amount of other equipment was shown and one of the more interesting things among it was the Roneo machine for making stencils for duplication purposes. In principle it is similar to a facsimile machine. The original is fixed to a rotating cylinder and scanned by a photocell. On the same shaft is another cylinder carrying the stencil, which is of carbon material, and scanned in synchronism with the photo-cell by a tungsten-wire electrode. A spark jumps from this electrode to the cylinder and in so doing it burns a hole in the stencil material the size of which depends on the intensity of the spark. This is controlled by amplitude-modulating a 20-kc/s carrier in accordance with the photo-cell output. The scanning is at the rate of 500 lines per inch and high-grade reproduction of pictures is possible in a duplicating process.



E.M.I. "In Situ" impedance bridge QD 215.

Among test equipment shown, the E.M.I. "In Situ" impedance bridge is of particular interest since it permits measurement to be made in many cases without disconnecting the element from other components. Transformers are used for the ratio arms and the arrangement is such that in the measurement of the series arm of a π-network the two shunt arms come in parallel with the source and indicator of the bridge, where they do not affect the balance. The principle is a known one[4] and the bridge has been in existence for some years, but has only now been made generally available.

Cossor have now produced a portable oscilloscope measuring only 5½ in. by 4½ in. by 11½ in. and weighing 9¼ lb complete. It has a 2¾-in. tube, a time-base giving symmetrical deflection from 10 c/s to 50 kc/s and a Y-amplifier which can be switched for high or low gain. At high gain the amplification is 60 times and the bandwidth is 24 c/s to 150 kc/s, while at low gain it is 10 times for a bandwidth of 25 c/s to 3·5 Mc/s. The limits are for a response 30% down. At high gain the sensitivity is 0·086 V/mm with a maximum undistorted trace of 4·5 cm, while at low gain the sensitivity is 0·52 V/mm and the maximum undistorted trace is 1 cm.

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I.E.E. MEETINGS

9th October. President's Inaugural Address, by Col. B. H. Leeson, O.B.E., T.D.

15th October. Radio Section Chairman's Address, by E. C. S. Megaw, M.B.E., D.Sc.

27th October. "The Impact of Television on Sound Broadcasting." Discussion to be opened by G. Parr, B.Sc.

6th November. "Telemetering for System Operation", by R. H. Dunn, B.Sc., and C. H. Chambers.

These meetings will be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2, and will commence at 5.30.

BRIT.I.R.E. MEETING

8th October. Annual Meeting followed by Presidential Address of W. E. Miller, M.A.(Cantab.). To be held at the London School of Hygiene and Tropical Medicine, Keppel St., Gower St., London, W.C.1, at 6.30.

CORRESPONDENCE

Letters to the Editor on technical subjects are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Approximations in Network Design

SIR,—The purpose of this note is to show that, in many cases which are of interest in network design, a *Taylor approximation* of order n at a point P_0 can be obtained as a particular case of the corresponding *Tchebychev approximation* of the same order for a range $x_1 \ldots x_2$ including P_0, by letting the width of the range decrease to zero (P_0 remaining within the range). It is realized that in any particular design problem the Taylor approximation can usually be found more easily than the Tchebychev approximation, and in such cases the ability to derive the simpler and known approximation from the more complex and unknown one appears to be of little practical value. However, as it seems that this relation between the two types of approximation has not been mentioned in the literature before*, a demonstration of this relation may be of interest from the theoretical point of view and may occasionally be also of help in the solution of practical problems.

Let $y = G(x)$ be the required and $y = F_n(x)$ the approximating function, and let P_0 have the co-ordinates x_0 and y_0. In the case of a Taylor approximation n independent parameters have to be so chosen that

$$\left[\frac{d^k(F_n(x) - G(x))}{dx^k}\right]_{x = x_0} = 0 \text{ for } k = 0, 1, \ldots (n - 1).$$

In the case of a Tchebychev approximation let $x_1 \ldots x_2$ be so chosen that $x_1 \leqslant x_0 \leqslant x_2$; then the n parameters have to be so chosen that for $x_1 \leqslant x \leqslant x_2$ the maximum of $|F_n(x) - G(x)|$ is as small as possible. We are going to show that for $x_1 \to x_0$ and $x_2 \to x_0$ the Tchebychev approximation becomes a Taylor approximation. Only the case $G(x) = G(x_0) =$ constant will be considered.

In order to study the relation between a Tchebychev and the corresponding Taylor approximation, it is necessary to describe the Tchebychev approximation in more detail. Here a difficulty arises because the form in which the approximating function appears in an engineering application may differ considerably from the form most suitable for a mathematical discussion. An example will illustrate this. The insertion loss in decibels of a symmetrical low-pass filter is $L = 10 \log_{10}(1 + E^2)$ where E is an odd rational function of x and where x is the normalized frequency. From an engineering point of view we are primarily interested in L. From a mathematical point of view, however, E or $y = E/H$ (where H is a real constant) is of greater interest. L and y are shown in the figure assuming a Tchebychev approximation, of order 5, in the pass band $0 \leqslant x \leqslant x_2$. L_0 and y_0 are the ideal values, L_1 and y_1 the lower, and L_2 and y_2 the upper limits of L and y, respectively. y is considered in the x-range $x_1 \ldots 0 \ldots x_2$ where $x_1 = -x_2$. In this range the equation $y = y_0 = 0$ has 5 simple roots at real x-values, and the same is true for the equations $y = y_1$ and $y = y_2$ if double roots (no roots of higher multiplicity occur) are counted twice. L is considered in the smaller range $0 \ldots x_2$ and it is seen that the number of roots of the equations $L = L_0 = 0$, $L = L_1$, and $L = L_2$ differs from the number of roots of the corresponding equations in y. This is due to the halving of the x-range, the squaring of y in the formula for L and the coalescence of L_1 and L_0.

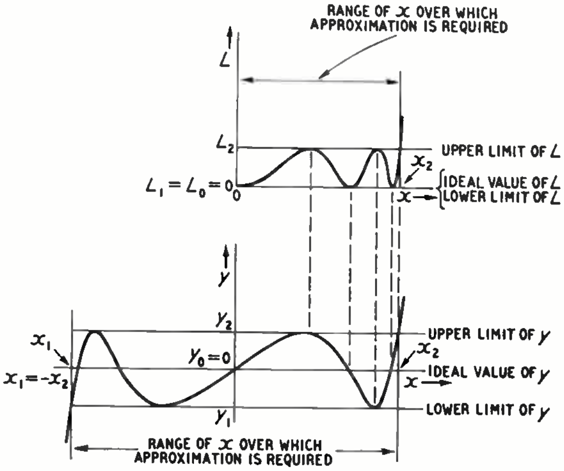
In the following discussion we shall consider the approximating functions in their "y-form". Then the two essential features, for our purposes, of a Tchebychev approximation of order n in the range $x_1 \ldots x_2$ are:—

(a) the equation $F_n(x) = y_0$ has n real and simple roots in this range;

(b) If $(x_2 - x_1) \to 0$, also $(y_2 - y_1) \to 0$.

If now $(x_2 - x_1) \to 0$ in such a way that $x_2 \to x_0$ and $x_1 \to x_0$, we obtain at $P_0(x_0, y_0)$ a root of the nth order of the equation $F_n(x) = y_0$. (a) would not be sufficient to ensure this, as the reduction of the range over which $F_n(x)$ shows an oscillatory behaviour might leave the amplitude of this oscillation unchanged. This is, however, excluded by virtue of (b). Owing to the occurrence of an nth order root at x_0, we have obtained a Taylor approximation at P_0.

This is, of course, not a rigorous mathematical proof. However, it will be shown that at least in the three examples discussed below the validity of this relation between Tchebychev and Taylor approximations can be proved rigorously.



The relation between L and y is $L = 10 \log_{10}[1 + (Hy)^2]$.

Example 1.—We consider a symmetrical low-pass filter and assume that L is required to have no poles except at $x = \infty$. We shall compare approximations to $L = 0$ in the pass band $0 \ldots x_c$. The Taylor approximation at $x = 0$ is $y = x^n$ where n must be odd. The Tchebychev approximation (see, e.g., Saraga[2,3]) is

$$y = x_c{}^n 2^{1-n} \cos\left[n \cos^{-1}(x/x_c)\right] = (x_c/2)^n \left\{\left[(x/x_c) + j\sqrt{1 - (x/x_c)^2}\right]^n + \left[(x/x_c) - j\sqrt{1 - (x/x_c)^2}\right]^n\right\}$$

For $x_c \to 0$ we obtain $y = x^n$; i.e., the Taylor approximation.

Example 2.—Let us assume that, in the case discussed above, approximations to $L = 0$ in the range $0 \ldots x_c$ and to $L = \infty$ in the range $1/x_c \ldots \infty$ are required. The Taylor approximation at $x = 0$ and at $x = \infty$ is again $y = x^n$ (n must again be odd). The Tchebychev approximation is (see Darlington[4])

$$\left.\begin{array}{l} y = \sqrt{\lambda}\ \mathrm{sn}\ [u(\Lambda/K)n,\ \lambda],\quad x = \sqrt{k}\ \ \mathrm{sn}(u,\ k), \\ \quad \text{where } k = x_c{}^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \end{array}\right\} \qquad (1)$$

sn is the symbol for the elliptic sine function and λ is given by

$$\Lambda/\Lambda' = K/(nK') \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (2)$$

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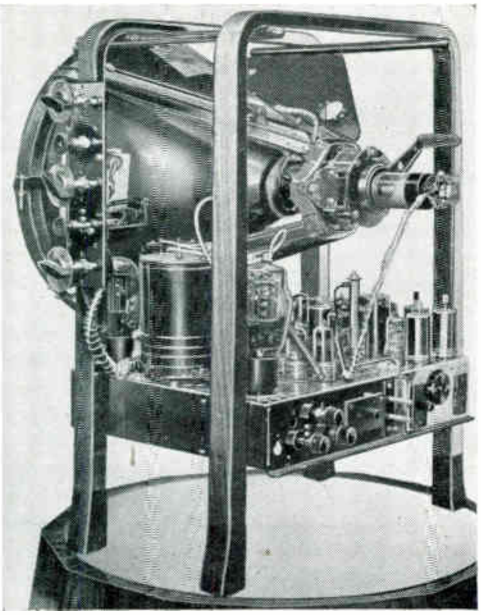
* After the material for this note had been prepared, an article by Linvill[1] was published in which this relation is shown to exist in the case discussed in this note as "Example 1."

The English Electric system has been previously described.[3] Pye have now introduced a different form in their FV2C. The saw-tooth generator is a multivibrator of the general Abrahams-Bloch form, but with additional cathode coupling in which an LC circuit tuned to 8,000 c/s is included. This exercises a stabilizing influence on the repetition frequency.



Ekco T161 chassis and tube assembly mounted in dummy frame. The tube is clamped at the front and the deflector coils and focus magnet are supported by four struts from the mounting.

The synchronizing pulses are compared in a two-diode discriminator with local pulses taken from a winding on the scan transformer. The discriminator develops an output voltage of magnitude and polarity dependent on the phase difference between the two sets of pulses. This is the control voltage and, after passing through a circuit of large time constant, it is applied to one grid of the multivibrator.

Ferguson have also adopted fly-wheel sync, but are using a different method. An LC oscillator is used to generate (indirectly) the scanning waveform and is controlled by a reactance valve. A double-diode discriminator compares the sync pulses with the local waveform and produces the controlling voltage for the reactance valve.

For the frame scan two-valve generators are usual, but that is all that one can say about them in general terms, for there is a large amount of variety in detail. A saw-tooth generator, usually a blocking oscillator, (but multivibrator types are not unknown), is employed to feed a triode or a pentode output stage. Transformer coupling to the deflector coils is usual, but there is an increasing tendency to employ an auto-transformer. Linearity is achieved sometimes by the Blumlein feedback circuit, sometimes by a simple RC network without feedback and sometimes mainly by the curvature of the valve characteristic.

Synchronizing in the frame circuit receives more attention than it used to do. The simple integrator is now rare. Semi-integrators with a time constant around 50 μsec are used with one or two diodes, to provide limiting and unequal charge and discharge time constants.

For the power supply there are two modes of thought. One is to adopt a.c./d.c. technique with valve heaters in series and to take the h.t. supply from a half-wave rectifier. This usually results in an h.t. line of around 170 V only and provision is sometimes made for cutting out the smoothing choke for low-voltage d.c. supplies in order to avoid its voltage drop. The alternative form of power supply includes an auto-transformer. This makes the set a.c. only but, by feeding the h.t. rectifier from the 250-V tapping, a line voltage of 200 V, or more, can be obtained from all supplies. For valve heaters there are two different arrangements. One is to connect them in parallel and feed them from a secondary on the auto-transformer, which then becomes only an auto-transformer as far as h.t. is concerned and is a double-wound transformer for l.t. The other is to connect most of the heaters in series and feed them from a tapping on the auto-transformer. One or two heaters are often run from a separate winding, however.

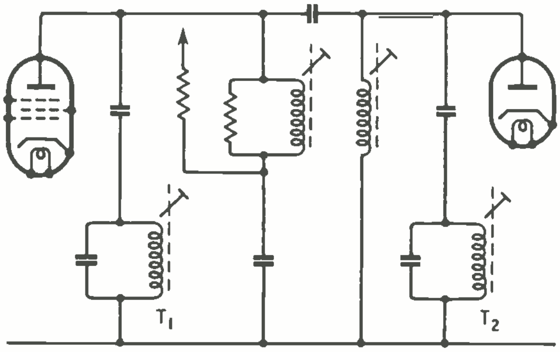
The main advantage of the auto-transformer technique is that the component is much smaller and cheaper than a double-wound transformer and has a smaller stray field to affect the c.r. tube. Its disadvantage is that the chassis is live to the mains and so careful protection is required to guard against the possibility of the user coming into contact with it. Particular attention is now paid to the safety aspect of television, and fire hazards are not overlooked. Fuses are used much more widely

G.E.C. 16-in. console type, BT6541 with inductance tuned station selector.

than at one time and attention is paid to the placing of components so that an overheated resistor, for example, is unlikely to affect anything else.

Turning now to the signal side, as one might have expected, the existence of five television channels, with the need for making sets suitable for use on any one of them, has resulted in the superheterodyne becoming practically universal. Only three or four circuits need alteration to change from one channel to another as compared with a dozen or more in the t.r.f. set. The usual practice is to have one stage at signal frequency followed by a frequency changer and two or three i.f. stages in both the sound and vision channels. A diode detector is used with one video stage and a diode noise limiter. On sound a diode detector is used with a series-diode noise limiter (in many cases) and one or two audio stages. Apart from the audio and video sides there is very little uniformity in the signal circuits. Coupled pairs of circuits are usual for the intervalve i.f. coupling in the sound channel and very often also in the vision channel. Stagger-tuned single circuits are sometimes used, however. Sufficient selectivity to avoid interference from the sound channel is usually achieved only with the aid of rejector circuits.

The Ferranti T.1225 affords one example of the use of rejectors, as shown below. An i.f. coupling, which comprises a coupled pair of circuits, has rejectors on both primary and secondary sides. The rejectors are in the form of parallel resonant circuits coupled by small capacitances to the main circuits, but they operate as series circuits since the rejection frequency occurs when the reactance of the coupling capacitance equals the inductive reactance of the parallel tuned circuit.



I.F. to detector coupling of Ferranti T1225. Sound-channel rejectors T_1 and T_2 are connected across primary and secondary of the main capacitively-coupled pair of circuits.

Pye, however, adopted last year and still use, three or four coupled circuits for each vision-channel i.f. coupling and with three stages get a total of 15 tuned circuits at i.f. With this number sufficient selectivity is obtained without rejectors.

The two-valve frequency changer with grid injection is quite a favourite type. Often a double-valve is used, sometimes a triode-pentode, in which case the pentode is used for mixing, but more often a double triode. Many sets have only a single-valve frequency changer, however, and then the oscillator has a tuned circuit between the control and screen grids to form a Colpitts or Hartley oscillator and the signal is fed in to a tapping at a null point on the circuit. Bush and Ekco favour this type of circuit.

A few sets, Murphy for instance, have two stages of amplification at signal frequency and then one i.f. stage less than the usual is employed.

For fringe-area reception a pre-amplifier can be used with many receivers, and an unusual example is the Belling & Lee head amplifier. It is a push-pull earthed-grid amplifier designed for mounting at the top of the aerial mast. The power is 33 V a.c. and is supplied along the coaxial feeder.

The methods of station selection vary a good deal. Many firms now make their sets complete in themselves for any television channel. Of these, some have continuous tuning accessible to the user (Bush, G.E.C.), others have tapped coils for dealer adjustment (Pye). Some makers have the signal side as a replaceable sub-unit, others have plug-in coils (Philips). The many and various solutions which have been found to a common problem suggest that the ideal one has yet to be found.

Stella ST.151A 6-valve all-wave receiver for a.c. operation. A tuning indicator is fitted, there is an internal plate aerial for local reception, and provision is made for the use of an extension speaker and a gramophone pick-up.

Although the inspection of circuit diagrams of receivers does not reveal many startling changes in design, the sets exhibited in operation gave noticeably better pictures than in previous years. This improved performance undoubtedly comes about through greater attention to detail in design and production. Bandwidths appear to have been appreciably increased, and both focus and interlace are better. The mechanical details, too, are often much better.

The television receiver is still usually an isolated article and there is no evidence of any trend towards its combination with the sound-broadcast receiver. There are some such sets, it is true, but relatively few. Apparently the public likes to have the two separate.

Compared with the television receiver, the sound-broadcast set of to-day is a very simple affair. The superheterodyne is used and a very common arrangement of the valves is as frequency-changer, one i.f. stage, duo-diode-triode for detection, a.g.c. and first audio stage and a pentode output stage. Provision is usually made for the use of a gramophone pick-up and also for an extension loudspeaker.

An internal aerial for local reception is now often provided and is sometimes a frame and sometimes a where K, K', Λ, Λ' are the quarter periods corresponding to the moduli k, $k' = \sqrt{1 - k^2}$, λ, $\lambda' = \sqrt{1 - \lambda^2}$, respectively. For $k \to 0$ we obtain $k' = 1$, $K = \frac{1}{2}\pi$ and $K' = \log_e(4/k)$. Because of $K/K' \to 0$, we have $\Lambda/\Lambda' \to 0$ and $\Lambda = \frac{1}{2}\pi$, $\Lambda' = \log_e(4/\lambda)$. Therefore (2) leads to $\lambda = 4^{1-n}k^n$. Thus we obtain from (1) $y = 2^{1-n}k^{\frac{1}{2}n} \sin [n \sin^{-1}(x/\sqrt{k})]$ or $y = -2^{-n}jk^{\frac{1}{2}n}\left\{\left[\sqrt{1 - (x/\sqrt{k})^2} + j(x/\sqrt{k})\right]^n - \left[\sqrt{1 - (x/\sqrt{k})^2} - j(x/\sqrt{k})\right]^n\right\}$. Therefore, for $k \to 0$, we obtain $y = j^{n-1}x^n$. As n is odd, $y = \pm x^n$. Thus we have again obtained the Taylor approximation.

Example 3.—We consider phase-shift networks with phase shifts β_1 and β_2. It is required that $y = \tan \frac{1}{2}(\beta_1 - \beta_2)$ approximates $y = 1$ (i.e., $\beta_1 - \beta_2 = \frac{1}{2}\pi$), and y is an odd rational function of x. The Taylor approximation at $x = 1$ is $y = \tanh[n \tanh^{-1}x]$ (see Saraga[3]). The Tchebychev approximation in the range $\sqrt{k} \leqslant x \leqslant 1/\sqrt{k}$ is $y = \sqrt{\lambda}\,\mathrm{sn}[u(\Lambda/K), \lambda]$, $x = \sqrt{k}\,\mathrm{sn}(u, k)$ (see Darlington[5], Orchard[6], Saraga[4,7]), where λ is given by $\Lambda/\Lambda' = n(K/K')$. For $k \to 1$ we obtain $k' = 0$, $K' = \frac{1}{2}\pi$, $K = \log_e(4/k')$, $K/K' \to \infty$. Therefore $\Lambda/\Lambda' \to \infty$, $\lambda = 1$, $\Lambda' = \frac{1}{2}\pi$. Then $y = \tanh nu$ and $x = \tanh u$; i.e., $y = \tanh [n \tanh^{-1}x]$. Thus we have again obtained the Taylor approximation.

W. SARAGA.

Telephone Manufacturing Co., Ltd.,
St. Mary Cray, Kent.
29th July, 1952.

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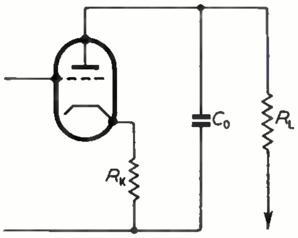
Amplifier Frequency Response

SIR,—In discussing the gain-bandwidth of feedback amplifiers (*Wireless Engineer*, May 1952, p. 118) Mr. Bell shows quite conclusively that for the particular case considered this quantity is a characteristic of the amplifier alone, but I am unable to agree with the statement that "the use of feedback to modify the frequency response of an amplifier cannot change the gain-bandwidth product." The example given below shows this generalization is not correct.

Consider an amplifier where feedback is obtained by using an unbypassed cathode resistance:



$$Z_L = \frac{R_L}{1 + j\,\omega\,C_0\,R_L}$$

Gain (with feedback)

$$A_f = \frac{\mu R_L}{\{r_a + R_k\,(1 + \mu)\}\,(1 + j\,\omega\,C_o\,R_L) + R_L}$$

$$|A_f| = \frac{\mu R_L}{[\{r_a + R_L + R_k\,(1 + \mu)\}^2 + \{(r_a + R_k\,(1 + \mu))\,\omega\,C_o\,R_L\}^2]^{\frac{1}{2}}}$$

The upper half-power frequency is obtained in the usual way. It is in this case

$$f_h = \frac{R_L + r_a + R_k\,(1 + \mu)}{2\,\pi\,C_o\,R_L\,\{r_a + R_k(1 + \mu)\}}$$

The mid-band gain with feedback is

$$A_{f\,mid} = \frac{\mu\,R_L}{R_L + r_a + R_k(1 + \mu)}$$

giving a product

$$A_{f\,mid} \times f_h = \frac{\mu}{2\,\pi\,C_o\,(r_a + R_k(\mu + 1))}$$

If the cathode resistor is bypassed (i.e., $Z_k = 0$), then the value of the corresponding product

$$A_{mid} \times f_h = \frac{\mu}{2\,\pi\,C_o r_a}$$

The latter will always be greater than the former, this difference being considerable in a triode. In general, where overall voltage feedback is used in the amplifier, the conclusion reached is valid, but some qualification is needed for circuits where some current feedback is employed.

A. E. FERGUSON.

Electrical Engineering Department,
The University of Melbourne,
Australia.
5th August 1952.

SIR,—In my article I was careful to compare two methods of achieving *the same result* rather than compare the two results of using the same apparatus in different ways. This simplified the demonstration for particular examples, but was perhaps unfortunate in concealing the implications of the fact that I always try to use 'gain' to mean 'power gain' (see B.S. 204 : 1943, definition No. 1227) and was careful to use 'amplification ratio' and 'feedback amplitude' when referring to the quantities proportional to the square root of the power which appear in the feedback formulae of the type $A\ (1 + A\beta)$. It is then clear that Mr. Ferguson's example based on *voltage* amplification with *current* feedback is likely to lead to complication, and in the light of these considerations Mr. Ferguson may even think that I have not proved my particular examples as conclusively as appeared.

If one is comparing *different* results the only safe basis is that of available output power for a given input power, (i.e., taking account of both output and input impedances) which means a debit to the current-feedback amplifier on the score of higher output impedance and a credit on the score of higher input impedance, in the process of specifying the gains as power gains, as well as the squaring involved in using gain rather than amplification ratio, and I believe that when all these factors are taken into account my generalization will apply.

The physical basis of my generalization is that all amplifiers known to me require a certain amount of *energy* to be stored in the input member in order to release *power* at the output member. For example, a 'voltage amplifying' valve requires the presence of energy $\frac{1}{2}\ C_{in}\ V_g^2$ in the input capacitance in order to release available power $1/4\ g_m^2 V_g^2 r_a$ in the anode circuit. The power gain then depends primarily on the *input* time-constant, since the input power can be reduced by allowing a longer time in which to build up the required input energy. It appears, unfortunately, that this input build-up time cannot be reduced by feedback; and the physical reason is presumably that whatever happens in the output circuit is after, rather than before, the input signal and feeding back some of the output will if anything delay the total power fed to the input. A similar argument applies to the feeding back of power developed in the output circuit in an attempt to compensate for the slow rate of growth of power in the output circuit. There is, however, the point that the time-constant of an amplifier of a given type of construction is directly proportional to the maximum power which it can handle (because of the output-power/input-energy relationship). It is therefore possible that the time-constant of a given device can be reduced by a form of feedback which reduces the maximum power output of the device.

In general, negative feedback may be thought of as 'the transfer of responsibility.' One uses it to transfer the responsibility for output waveform from a heavily-loaded output valve to the more lightly-loaded earlier stages, or to transfer responsibility for the frequency response from one part of the circuit to another, but it cannot improve on the maximum performance of the available pieces of apparatus.

D. A. BELL.

The Electrical Engineering Department,
The University, Birmingham.
15th August 1952.

NEW BOOKS

Kurze Zusammenfassung der Elektrizitätslehre (Eine Einführung des rationalisierten Giorgischen Mass-Systems.)

By P. CORNELIUS. Pp. 89 + viii, with 11 illustrations. Springer-Verlag, Vienna 1, Mölkerbastei 5.

It should be noted that the sub-title is not an introduction *to* the Giorgi rationalized system but an introduction *of* the system. It is a discussion of the best method of approaching the subject and laying the foundations of electrical science on the basis of the rationalized Giorgi system. The author is associated with the Philips Research Laboratories in Holland and Dr. de Groot contributes an introduction. The book is addressed to the teacher rather than the student, and it should do much to further the complete adoption of the system in German-speaking countries. In the foreword the author says that the three objects of the book are: (1) to bring to an end the discussion over electrical units; (2) to make the reader familiar with the rationalized Giorgi system with absolute volts and amperes in the quickest possible way, and (3) to recommend that the teaching of electricity from the school to the technical college be brought into line with the conceptions and methods set forth in this book.

The first 28 pages are devoted to the laws of electricity and magnetism and to the mechanical forces in the fields. It begins with Ohm's law, but the ohm is banished to a footnote and the development based on conductance rather than resistance. Then follows capacitance and the electric field, and then inductance and the magnetic field. In accordance with suggestions made by R. W. Pohl, the two absolute constants ϵ_0 and μ_0 are called the "influence constant" and the "induction constant" respectively, each of which has exactly the same number of letters as the more expressive 'space permittivity' and 'space permeability.' Some of the comparisons between electric and magnetic fields seem rather confused; for example, on p. 19 we read. "There are certain differences between the magnetic field and the current and the electric field. In the latter the closed line integral $\int_0 E_s$ is zero if there is no varying magnetic field. Between the neighbouring ends of a wire ring, for example, there is no voltage, whereas a straight wire in the direction of the field appears to have a positive charge at one end and a negative charge at the other. [But there is no potential difference between the ends.] On the other hand if, as an analogy to the ring in the electric field, we bend a piece of iron around a wire carrying a continuous current, the neighbouring ends become magnetized north and south." While each of these statements is correct, their comparison is apt to be confusing.

After discussing Maxwell's laws and the mechanical forces in electric and magnetic fields, the author considers the choice of a system of units and the method of teaching the subject. He approves heartily the decision to give up the international ohm, volt, and ampere, and to adopt the absolute units as the internationally recognized units; this came into force on 1 January 1948. He then discusses a number of questions that arise, especially the distinction between H and B and also between E and D, not only in magnitude but in their nature, which he considers essential but which some physicists oppose. Polarization, both electric and magnetic, are discussed very fully and much attention is devoted to the subject of permanent magnets and their design. (In formula (101) on p. 50 D_0 should be B_0.)

In the concluding section the author acknowledges his indebtedness to R. W. Pohl's "Einführung in die Elektrizitätslehre" now in its fourteenth edition. Although Professor of Physics at the University of Göttingen, he adopted the rationalized Giorgi system, and the general method followed in the book under review, in his first edition in 1927. The final section of the book consists of a number of tables giving very full information concerning the relations between all the various electric and magnetic magnitudes that are mentioned in the book (but Mossoti does not look very nice on p. 72). An appendix is addressed to physicists to whom the book may appear distasteful. The author says that although it was not written primarily for physicists, it can be recommended to them: their objections may not be so much to the Giorgi system as to the method of approaching electrical science.

It is undoubtedly a book that can be recommended to the attention of anyone engaged in teaching electrical science and engineering or in writing papers on the subject.

G. W. O. H.

Wireless Fundamentals

By E. ARMITAGE, M.A.(Cantab.), B.Sc.(Lond.). Pp. 368. Sir Isaac Pitman & Sons Ltd., Parker St., Kingsway, London, W.C.2. Price 18s.

"This book is intended to fill a gap that at present exists between books whose aim is to teach 'wireless' to students with no previous knowledge of electricity and those which are written for readers of University standard, equipped with the Calculus and the desire for a rigorously mathematical treatment of the subject." This is the opening sentence of the author's preface and most people will agree that his intention is a laudible one.

"A knowledge of electricity up to Ohm's law" is assumed. This is the only indication of the amount of prior knowledge required for an understanding of the book. Unfortunately, it is rather a vague one, for the position of Ohm's law in the scale of knowledge depends very much upon the method of teaching. It can precede or follow elementary electrostatics and electromagnetism.

The introductory chapter of 8½ pages, in which the nature of an electric current, Ohm's law, alternating current and modulation are very briefly explained, gives one a clue. Since it contains no mention of electrostatic or electromagnetic phenomena, the reader is presumably not supposed to know anything about them. However, if he does not, the serious reader will find difficulty in chapter 2, in which the diode and the triode valve are discussed. Here space charge is introduced and the reader is given no clue as to why a positive anode should attract electrons. Chapter 4, on capacitors, is also likely to be troublesome for, as the treatment avoids mentioning electric fields, it necessarily becomes little more than a statement of facts.

The following chapter on "Alternating Current," however, starts with the statement that "It is convenient to think of magnetic fields in terms of lines of force." Except for the statement that "A field of unit strength is thought of as being represented by one line of force per square centimetre . . .," there is, at that place, no other indication of what a magnetic field or a line of force is. Not until chapter 7 do we find anything further related to this and there little more than some magnetic-field diagrams.

The chapter on resistance is largely concerned with types of resistor, the colour code and the placing of measuring instruments for current and voltage.

Alternating Current is the next subject to be discussed and under this heading are included electromagnetic induction, the generation of a.c. and its measurement, r.m.s. values and the cathode-ray oscillograph! Rather more than one-third of the chapter is devoted to the last item. Chapter 6 has for its title "Simple Harmonic Motion: The Behaviour of a Resistance and a Capacitance towards Alternating Current." The following chapters cover power supplies and amplifying triodes; then resonant circuits are treated and followed by the valve as an oscillator. In turn, this is followed by tetrodes and pentodes for r.f. amplification, the carrier wave, modulation, detection, a.f. amplification and the final chapter deals very briefly with the superheterodyne. There are three mathematical appendixes.

Throughout, the treatment is elementary and nothing more than simple algebra is used. A good point is the way in which the reader's interest is held by continually relating the material to practical matters. This fact alone is likely to make many readers prefer the book to those of a more academic outlook in which the subject is more logically developed.

In the reviewer's opinion, the main defect of the book is its title. "Wireless Fundamentals" makes one expect something much more profound, something more in the nature of electrostatics and electromagnetism so written as to bring out their radio aspects. The book is very far from being that and its primary appeal is to those interested in wireless who have already some smattering of electrical knowledge. The book will keep their interest and increase their knowledge. At the end, however, their knowledge will be largely superficial and the danger is that they may not realize it. Having digested this book, the reader should follow it with another which covers similar ground from a more fundamental aspect and, in particular, he should follow it by a thorough study of the fundamentals of electricity and magnetism. Logically, this should be his first study; practically, it is often better to make it a second or third stage, for only then can the student see sufficiently well where the fundamentals are leading to appreciate their necessity and to keep sufficient interest in them to make learning easy.

This book, therefore, serves a useful purpose as long as the reader remembers that it is of limited scope. It is clearly written and unusually free from errors and misleading statements. W. T. C.

Textbook on Sound

By J. W. Winstanley, M.Sc., A.Inst.P. Pp. 239 + xi, with 153 figures and four plates. Longmans, Green & Co., 6 and 7 Clifford Street, London, W.1. Price 12s. 6d.

Written primarily for the use of students preparing for the General Certificate of Education at Advanced or Scholarship level, this book provides an excellent summary of the classical acoustics of Rayleigh and Barton and the physics of music as developed by A. Wood. An effort is made to give an outline of recent developments in electro-acoustics, but here the author is less sure of his ground and the picture is incomplete. For example, the section on magnetic recording deals only with metallic tapes and wires and does not mention the oxide-coated plastic tapes which are now generally used. The treatment of loudspeakers, microphones and pick-ups is sketchy and the architectural acoustics are those of Sabine and Eyring rather than of Morse and Bolt.

The sections dealing with current ideas and practice should be treated with reserve, but the main body of the book can be recommended as an inexpensive introduction to the classical foundations of acoustics, without which the technician, however modern his outlook, must feel theoretically insecure. F. L. D.

Advanced Antenna Theory

By Dr. S. A. Schelkunoff. Pp. 216 + xii with 64 illustrations. Chapman & Hall Ltd., 37 Essex St., London, W.C.2. Price 52s.

In this book the author devotes himself to a thorough investigation of the important developments that have been made during the last 25 years in rigorous antenna theory. Much of it is, of course, very mathematical, but the author sets it out as clearly as possible and stresses the physical interpretation of the mathematical procedure and results.

The six chapters into which the book is divided are entitled spherical waves, mode theory of antennas, spheroidal antennas, integral equations, cylindrical antennas, and natural oscillations. In the first chapter the various ways of approach are considered, Maxwell's equations set out and applied to TE, TM, and TEM waves under various conditions, including biconical transmission lines. The second chapter is devoted mainly to the radiation from biconical antennas and their various modifications. The third chapter deals with the rather academic problem of prolate and oblate spheroidal antennas, but these form useful approximations to actual antennas, and reference is made to the work of Stratton and Chu on this subject. In the fourth chapter equations are established for surface currents and applied to oscillations on closed surfaces of revolution: the equations are discussed in their relation to Kirchhoff's network equations. Chapter V is devoted to cylindrical antennas and especially to Hallén's method of obtaining asymptotic solutions; special attention is also devoted to the work of King and Middleton in expounding Hallén's method. The final chapter deals with forced and natural oscillations, the derivation of equivalent networks, and the application to oscillations on thin wires. This is followed by 44 problems mostly of a very mathematical type. There are nine appendices, mainly tables of integrals and numerical values of various constants.

This book undoubtedly gives a very masterly presentation of a very difficult subject; although mathematical, the excellent diagrams and physical explanations do much to help the reader to follow every step in the development. G.W. O. H.

Electrical Communications Experiments

By Henry R. Reed, Ph.D., T. C. Gordon Wagner, Ph.D., and George F. Corcoran, M.S. Pp. 458+viii. Chapman & Hall, Ltd., 37 Essex Street, London, W.C.2. Price 54s.

In this American book, some 60 laboratory experiments are described with a theoretical introduction to each. The book is intended to assist the practical side of a course in communications engineering.

Principles of Radio. 6th Edition

By Keith Henney and Glen A. Richardson. Pp. 655+vii. Chapman & Hall, Ltd., 37 Essex Street, London, W.C.2. Price 44s.

This well-known American book has been revised after an interval of seven years and it covers in an elementary manner the essential theory and practice of radio apparatus. The authors have written it to be useful to those working alone.

Units and Standards of Measurement III: Electricity

Pp. 14. H.M. Stationery Office. Price 9d. (postage 1½d.).

An account of the standards used at the National Physical Laboratory for the measurement of current, voltage, resistance, power, energy, inductance, capacitance, frequency, etc.

Ein Ultrakurzwellen-Telefoniesystem hoher Kanalzahl mit Frequenzweiche

By Gustav Ch. Fontanellaz. No. 12. Pp. 74. Price 10.40 francs.

Studien über Radarsysteme mit Frequenzmodulation

By Kurt J. Witmer. No. 13. Pp. 117. Price 14.55 francs.

Secondary Electron Emission at High Current Densities

By Dietrich Alfred Jenny. No. 14. Pp. 77. Price 8.30 francs.

Beitrag zur Frage der Anpassung von Energieleitungen an den freien Raum (Doppelkonusantenne)

By Alfred Ess. No. 15. Pp. 47. Price 6.25 francs.

Eine Frequenzweiche für Mikrowellen

By Walter Neu. No. 16. Pp. 55. Price 6.25 francs.

The five publications above, Nos. 12-16, are reports of the Institut fur Hochfrequenztechnik of the Eidgenössische Technische Hochscule of Zurich. They are obtainable from Verlag Leemann, Zürich, Switzerland.

Tables of Coulomb Wave Functions, Vol. I

National Bureau of Standards Applied Mathematics Series 17. Pp. 141. Price $2 (plus postage).

Measurement of the Thickness of Capacitor Paper

By Wilmer Souder and S. B. Newman. Pp. 10 with 6 illustrations and 4 tables. National Bureau of Standards. Circular 532. Price 15 cents (postage 5 cents).

Extension and Dissemination of the Electrical and Magnetic Units by the National Bureau of Standards

By Francis B. Silsbee. Pp. 33 with 27 illustrations. National Bureau of Standards, Circular 531. Price 25 cents (postage 9 cents).

Molecular Microwave Spectra Tables

By Paul Kisliuk and Charles H. Townes. National Bureau of Standards, Circular 518. Pp. 127. Price 65 cents (postage 22 cents).

Guide to Tables of the Normal Probability Integral

National Bureau of Standards Applied Mathematics Series 21. Pp. 16. Price 15 cents (postage 5 cents).

The above five publications can be obtained from the Government Printing Office, Washington D.C., U.S.A.

British Standard for Synthetic-Resin Bonded Paper Insulating Tubes (Rectangular Cross Section) for Electrical Power Circuits up to 1000 Volts

B.S.1885:1952. British Standards Institution, Sales Branch, 24 Victoria St., London, S.W.1.

Radio Interference Suppression (as applied to Radio and Television Reception).

By G. L. Stephens, A.M.I.E.E. Pp. 132, with 65 illustrations. Published for *Wireless World* by Iliffe & Sons Ltd., Dorset House, Stamford St., London, S.E.1 Price 10s. 6d. (postage 5d).

R.C.A. Technical Papers (1951) Index Vol. III (a)

Pp. 23 + v. *R.C.A. Review*, Radio Corporation of America, R.C.A. Laboratories Division, Princeton, New Jersey, U.S.A.

An index to papers published in English by authors associated with R.C.A. It supplements Vol. I (1919-1945) and Vol. II (1946-1950).

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for August 1952

Date 1952 August	Frequency deviation from nominal: parts in 10^8		Lead of MSF impulses on GBR 1000 G.M.T. time signal in milliseconds
	MSF 60 kc/s 1029-1130 G.M.T.	Droitwich 200 kc/s 1030 G.M.T.	
1	— 0·3	+ 2	— 46·0
2	— 0·3	N.M.	— 47·7
3	— 0·3	N.M.	— 49·2
4	— 0·2	N.M.	— 49·8
5	— 0·1	+ 3	— 50·6
6	0·0	+ 3	— 52·9
7	— 0·1	+ 2	— 53·9
8	— 0·2	+ 3	— 55·1
9	— 0·2	+ 3	— 56·8
10	— 0·2	+ 4	— 57·7
11	— 0·1	+ 4	— 59·1
12	0·0	+ 3	— 60.4
13	— 0·1	+ 3	— 61·4
14	— 0·1	+ 3	— 62·5
15	0·0	+ 4	— 63·3
16	0·0	+ 4	— 63·4
17	0·0	+ 4	— 63·2
18	0·0	+ 4	— 62·7
19	+ 0·1	+ 5	— 63·6
20	+ 0·1	+ 5	— 64·5
21	+ 0·1	+ 5	— 63·8
22	+ 0·1	+ 5	— 63·8
23	+ 0·1	+ 4	— 64·8
24	+ 0·2	+ 4	— 64·1
25	+ 0·2	+ 5	— 64·7
26	+ 0·2	— 3	— 64·5
27	+ 0·2	— 3	— 64·4
28	— 0·1	— 4	— 64·3
29	0·0	— 4	— 64·7
30	0·0	— 3	— 64·3
31	0·0	— 3	— 63·7

The values are based on astronomical data available on 1st September 1952.

NM. = Not measured.

The value given for the frequency deviation of Droitwich 200 kc/s at 1030 G.M.T. on the 22nd June 1952 is revised to — 1 x 10^{-8}.

ABSTRACTS and REFERENCES

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research and published by arrangement with that Department.

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of the titles of journals are taken from the World List of Scientific Periodicals. Titles that do not appear in this List are abbreviated in a style conforming to it.

ACOUSTICS AND AUDIO FREQUENCIES

016:534 **2675**

References to Contemporary Papers on Acoustics.—R. T. Beyer. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 330–334.) Continuation of 2406 of September.

534.2 **2676**

Connection between the Problem of Acoustic Diffraction at a Sphere and the Reciprocity Theorem.—S. N. Rzhevkin. (*Zh. tekh. Fiz.*, Oct. 1951, Vol. 21, No. 10, pp. 1224–1227.) It is shown by solving the diffraction problem that the sound pressure at a remote point B caused by a radiator at a point P on the surface of a fixed rigid sphere is equal to that which would be caused at the point P by a radiator of the same output at the point B.

534.231 **2677**

A More Rapidly-Convergent Expansion for the Velocity Potential of a Piston Source.—H. Elrod, Jr. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 325–326.) A variation of the expansion given by Carter & Williams (1815 of 1951) is presented which is particularly useful for calculations in the paraxial regions.

534.231 : 534.321.9 **2678**

The Acoustical Field Near a Circular Transducer.—E. W. Guptill & A. D. MacDonald. (*Canad. J. Phys.*, March 1952, Vol. 30, No. 2, pp. 119–122.) An approximate formula is derived for the case of a circular diaphragm clamped at its periphery. Particle velocity in the near field is greater than that for a plane wave; in the case of a crystal of 1-cm radius operating at about 1 Mc/s in water, the difference is roughly 0·1%.

534.232 + 534.321.9 **2679**

New Ultrasonic and Sonic Generators.—R. Göbel. (*Nachrichtentechnik*, Jan. 1952, Vol. 2, No. 1, pp.7–11.) Illustrated review of many different types of generator available commercially.

534.232 **2680**

Radiation Loading of Cylindrical and Spherical Surfaces.—M. C. Junger. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 288–289.) Series of curves are presented for the acoustic reactance and resistance ratios of partial waves emitted by cylindrical and spherical sources whose dynamic configuration can be expressed by infinite series.

534.232 : 534.141.4 **2681**

Acoustical Characteristics of Jet-Edge and Jet-Edge-Resonator Systems.—W. L. Nyborg, M. D. Burkhard & H. K. Schilling. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 293–304.)

534.24 **2682**

The Reflection of a Pulse by a Spherical Surface.—D. V. Anderson, T. D. Northwood & C. Barnes. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 276–283.) The Kirchhoff integral is applied to obtain an approximate solution for the reflection of a pulse back to a receiver near the source. For a minimum-time path the reflected pulse develops a tail, and for a maximum-time path a head. Experiments confirmed this.

534.24 **2683**

Reflection of a Pulse by a Concave Paraboloid.—D. V. Anderson. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 324–325.) The existence of a secondary pressure maximum about $3f/4$ from the axis (f = focal length of reflector), as predicted by Friedlander (98 of 1943), is confirmed experimentally.

534.24 : 534.321.9 **2684**

On the Failure of Plane-Wave Theory to predict the Reflection of a Narrow Ultrasonic Beam.—M. S. Weinstein. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 284–287.) Reflection measurements at 3·35 Mc/s in water for air-backed Al plates of thicknesses from 0.25 to 0·025 in. and for an Al plate 2 in. thick indicate that plane-wave theory is not strictly applicable to the reflection of a narrow beam. The excess pressure of the reflected wave is considerably lower than that predicted by the plane-wave theory when the angle of incidence is such that the change of phase on reflection varies greatly with a small change of the angle of incidence.

534.26 + 535.43 **2685**

Multiple Scattering of Radiation by an Arbitrary Planar Configuration of Parallel Cylinders and by Two

Parallel Cylinders.—V. Twersky. (*J. appl. Phys.*, April 1952, Vol. 23, No. 4, pp. 407–414.) The solution previously given (1803 of July) is applied to the particular case where all the axes lie in the same plane. The scattered wave is expressed as an infinite sum of orders of scattering, the first order being the usual single-scattering approximation. Both e.m. and acoustic waves are considered.

534.26 **2686**

On Acoustic Diffraction Cross-Sections for Oblique Incidence.—J. W. Miles. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, p. 324.) The variational method of Schwinger furnishes a convenient means for relating the plane-wave transmission cross-section of an aperture for oblique incidence to that for normal incidence. Bouwkamp's results (2160 of 1951) are then used to obtain the oblique-incidence transmission cross-section for moderate values of *ka*, where *k* is the wave number and *a* the radius of the aperture.

534.373 : 534.414 **2687**

The Damping of Acoustic Resonators.—K. Voelz. (*Z. angew. Phys.*, Jan. 1952, Vol. 4, No. 1, pp. 18–19.) Addendum to 2087 of 1951.

534.61 : 621.317.78.029.4 **2688**

Measuring the Mean Power of Varying-Amplitude Complex Audio Waves.—H. W. Curtis. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 775–779.) An instrument for measuring a.f. signals in which the power varies rapidly (e.g., speech sounds) is essentially a computer with circuits performing the operations of squaring, integrating, putting limits on the integral, and taking a logarithm. The result is presented as a continuous strip recording of oscilloscopic deflections, giving readings accurate to within 1 db over a 25-db range.

534.612.4 **2689**

Absolute Calibration of Acoustic Transducers by the Method of Reciprocity in a Tube with Standing Waves.—M. V. Kazantseva. (*Zh. tekh. Fiz.*, Oct. 1951, Vol. 21, No. 10, pp. 1213–1223.) The method described previously (1060 of 1950) was applicable at frequencies up to about 1 500 c/s. This range is extended to 10 kc/s by using a hydrogen-filled tube of diameter 4 cm and length 86 cm. The results are plotted and the theory of the method is discussed.

534.612.4 : 621.395.61 **2690**

Absolute Method of Calibrating Microphones at Audible and Ultrasonic Frequencies.—V. Gavreau, M. Dratz & A. Calaora. (*C. R. Acad. Sci., Paris*, 16th April 1952, Vol. 234, No. 16, pp. 1603–1605.) For frequencies up to 40 kc/s, a source consisting of a solid duralumin cylinder vibrating longitudinally is used [see 2455 of 1951 (St Clair)]. An optical method is used for measuring the amplitude, the end of the cylinder being polished to form a mirror and the displacement of the image of a razor edge observed with a stroboscopic arrangement. Tables are given of measurements made in an anechoic room on an electrodynamic and on a piezoelectric microphone.

534.614 : 533.5 **2691**

The Velocity of Sound in Gases at Low Pressures.—R. L. Abbey. (*Aust. J. sci. Res., Ser. A*, March 1952, Vol. 5, No. 1, pp. 223–225.) Report of experiments made to clear up the discrepancy between Maulard's results (3009 of 1949) and those of Abbey & Barlow (*Aust. J. sci. Res., Ser. A*, 1948, Vol. 1, p. 175). A tube of diameter 3·5 cm was used. The new results indicate that the discrepancy was largely due to inadequate tube correction for diameter and frequency variations.

534.75 : 534.79 **2692**

The Anomalous Behaviour of the Threshold of Hearing in Relation to the Equal-Loudness Contours.—R. Guelke & H. Helm. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 317–322.) Tests on 48 subjects show that the intensity jump from threshold to 10 phons is greater at 100 c/s than at 1 000 c/s. This is contrary to experience at higher intensities. A possible explanation is suggested.

534.78 : 534.791 **2693**

On the Measurement of the Loudness of Speech.—I. Pollack. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 323–324.) A loudness scale for speech is presented which is based on available experimental data. Apparatus and methods used were the same as for measurements on white noise (1501 of June).

534.84 : [621.395.61 + 621.395.623.7 **2694**

Quality Assessments of Rooms for Electroacoustic Transmissions.—H. Etzold. (*Funk u. Ton*, April 1952, Vol. 6, No. 4, pp. 191–197.) Discussion of the relation between the acoustical properties of rooms and the quality of the reproduction in a microphone-amplifier-loudspeaker system, the microphone and loudspeaker being in different rooms, account being taken of physiological and psychological factors.

534.845 **2695**

Note on Beranek's Theory of the Acoustic Impedance of Porous Materials.—J. W. McGrath. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 305–309.) The theory previously given by Beranek (1410 of 1942) is modified so as to avoid two approximations. The modified theory appears to be quite adequate for very porous materials with low flow resistance.

534.845 **2696**

An Experimental Investigation of Resonant Sound Absorbers.—K. A. Velizhanina. (*Zh. tekh. Fiz.*, Sept. 1951, Vol. 21, No. 9, pp. 1087–1099.) A detailed report is presented on experiments with sound-absorbing systems consisting of perforated sheets mounted at a distance from a wall. The theory of such systems is discussed and design formulae are derived.

534.845 **2697**

The Use of Perforated Facings in Designing Low-Frequency Resonant Absorbers.—D. B. Callaway & L. G. Ramer. (*J. acoust. Soc. Amer.*, May 1952, Vol. 24, No. 3, pp. 309–312.)

534.851/.852 : 534.321 **2698**

Measurement of Pitch Fluctuations.—H. Vollmer. (*Funk u. Ton*, April 1952, Vol. 6, No. 4, pp. 169–175.) Various possible methods of measurement of fluctuations in sound-reproduction equipment are considered briefly. The method adopted was a phase-measurement bridge, the indicating instrument in which gives the frequency deviation direct, with maximum scale readings on the two ranges of ±0·5% and ±1·5%. A standard test frequency of 5 kc/s is used.

621.395.61/.62 + 534.85/.86 **2699**

I.R.E. Show Review—1952.—H. K. Richardson. (*Audio Engng*, April 1952, Vol. 36, No. 4, pp. 26–28, 53.) Brief notices of some of the a.f. equipment exhibited.

621.395.62 **2700**

Equipment for Sound Reproduction.—(*Wireless World*, July 1952, Vol. 58, No. 7, pp. 255–258.) Illustrated descriptions of disk and magnetic recorders, amplifiers, loudspeakers, pickups and microphones shown at recent exhibitions.

621.395.623.73 **2701**

Electrical Loudspeakers.—L. Iglück. (*Nachrichtentechnik*, Jan. 1952, Vol. 2, No. 1, pp. 11–15.) A short review of the basic principles of various types of loudspeaker, including high-power types, and details of the construction of a giant 1-kW loudspeaker and of the means adopted for increasing its efficiency.

621.395.625.6 : 534.862.3 **2702**

New Sound-Recording System.—J. P. Shields. (*Radio-Electronics*, April 1952, Vol. 23, No. 7, pp. 26–28.) Description of a system using spiral scanning of an intensity-modulated electron beam to record 30-minute programmes on disks of ordinary photographic film. For reproduction, the developed film is interposed between the screen of the scanning c.r. tube and a lens focusing the light from the screen on a photocell, whose output voltage is fed to a loudspeaker via an amplifier.

621.395.813 : 621.317 **2703**

Objective Measurements of Intelligibility on Subscribers' Telephones.—G. Fontanellaz. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Dec. 1951, Vol. 29, No. 12, pp. 445–466. In German and French.) Report of tests made by the Swiss Post Office in conjunction with the C.C.I.F., complementary to the subjective measurements made previously by the latter body (1191 of May). The methods of measurement are described; results are in satisfactory agreement with those obtained from the subjective tests.

AERIALS AND TRANSMISSION LINES

621.392.09 : 621.392.26 **2704**

On the Excitation of Surface Waves.—G. Goubau. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 865–868.) A theoretical proof is given of the existence of surface waves. The complete solution of the field equations for cylindrical surface waveguides includes terms corresponding to the surface wave and to supplementary fields; these are separable by means of certain orthogonality relations. The amplitude of the surface wave excited by a dipole or other source can be determined without solving the entire excitation problem.

621.392.21 **2705**

Etched Sheets serve as Microwave Components.—R. M. Barrett. (*Electronics*, June 1952, Vol. 25, No. 6, pp. 114–118.) The flat-strip transmission line has the advantages of a coaxial line and a form factor suited to the printed-circuit technique. The characteristic impedance of the line is a function of the width of the central strip. A plot of the field distribution in such lines shows that the field is largely concentrated near the inner strip, and no energy is propagated laterally. A practical method of feeding the line from a coaxial system is to insert a normal N-type connector between the edges of the dielectric. All conventional microwave components such as hybrid junctions, directional couplers, power-division networks and filters are readily manufactured by the technique. When losses due to a continuous dielectric sheet are too high, or when high power is used, a compensated stub-supported transmission line is useful.

621.392.22 **2706**

Determination of Conditions for Integrating the Equations of Propagation of Electricity along a Heterogeneous Line.—M. Parodi. (*C. R. Acad. Sci., Paris*, 21st April 1952, Vol. 234, No. 17, pp. 1674–1676.) Solutions are obtained by an iterative process for the differential equations of steady-state propagation.

621.392.26 **2707**

The Impedance of Unsymmetrical Strips in Rectangular Waveguides.—L. Lewin. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 168–176.) Full paper. See 2434 of September.

621.392.26 **2708**

Single- and Multi-Iris Resonant Structures.—I. Reingold, J. L. Carter & K. Garoff. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 861–865.) An experimental investigation was made of the effect of varying the position of a rectangular window in a thin transverse diaphragm in a waveguide. The Q of a window of given dimensions is increased as the distance of the window from the broad wall of the waveguide is decreased. Low-Q multiwindow structures can be obtained in which the Q of the individual windows is comparatively high.

621.392.26 : 517.932 **2709**

Generalized Telegraphist's Equations for Waveguides.—S. A. Schelkunoff. (*Bell Syst. tech. J.*, July 1952, Vol. 31, No. 4, pp. 784–801.) "Maxwell's partial differential equations and the boundary conditions for waveguides filled with a heterogeneous and non-isotropic medium are converted into an infinite system of ordinary differential equations. This system represents a generalization of 'telegraphist's equations' for a single-mode transmission to the case of multiple-mode transmission. A similar set of equations is obtained for spherical waves. Although such generalized telegraphist's equations are very complicated, it is very likely that useful results can be obtained by an appropriate modal analysis."

621.392.26 : 538.614 **2710**

Faraday Rotation of Guided Waves.—H. Suhl & L. R. Walker. (*Phys. Rev.*, 1st April 1952, Vol. 86, No. 1, pp. 122–123.) An extension of the theory of Faraday rotation to include the case of transmission in a bounded waveguide system, as opposed to that of propagation in an unbounded medium, for which the theory already exists. A modified Verdet's constant, appropriate to waveguide transmission, is derived. See also 2911 of 1951 (Goldstein et al.), 1233 of May (Hogan) and 1587 of June (Wicher).

621.392.26 : 621.314.25.088 **2711**

Errors in a Microwave Rotary Phase Shifter.—A. J. Simmons. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, p. 869.) A discussion of the effect of nonlinearity of the phase-shift/rotation characteristic on the performance of the adjustable waveguide phase changer described by Fox (1255 of 1948).

621.392.26 : 621.392.52 **2712**

The Calculation of the Dispersion in a Waveguide Filter with Slot Couplings.—G. N. Rapoport. (*Zh. tekh. Fiz.*, Sept. 1951, Vol. 21, No. 9, pp. 1076–1086.) Discussion of propagation of waves in a cylindrical waveguide divided into sections by partitions with annular slots. The field inside each section is expanded in series with respect to the characteristic functions of the closed cylindrical resonator. Using the continuity of the magnetic field and the flux of the Umov-Poynting vector through the slot, equations are derived determining dispersion and the electric field of the slot. The spectrum of the frequencies passed by the filter is considered and also the relation between the bandwidth and the width of the slots.

621.392.43 : 621.385.029.6 : 621.396.65 **2713**

Impedance Matching of a Travelling-Wave Valve [Type M8] to a Waveguide.—Chavance & Moutte. (See 2940.)

621.392.43 : 621.385.029.6 : 621.396.65 **2714**

Impedance Matching of Travelling-Wave Valves [Types M8 and M11] **to Coaxial Lines.**—Clostre & Wallauschek. (See 2939.)

621.396.67 **2715**

Cylindrical Aerials.—B. Storm. (*Wireless Engr*, July 1952, Vol. 29, No. 346, pp. 174–176.) A new method of solving Hallén's integral equation for the current in an aerial is presented which is simpler and more direct than the Hallén-King iteration method. The current is determined as the sum of a dominant sinusoidal current and a series of higher harmonics corresponding to a trigonometric series, which are integrated term by term, giving a series of sums of Si and Ci functions. Theoretically it is possible to calculate the aerial current and impedance with great accuracy. The amount of labour increases with the number of points considered along the aerial, but no new mathematical difficulties are encountered. Five points give sufficient accuracy for most practical cases. Calculated results for a $\lambda/2$ dipole and a λ dipole are compared with 1st-order and 2nd-order calculations by King.

621.396.67 **2716**

The Absorption Gain and Back-Scattering Cross-Section of the Cylindrical Antenna.—S. H. Dike & D. D. King. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 853–860.) The method of Hallén (2763 of 1939) as modified by Middleton & King (1771 of 1946) is used to derive first-order formulae for the gain and back-scattering cross-section of a receiving dipole arranged broadside on. Calculated values are compared with values obtained from measurements on unloaded and on matched-loaded dipoles; explanations are advanced for the discrepancies found.

621.396.67 **2717**

A Slot Aerial with Directing Elements.—M. L. Levin. (*Zh. tekh. Fiz.*, July 1951, Vol. 21, No. 7, pp. 795–801.) In order to increase the directivity of a slot aerial a passive dipole is placed in front of the slot. The theory of such a system is discussed.

621.396.67 **2718**

Derivation of the Fundamental Equation of the Theory of Slot Aerials.—M. L. Levin. (*Zh. tekh. Fiz.*, July 1951, Vol. 21, No. 7, pp. 787–794.) The voltage distribution along a narrow slot cut in a thin conducting surface is derived from the theory of metal aerials.

621.396.67 : 621.392 **2719**

Multiple Reflections in Long Feeders.—L. Lewin. (*Wireless Engr*, July 1952, Vol. 29, No. 346, pp. 189–193.) The signal distortion produced by reflections at many points along a mismatched waveguide feeder is analysed in terms of harmonic content for a single-tone signal, and in terms of interchannel interference in the case of a multichannel source. Such distortion is negligible for short feeders, but dominant for long ones. Measurements on a 120-ft feeder, made up of 10-ft sections, confirm the incoherent nature of the reflected waves. Considerable improvement in transmission should result from reduction of reflections at waveguide joints. The use of long sections on very long runs is desirable.

621.396.67 : 621.392.26 **2720**

On the Theory of Slot Aerials in a Circular Waveguide.—M. L. Levin. (*Zh. tekh. Fiz.*, July 1951, Vol. 21, No. 7, pp. 772–786.) Results obtained by Pistol'kors (1266 and 1267 of 1948) for the radiation from transverse slots are shown to be erroneous; correct formulae are derived.

621.396.67 : 621.392.26 : 538.221 **2721**

Microwave-Antenna Ferrite Applications.—N. G. Sakiotis, A. J. Simmons & H. N. Chait. (*Electronics*, June 1952, Vol. 25, No. 6, pp. 156..166.) For general radar scanning purposes an axial d.c. magnetic field is applied to a ferrite-cored transmission line, the variation of permeability effecting a phase shift of the circularly polarized input. The nonreciprocity of the simple system for transmission and reception is overcome with a combination of ferrite cylinders; by eliminating a 45° phase-shift element at one end the system can be used as a TR switch. Phase shift per unit length of a ferrite rod is a function of the length, increasing as the length increases, due to the change in the demagnetization factor.

621.396.671 **2722**

Input Impedance of Horizontal Dipole Aerials at Low Heights above the Ground.—R. F. Proctor. (*Proc. Instn Radio Engrs, Aust.*, Feb. 1952, Vol. 13, No. 2, pp. 58–61.) Reprint. See 2134 of 1950.

621.396.671 : 537.311.5 : 538.569 **2723**

On the Current Induced in a Conducting Ribbon by the Incidence of a Plane Electromagnetic Wave.—E. B. Moullin & F. M. Phillips. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 137–150.) Full paper. See 2441 of September.

621.396.676 **2724**

The Slot Aerial and its Application to Aircraft.—R. H. J. Cary. (*Proc. Instn elect. Engrs*, Part III, July 1952, Vol. 99, No. 60, pp. 187–196. Discussion, pp. 210–213.) Measurements on full-scale and model aircraft show that the types of polar diagram frequently required for aircraft can be obtained with slot aerials, for which there is some agreement between measured polar diagrams and those calculated from ray and diffraction theories. Exact diagrams must be determined experimentally, since aircraft do not have simple shapes which permit accurate calculation. The installation of slots for metre or shorter wavelengths presents little difficulty, but their application for longer waves depends on what can be achieved in matching devices and on the limit of possible modification of aircraft structure.

621.396.676 **2725**

A Survey of External and Suppressed Aircraft Aerials for Use in the High-Frequency Band.—R. H. J. Cary. (*Proc. Instn elect. Engrs*, Part III, July 1952, Vol. 99, No. 60, pp. 197–210. Discussion, pp. 210–213.) The characteristics of external wire aerials are compared with those of 'suppressed' aerials within the aircraft skin. Some of the latter type have performances which compare favourably with those of external wire types and in some respects have better electrical characteristics. In particular, folded or near-end-fed aerials, or those which involve an insulated stabilizer unit, have a large bandwidth and are reasonably efficient. The impedance characteristics of some of the suppressed aerials render them suitable for frequencies lower than the h.f. band. Methods of excitation for suppressed aerials are discussed. Measurements of the characteristics of aircraft aerials are mostly economically carried out on scale models.

621.396.677 **2726**

Radiation Field of a Square Helical Beam Antenna.—H. L. Knudsen. (*J. appl. Phys.*, April 1952, Vol. 23, No. 4, pp. 483–491.) Rigorous formulae are derived for the field of an aerial with a uniformly progressing current wave of constant amplitude; these are compared with the Kraus approximation (643 and 1860 of 1949) for a circular-helix aerial. The two methods of calculation give results in fair agreement, the rigorous formulae being simpler and of direct application to the square helices often used in the metre-wave band. See also 1844 of 1951.

621.396.677 **2727**

Waves in a Pyramidal Horn.—E. G. Zelkin. (*Zh. tekh. Fiz.*, Oct. 1951, Vol. 21, No. 10, pp. 1228–1239.) A theoretical investigation in which simplification is introduced by considering an approximation to the pyramidal horn consisting of a biconical sector with two additional walls (Fig. 1). The walls of such a horn coincide with the coordinate surfaces of a spherical system. The propagation of waves and the configuration of the field inside this horn is discussed. The polar diagram is also considered.

621.396.677.3.012† **2728**

Design Data for Horizontal Rhombic Antennas.—E. A. Laport. (*RCA Rev.*, March 1952, Vol. 13, No. 1, pp. 71–94.) A method is described which greatly simplifies design calculations. Using tables which give the spherical coordinates for all radiation-pattern lobes up to those of the sixth order, the performance of a horizontal rhombic aerial over a range of frequencies can easily be investigated. The complete radiation pattern is then determined from stereographic charts of the type suggested by Foster (119 of 1938). A set of 13 transparent charts for leg lengths of 2–7 λ covers the usual practical range.

621.396.679 **2729**

Design of Optimum Buried-Conductor R.F. Ground System.—F. R. Abbott. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 846–852.) Design formulae and charts are presented for a radial-conductor earthing system particularly suitable for operation at frequencies below 1 Mc/s and leading to aerial radiation efficiencies of 50% or more.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.015.7 : 621.387.4 **2730**

Millimicrosecond-Pulse Techniques.—N. F. Moody, G. J. R. Maclusky & M. O. Deighton. (*Electronic Engng*, May–July 1952, Vol. 24, Nos. 291–293, pp. 214–219, 287–294 & 330–333.) A report of experimental work in the development of pulse circuits, particularly for laboratory measurements. Particular attention is given to circuits using secondary-emission pentodes. Descriptions are included of oscillographic equipment for viewing rapidly repeated waveforms, and of devices for expanding pulses on an analogue principle. Application of the techniques to the study of short nuclear half-lives is discussed.

621.314.3† **2731**

Compensating for Quiescent Current in Multistage Magnetic Amplifiers.—A. S. Fitzgerald. (*Elect. Engng, N.Y.*, March 1952, Vol. 71, No. 3, pp. 206–211.) Essential text of 1952 A.I.E.E. Winter General Meeting paper. Three different compensation circuits are discussed and a fourth circuit, designed to combine the best features of the others, is described. This includes, in addition to the single saturable reactor with the usual a.c. and d.c. windings, a transformer and two resistors.

621.314.3† **2732**

Improvements extend Magnetic-Amplifier Applications.—F. Benjamin. (*Electronics*, June 1952, Vol. 25, No. 6, pp. 119–123.) The characteristics of modern core materials and rectifiers are noted and their bearing on magnetic-amplifier performance is discussed.

621.316.726 : 621.396.615.141.2 **2733**

Frequency Control of Modulated Magnetrons by Resonant Injection System.—L. L. Koros. (*RCA Rev.*, March 1952, Vol. 13, No. 1, pp. 47–57; *Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 39–45.) Two systems are described by which the output frequency f_m of a modulated magnetron can be crystal-controlled. 'Pushing' and 'moding' are thereby suppressed and the carrier can be modulated 100% with high fidelity. In one system the crystal drive excites the input cavity of a grounded-grid frequency doubler at a frequency $f_m/2$; the anode cavity, tuned to f_m, is coupled to the magnetron output, which is adjusted for correct loading. In the second system the injection frequency for the magnetron is a subharmonic of f_m; in a particular case the anode cavity of the multiplier was tuned to $f_m/2$, the crystal-drive frequency being $f_m/6$.

621.316.726.078.3 : 621.396.615 **2734**

The Attainment of Very High Frequency Stability.—W. Herzog. (*Arch. elekt. Übertragung*, April 1952, Vol. 6, No. 4, pp. 159–162.) Methods are indicated for improving the Q of the feedback circuits of various well-known oscillators by the inclusion of a compensating resistance.

621.316.729 : 621.396.615.072.9 **2735**

Representation of Oscillator Synchronization by Nonlinear Equations.—A. Blaquière. (*C. R. Acad. Sci., Paris*, 28th April 1952, Vol. 234, No. 18, pp. 1741–1743.) Theory previously given (335 of February) is extended to the study of forced oscillations, and the limits of synchronization are determined by consideration of a diagram in the complex plane. A method for investigating synchronization stability is outlined. Application of the graphical treatment to the van der Pol equation has given all the results established by other methods by van der Pol.

621.316.84 : 539.23 **2736**

Metal-Film Resistors.—R. J. Heritage. (*Electronic Engng*, July 1952, Vol. 24, No. 293, pp. 324–327.) The production of such resistors by chemical reduction, evaporation, sputtering, or firing-on methods is discussed briefly. The firing-on process appears to be the most suitable for mass-production methods; the technique is described and examples are shown of various practical types.

621.316.86 : 546.281.26 **2737**

Industrial Applications of Semiconductors: Part 2—Silicon Carbide Resistors.—R. W. Sillars. (*Research, Lond.*, April 1952, Vol. 5, No. 4, pp. 169–175.) The manufacture and properties of SiC resistors of different types are described, and their applications for overvoltage protection, voltage discrimination in communication circuits, voltage regulation etc., are considered. Conduction in n- and p-type SiC, and barrier-layer effects, are discussed.

621.318.57 **2738**

Switching Action in Circuits including Valves.—W. Taeger. (*Funk u. Ton*, April 1952, Vol. 6, No. 4, pp. 198–201.) Analysis of effects in circuits such as that of a pentode with a choke and resistor in the anode lead. The time required to reach the valve saturation current is the shorter the lower the value of the saturation current and the less the resistance in the anode circuit.

621.318.572 : 681.142 **2739**

Universal High-Speed Digital Computers: Serial Computing Circuits.—Williams, Robinson & Kilburn. (See 2838.)

621.319.4 **2740**

R.F. Characteristics of Capacitors.—R. Davidson. (*Wireless World*, Aug. 1952, Vol. 58, No. 8, pp. 301–304.) Examination of the inductance and other properties of different types of capacitor used for decoupling and interference suppression.

621.319.43 **2741**

Profile Calculation for Rotary [plate] **Capacitors.**—O. Schmid. (*Frequenz*, April 1952, Vol. 6, No. 4, pp. 105–107.) A general formula relating the plate shape and insertion angle is given and applied to the types with linear variation of (*a*) capacitance, (*b*) wavelength, (*c*) frequency, and with logarithmic variation of capacitance with insertion angle.

621.392.5 : 512.31 **2742**

Network Synthesis using Tchebycheff Polynomial Series.—S. Darlington. (*Bell Syst. tech. J.*, July 1952, Vol. 31, No. 4, pp. 613–665.) "A general method is developed for finding functions of frequency which approximate assigned gain or phase characteristics, within the special class of functions which can be realized exactly as the gain or phase of finite networks of linear lumped elements. The method is based upon manipulations of two Tchebycheff polynomial series, one of which represents the assigned characteristic, and the other the approximating network function. The wide range of applicability is illustrated with a number of examples."

621.392.5 : 537.228.1 **2743**

Piezoelectric Transducers for Ultrasonic Delay Lines.—H. N. Beveridge & W. W. Keith. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 828–835.) "The over-all frequency response and loss of the transducers of a delay line are derived from Roth's equivalent circuit [3021 of 1949]. The transient response of a delay line is computed from an equivalent transmission-line circuit. The bandwidths and transient responses measured on practical delay lines are given for comparison with theoretical values."

621.392.5 : 621.385.3 : 512.83 **2744**

Matrix Theory applied to Thermionic Valve Circuits.—S. R. Deards. (*Electronic Engng*, June 1952, Vol. 24, No. 292, pp. 264–267.) Extension of linear-quadripole theory to include valves as network elements. The method is illustrated by analysis of a cathode-follower circuit.

621.392.5.029.3 : 621.3.012.3 **2745**

The Prediction of Audio-Frequency Response: No. 3 — Single Complex Impedance in Resistive Network.—N. H. Crowhurst. (*Electronic Engng*, May 1952, Vol. 24, No. 291, pp. 241–243.) Formulae and charts are given for computing the response of networks with series or shunt complex impedances. No. 2: 1540 of June.

621.392.5.029.3 : 621.3.012.3 **2746**

The Prediction of Audio-Frequency Response: No. 4 — Step Circuits.—N. H. Crowhurst. (*Electronic Engng*, July 1952, Vol. 24, No. 293, pp. 337–339.) Circuits using a single reactance to produce a step in the amplitude response are discussed and basic and practical types are shown. Charts are provided from which the amplitude and phase response can be found. Numerical examples illustrate their use. No. 3: 2745 above.

621.392.52 **2747**

Elementary Introduction to Filter Theory.—C. Wisspeintner. (*Funk u. Ton*, Jan.–April 1952, Vol. 6, Nos. 1–4, pp. 29–40, 89–97, 141–153 & 202–213.) A practical treatment based on vector diagrams. The various types of filter are considered in turn, starting with low-pass filters, and phase relations and the effect of circuit losses are discussed.

621.392.52 **2748**

Construction of Band-Pass Filters from Basic Elements.—W. Nonnenmacher. (*Frequenz*, April 1952, Vol. 6, No. 4, pp. 107–113.) Detailed treatment of the transmission properties of various basic circuits and their use in the construction of band-pass filters with symmetrical and with asymmetrical transmission curves. Rumpelt's template method of filter design (729 of 1943) is explained.

621.392.52 **2749**

Some Considerations in the Design of a Miniature Filter-Transformer.—T. T. Brown. (*Marconi Rev.*, 2nd Quarter 1952, Vol. 15, No. 105, pp. 90–94.) Means of attenuating upper and lower frequencies in audio circuits are discussed, with reference to miniature airborne equipment. The design of a filter unit is described which includes the input transformer as an integral part and has a voltage step-up of 12 : 1 within 1 db from 300 c/s to 5 kc/s, and an attenuation slope of over 24 db per octave outside these limits. It is mounted in a can 2 × 1·6 × 1·2 in.

621.392.52 : 517 **2750**

Some Problems in the Analysis of Curves by Calculus Methods.—M. Levy. (*Canad. J. Phys.*, March 1952, Vol. 30, No. 2, pp. 147–158.) A discussion of transform methods in relation to filter theory. The process considered consists of performing combinations of arithmetical operations on the successive ordinates of the curve representing a signal function; it is inherently frequency selective. One problem is to find combinations of only a few operations yielding pass-band selectivity; the second problem is, whether the results of the analysis are unique. Consideration is given first to continuous transforms, yielding integrals, and then to discontinuous transforms, yielding sums and differences.

621.392.52 : 518.4 **2751**

New Graphical Methods for Analysis and Design.—G. R. Schneider. (*Wireless Engr*, July 1952, Vol. 29, No. 346, pp. 194–195.) Comment on paper noted in 1546 of June (Saraga & Fosgate), calling attention to similar methods of determining filter insertion loss described in 1939 by Piloty (46 and 959 of 1940).

621.392.52 : 534.11-18 **2752**

A Band-Pass Mechanical Filter for 100 kc/s.—L. L. Burns, Jr. (*RCA Rev.*, March 1952, Vol. 13, No. 1, pp. 34–46.) The filter is a development of the neck-type design previously described [59 of 1950 (Roberts & Burns)]. It comprises eight /2 rods of Ni-Span C coupled by thin steel λ/4 necks silver-soldered to the rods. The terminations are lossy lines consisting of 5-ft lengths of rubber-coated Cu wire coiled on $\frac{7}{8}$-in. formers. Two separate compartments are provided in the chassis to isolate the magnetostriction input and output circuits. The filter response compares favourably with that of a 3-section quartz-crystal filter. The insertion loss of the filter alone is about 8 db. Design procedure is described in an appendix.

621.392.52 : 621.396.611.3 : 621.396.621.54 **2753**

The Calculation of Coupled H.F. Band-Pass Filters comprising Any Number *n* of Circuits with Equal *Q* Factor.—W. Pfost. (*Arch. elekt. Übertragung*, April 1952, Vol. 6, No. 4, pp. 135–142.) A previous paper by Behling (380 of 1947) gives the calculation for a four-circuit filter. In the method now described a multicircuit filter is reduced by successive steps to more elementary forms whose input admittances are simply evaluated. Formulae are established also for the voltage transfer, efficiency and selectivity.

621.396.6 **2754**

New Techniques for Electronic Miniaturization.—R. L. Henry, R. K. F. Scal & G. Shapiro. (*Proc. Instn Radio Engrs, Aust.*, March 1952, Vol. 13, No. 3, pp. 75–81.) Reprint. See 307 of 1951.

621.396.6 : 621.317.755 **2755**

Slow-Speed Circular Timebase.—A. M. Hardie & P. A. V. Thomas. (*Wireless Engr*, July 1952, Vol. 29, No. 346, pp. 177–183.) Two methods of c.r.o. display in polar form, in correct phase relation with reference to a rotating member, are described. In the first method, currents proportional respectively to sin θ and cos θ are derived from an a.f. oscillator in conjunction with an Admiralty magslip transmitter and applied to the deflection coils of a c.r.o. with a central deflecting electrode sealed through the tube face, to produce a constant rotating magnetic field. A method of correcting the effects of spurious phase shifts in this system is described. The second method makes use of a specially designed sine-cosine potentiometer, full details of which are given, in conjunction with a normal e.s. c.r. tube.

621.396.611.1 : 517.51 **2756**

Resonant Circuit with Periodically Varying Parameters.—D. G. Tucker: P. Bura & D. M. Tombs. (*Wireless Engr*, Aug. 1952, Vol. 29, No. 347, pp. 222–224.) Discussion of paper abstracted in 2471 of September.

621.396.611.21 **2757**

Note on Safe Resonator Current of Piezoelectric Elements.—E. J. Post. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, p. 835.) Values of the optimum current for commonly used quartz cuts are tabulated.

621.396.615.17 **2758**

Some New Multivibrators.—Chang Sing & Chu Yao-I. (*Electronic Engng*, June 1952, Vol. 24, No. 292, pp. 270–271.) Circuits and waveforms are shown for modified multivibrators in which capacitors are inserted between cathodes and earth, the d.c. paths being completed by resistors connecting cathode to grid.

621.396.615.17 : 621.317.755 **2759**

Feedback in Time-Base Circuits.—A. E. Ferguson. (*Electronic Engng*, June 1952, Vol. 24, No. 292, pp. 280–281.) A comparison of the Miller and constant-current-pentode timebase circuits.

621.396.645 **2760**

Distributed Amplification.—R. W. A. Scarr: A. Cormack. (*Electronic Engng*, June 1952, Vol. 24, No. 292, p. 295.) Comment on 2167 of August and author's reply.

621.396.645 **2761**

Heater-Voltage Compensation for Alternating-Current Amplifiers.—N. W. Broten. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 843–845.) Variations of gain due to heater-voltage variations are reduced by means of a d.c. feedback network. The design procedure is indicated, and a comparison is made of the results of measurements on (*a*) a compensated and (*b*) an uncompensated wide-band i.f. amplifier for operation at 30 Mc/s.

621.396.645.015.3 **2762**

Calculating Transient Response.—T. Roddam. (*Wireless World*, Aug. 1952, Vol. 58, No. 8, pp. 292–295.) Description of a simplified method of compounding frequency and phase characteristics and applying a superposition principle based on trapezoidal response curves.

621.396.645.211 **2763**

Theory of the Resistance-Coupled Amplifier.—R. Rücklin. (*Arch. elekt. Übertragung*, April & May 1952, Vol. 6, Nos. 4 & 5, pp. 163–170 & 198–205.) By plotting against normalized frequency and introducing the concept of bandwidth factor, amplification and phase angle of all possible resistance-coupled amplifiers are represented by a single family of curves. The noise voltage at the output is evaluated as an integral which has a closed solution. On replacing t by the normalized time $\omega_0 t$ in the equations representing the output voltage, functions of general applicability are obtained; these are used to find the form of the output voltage for any input, in particular for triangular pulses. The optimum frequency response is determined for separating triangular pulses of given duration from background noise. Build-up transients are treated by splitting the step-function response into a step-voltage amplification and a decay function, the latter affording a criterion for the amplifier distortion. The decay function is calculated for an amplifier with feedback via the supply battery.

621.396.645.371 **2764**

Negative-Feedback Amplifiers. Overloading under Pulse Conditions.—J. E. Flood. (*Wireless Engr*, Aug. 1952, Vol. 29, No. 347, pp. 203–212.) "The overloading of simple resistance-coupled negative-feedback amplifiers is investigated for an input signal which rises from zero to its final value at a uniform rate. The amplifiers are assumed to be linear unless the applied signal exceeds the permitted value. For the single-stage amplifier, the permissible input voltage decreases as the rise time of the signal is reduced. Two-stage and three-stage critically damped amplifiers can be made to handle quickly changing signals which are as large as the maximum permissible slowly changing signal, provided that the time-constant of the first stage of the amplifier is sufficiently large compared with that of the second stage. Overloading of the amplifier by step voltages and by sinusoidal signals is studied in appendices."

621.385 : [621.396.621 + 621.396.645 **2765**

Electronic Valves: Book V — Application of the Electronic Valve in Radio Receivers and Amplifiers; Vol. 2 — A.F. Amplification, the Output Stage, Power Supply. [Book Review]—B. G. Dammers, J. Haantjes, J. Otte & H. van Suchtelen. Publishers: Cleaver-Hume Press, London, 431 pp., 45s. (*Wireless Engr*, July 1952, Vol. 29, No. 346, pp. 197–198.) "The authors have chosen to make it almost a textbook of broadcast receiver practice and have succeeded admirably in doing so." See 991 and 2888 of 1950 for previous books in this series.

GENERAL PHYSICS

530.12 : 530.145.6 **2766**

The Relativistic Relations between Frequency, Wavelength, Phase Velocity and Group Velocity.—J. L. Synge. (*C. R. Acad. Sci., Paris*, 21st April 1952, Vol. 234, No. 17, pp. 1669–1670.) Formulae established by de Broglie (76 of 1948) are here derived from considerations of relativistic invariance.

530.12 : 538.3 **2767**

The Physics of the Electromagnetic Universe.—B. Jouvet. (*C. R. Acad. Sci., Paris*, 7th April 1952, Vol. 234, No. 15, pp. 1532–1534.) Discussion of the significance of changes of coordinates of the electromagnetic universe, leading to a fundamental principle of electromagnetic relativity; the experimental consequences are indicated.

534.26 + 535.43 **2768**

Multiple Scattering of Radiation by an Arbitrary Planar Configuration of Parallel Cylinders and by Two Parallel Cylinders.—Twersky. (See 2685.)

535.13 : 538.3 **2769**

Is there an Aether?—L. Infeld: P. A. M. Dirac. (*Nature, Lond.*, 26th April 1952, Vol. 169, No. 4304, p. 702.) Comment on paper noted in 1573 of June and author's reply.

535.312 **2770**

On the Theory of the Displacement of Rays in Total Internal Reflection of a Spherical Wave.—L. M. Brekhovskikh. (*Zh. tekh. Fiz.*, Aug. 1951, Vol. 21, No. 8, pp. 874–880.) A formula (1) is quoted determining the displacement of a beam along the boundary between the two media where the beam undergoes total reflection. This formula also applies to the case of a spherical wave.

535.42 **2771**

On the Diffraction of Cylindrical Electromagnetic Waves.—N. V. Zernov. (*Zh. tekh. Fiz.*, Sept. 1951, Vol. 21, No. 9, pp. 1066–1075.) Diffraction at a circular aperture in an ideally conducting plane is considered. The boundary problem is reduced to an infinite system of linear algebraic equations which are solved by the reduction method. For an approximate calculation of the field it is sufficient to use only a few of the equations. A relation is established between the proposed method and the variation method of solving the same boundary problem. The problem can also be reduced to an integral equation of the second kind.

537.226.3 **2772**

The Dielectric Properties of Systems containing Straight Polar Chains.—R. A. Sack. (*Aust. J. sci. Res., Ser. A*, March 1952, Vol. 5, No. 1, pp. 135–145.) Mathematical theory is developed which provides an explanation of the high losses at low frequencies observed in solids containing hydroxyl groups, and also of the low-frequency absorption in ionic crystals containing lattice imperfections.

537.315 : 539.163.001.8 **2773**

Study of the Distribution of Surface Potential by means of Radioactive Deposits.—T. Westermark & L. G. Erwall. (*Nature, Lond.*, 26th April 1952, Vol. 169, No. 4304, pp. 703–704.)

537.523.4 **2774**

Observations on the Electrical Breakdown of Gases at 2 800 Mc/s: Part 2 — Relative Breakdown Stresses, Statistical Lags and Formative Lags.—W. A. Prowse & W. Jasinski. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 194–203. Summary, *ibid.*, Part III, July 1952, Vol. 99, No. 60, pp. 215–217.) The formative time is found to be zero, within the limits of experimental error, for spark breakdown in air, N, O and H in all conditions examined, but is appreciable in Ne, Ar and He. Statistical time-lags are much greater in air and N than in O and H. The results are discussed with reference to the mechanism of breakdown. Part 1: 650 of March.

537.713 **2775**

A Simple System of Dimensions in Electrical Engineering.—M. Eskenazi. (*C. R. Acad. Sci., Paris*, 21st April 1952, Vol. 234, No. 17, pp. 1673–1674.) It is proposed to base dimensional equations on the system R, E, L, T (resistance, e.m.f., length, time); this has the advantage over Tarbouriech's system (696 of 1947) that the fundamental magnitudes are all represented by commonly used material standards.

538.3 **2776**

Electromagnetic Energy Density and Flux.—C. O. Hines. (*Canad. J. Phys.*, March 1952, Vol. 30, No. 2, pp. 123–129.) A comparison is made of the validity and usefulness of Poynting's theorem and of Macdonald's theorem; reasons are given for preferring the latter. Only nonmagnetic media are considered, though this restriction may not be necessary.

538.56 : 537.525 **2777**

Plasma Oscillations and Striations.—G. V. Gordeev. (*C. R. Acad. Sci. U.R.S.S.*, 11th Aug. 1951, Vol. 79, No. 5, pp. 771–774. In Russian.) Previous investigators have established a connection between the striations and one of the plasma waves. The method is extended, and striations are considered as a group of waves. Equations (9) and (15) are derived in which the group velocity and wavelength of the almost monochromatic group of waves are related to the parameters of the discharge.

538.56 : 537.525 **2778**

Oscillations in a Discharge as a Source of Travelling Striations.—A. A. Zaitsev. (*C. R. Acad. Sci. U.R.S.S.*, 11th Aug. 1951, Vol. 79, No. 5, pp. 779–781. In Russian.) Oscillatory phenomena were studied in pure neon, in neon and argon with molecular impurities, and in air. A close connection between the travelling striations and the oscillations of potential in the discharge was observed.

621.317.35 : 518.4 **2779**

Graphical Method applicable to Harmonic Analysis and to Symbolic Calculus.—G. Laville. (*C. R. Acad. Sci., Paris*, 28th April 1952, Vol. 234, No. 18, pp. 1728–1730.)

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.72 + 523.82] : 621.396.822 **2780**

Electromagnetic Radiation produced by Electron Collisions in a Very Strongly Ionized Medium.—B. Kwal. (*J. Phys. Radium*, Jan. 1952, Vol. 13, No. 1, pp. 35–38.) The problem of e.m. emission on long wavelengths due to electron collisions, when the electrons have non-relativistic velocities, cannot be satisfactorily treated from the quantum theory point of view, and classical theory must be applied. In the case of ionic plasma, for radiation frequencies below a critical value (100 Mc/s for interstellar ionized regions and 10 kc/s for the solar corona) the emissions should have a constant intensity, though propagation at these frequencies cannot take place unless the adjacent region is one of lower density. For frequencies sufficiently low with respect to the critical frequency, classical theory no longer holds.

523.72 : 621.296.822 **2781**

The Position and Movement on the Solar Disk of Sources of Radiation at a Frequency of 97 Mc/s: Part 3 — Outbursts.—R. Payne-Scott & A. G. Little. (*Aust. J. sci. Res., Ser. A*, March 1952, Vol. 5, No. 1, pp. 32–46.) Observations indicate that initially the position of an outburst almost coincides with that of the accompanying flare, but the outburst moves rapidly toward, and sometimes off, the solar limb. Its displacement is consistent with the assumption that the outburst is initiated by an agency, such as corpuscular streams, originating at the flare and moving outward with a velocity between 500 and 3 000 km/s. The polarization of the outbursts is discussed. Part 2: 1902 of July.

523.746 : 523.72 **2782**

Reversal of Polarisation of Microwaves from Sunspots.—U. C. Guha. (*Indian J. Phys.*, Jan. 1951, Vol. 25, No. 1, pp. 8–16.) The reflection coefficients of the ordinary and the extraordinary waves are calculated for a barrier with a parabolic distribution of ions. The results are applied to explain the observed reversal of the polarization of microwaves escaping from sunspots.

523.746 "1952.01/.03" 2783

Provisional Sunspot-Numbers for January to March, 1952.—M. Waldmeier. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, p. 310; *Z. Met.*, May 1952, Vol. 6, No. 5, p. 158.)

523.78 2784

The Total Solar Eclipse of February 25, 1952.—R. O. Redman. (*Nature, Lond.*, 26th April 1952, Vol. 169, No. 4304, pp. 686–688.) A preliminary report of the results of observations made in the Sudan by various groups of astronomers and technicians, nearly all from Europe and the United States, during the eclipse.

523.78 2785

Combined Observations of the Total Eclipse of the Sun at Khartoum (Sudan) and of the Partial Eclipse observed by Radio-Telescope at Meudon, 25th February 1952.—M. Laffineur, R. Michard, J. C. Pecker, M. d'Azambuja, A. Dollfus & I. Atanasijević. (*C. R. Acad. Sci., Paris*, 7th April 1952, Vol. 234, No. 15, pp. 1528–1530.) A brief account of the radio and optical equipment used and the measurements made by the French expedition to Khartoum. In the middle of totality the intensity of the radiation received on 550 Mc/s was 19·5% and on 255 Mc/s was 30·5% of that from the unobscured sun. At Meudon, the intensity of radiation received at the maximum of the partial eclipse was 83% of that from the unobscured sun.

523.78 : 523.72 2786

The Ellipsoidal Form of the Sun observed at Metre Wavelengths.—É. J. Blum, J. F. Denisse & J. L. Steinberg. (*C. R. Acad. Sci., Paris*, 16th April 1952, Vol. 234, No. 16, pp. 1597–1599.) Curves showing the variation of intensity of radiation received from the sun on 169 Mc/s during the eclipses of 1st September 1951 and 25th February 1952 are interpreted as indicating that the coronal radiation from the equatorial regions is greater than that from the polar regions, the radiation at this frequency corresponding to that from a greatly flattened ellipsoid with nearly uniform brightness. See also 1282 of May (Bosson et al.).

523.78 : 523.72 2787

Khartoum Expeditions for Total Solar Eclipse of February 25th, 1952.—M. K. Aly. (*Observatory*, April 1952, Vol. 72, No. 867, pp. 63–72.) Report of meetings held prior to the eclipse, with statements of the measurements planned by the various research groups. Skeleton descriptions are given of equipment for measurement of solar r.f. radiation at wavelengths 8·5 mm, 9·4 cm, 0·55 m and 1·17 m.

523.85 : 621.396.822 2788

Radio-Frequency Radiation from the Constellation of Cygnus.—J. H. Piddington & H. C. Minnett. (*Aust. J. sci. Res., Ser. A*, March 1952, Vol. 5, No. 1, pp. 17–31.) Observations were made at frequencies of 1 210 and 3 000 Mc/s, using apparatus and methods described previously (1906 of July). At the lower frequency two sources were observed, one being the known radio star Cygnus A and the other a diffuse source or 'radio nebula', probably due to thermal emission from clouds of ionized interstellar gas. Neither of these sources was observed at the higher frequencies.

550.38 "1952.01/.03" 2789

Indices of Geomagnetic Activity of the Observatories Abinger, Eskdalemuir and Lerwick, January to March 1952.—(*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 4, pp. 256–258.) Three-hour *K*-indices are tabulated.

550.38 "1952.01/.03" 2790

Cheltenham Three-Hour-Range Indices *K* for January to March, 1952.—R. R. Bodle. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, p. 310.)

550.385 "1951.10/1952.03" 2791

Principal Magnetic Storms [Oct. 1951–March 1952].—(*J. geophys. Res.*, June 1952, Vol. 57, No. 2, pp. 311–313.)

550.386 "1951.10/.12" 2792

International Data on Magnetic Disturbances, Fourth Quarter, 1951.—J. Bartels & J. Veldkamp. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, pp. 305–309.)

551.311.234 : 621.317.335.3 2793

The Effect of Moisture on the Electrical Properties of Soil.—A. Cownie & L. S. Palmer. (*Proc. phys. Soc.*, 1st April 1952, Vol. 65, No. 388B, pp. 295–301.) Measurements of the permittivity of samples of soil containing 4·1–47·7% moisture were made at a frequency of 430 Mc/s, using a coaxial transmission line terminated by the sample under test. The permittivity increases with moisture content, the observed values ranging from 4·0 to 31·4. Comparison is made with the results of other investigators.

551.510.41 : 546.214 2794

Direct Measurements of the Vertical Distribution of Atmospheric Ozone to 70 Kilometers Altitude.—F. S. Johnson, J. D. Purcell, R. Tousey & K. Watanabe. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, pp. 157–176.) Measurements in rockets at White Sands, New Mexico, showed that the ozone concentration above 35 km height decreased approximately exponentially.

551.510.535 2795

The Dependence of Ionospheric Disturbances on Local Time.—J. M. Ardillon. (*C. R. Acad. Sci., Paris*, 7th April 1952, Vol. 234, No. 15, pp. 1568–1571.) Observations made at Poitiers and at Washington during 1949–1950 are reported. The onset of a decrease of F_2-layer critical frequency is never observed during the daytime. Comparison is made of the diurnal variation of this critical frequency for quiet and disturbed days by plotting the differences between mean values for the five quietest and five most disturbed days of the month. The curve exhibits minima at 0600 and 1800 hours, with a maximum between those times. These diurnal variations are more marked at the equinoxes than at other seasons.

551.510.535 2796

On Negative Ions of Molecular Oxygen in the *D* Layer.—D. R. Bates & H. S. W. Massey. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 4, pp. 253–254.) Note supplementary to paper abstracted in 983 of April. Original estimates of the daytime ratio of negative ions to electrons may be too high.

551.510.535 2797

Theory of Formation of an Ionospheric Layer below E Layer Based on Eclipse and Solar Flare Effects at 16 kc/s.—R. N. Bracewell. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 4, pp. 226–235.) An anomaly in the height of reflection of steeply incident 16-kc/s waves during the partial solar eclipse of 1949 and observed effects of solar flares are incompatible with the theory that reflection takes place from the bottom of a Chapman layer. An alternative mechanism is proposed which does not require that electron density be negligible compared to the density of ionizable particles.

551.510.535 **2798**

The Effect of Collisions between Electrons on the Absorption of Radio Waves in the F-Layer and in the Solar Corona.—V. L. Ginzburg. (*Zh. tekh. Fiz.*, Aug. 1951, Vol. 21, No. 8, pp. 943–947.) A mathematical discussion showing that collisions between electrons do not contribute appreciably to the absorption of radio waves.

551.510.535 : 523.745 : 525.624 **2799**

Effect of Vertical Transport of Ions Caused by Solar Tides in F_2 Region.—D. C. Choudhury. (*Indian J. Phys.*, Jan. 1951, Vol. 25, No. 1, pp. 1–7.) According to Martyn's theory (1053 of 1949 and back references) there is a marked vertical drift of ions. If the drift velocity is represented by the relation $v = v_0 e^{-\gamma z} \cos(\omega t + \delta)$, the night-time Chapman distribution will be markedly affected even if electron reduction by recombination is negligible. Calculated results are in general agreement with observations if the value of γ is about unity.

551.510.535 : 523.78 **2800**

Ionospheric Effects of Solar Eclipse at Sunrise, September 1, 1951.—H. W. Wells. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, pp. 291–304.) Results obtained during the annular eclipse, which started before sunrise, show no evidence of any considerable ion production at any of the three observation stations until more than a third of the sun's disk was exposed during the recovery phase. Ion density increased rapidly about 15 min after maximum phase, and the high rate of increase, about double the normal rate, continued for half an hour after the end of the eclipse.

551.510.535 : 525.624 **2801**

The Calculation of the Probable Error of Determinations of Lunar Daily Harmonic Component Variations in Geophysical Data: a Correction.—S. Chapman. (*Aust. J. sci. Res. Ser. A*, March 1952, Vol. 5, No. 1, pp. 218–222.) Comment on 636 of 1950 (Tschu), indicating certain inaccuracies.

551.510.535 : 550.385 **2802**

The Morphology of Storms in the F_2 Layer of the Ionosphere: Part 1 — Some Statistical Relationships.—E. V. Appleton & W. R. Piggott. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 4, pp. 236–252.) A statistical study is made of ionospheric storm phenomena at a number of stations. The phenomena show marked diurnal variations and for correlation purposes must be referred to local time. Sequences of storm events at auroral, temperate and equatorial latitudes are contrasted; in temperate latitudes at least, such sequences are subject to seasonal variation.

551.510.535 : 621.396.11 **2803**

Lunar Variations in F_2-Region Critical Frequency at Singapore.—Osborne. (See 2869.)

551.510.535 : 621.396.11.029.45 **2804**

An Explanation of Radio Propagation at 16 kc/s in Terms of Two Layers below E Layer.—R. N. Bracewell & W. C. Bain. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 4, pp. 216–225.) An ionospheric model is proposed to explain observed features of propagation over distances of 90 km and 535 km. At a range of 90 km, a wave is received by reflection from the upper of the postulated layers. At a range of 535 km, waves reflected from both layers contribute to the total field, especially the wave reflected once from the lower layer and those reflected more than once from the upper layer. Anomalous effects at distances of about 300 km from the transmitter are explained by the proposed model.

551.510.535(71) **2805**

Ionospheric Disturbances in Canada.—J. H. Meek. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, pp. 177–190.) Analysis of variations of F-region ionization and of abnormally high absorption of radio waves in northern latitudes indicates that disturbances appear first in one part of the auroral zone and then move round the earth with the sun for several days. The effect of a disturbance is enhanced and extends farther south near certain geographic latitudes. Diurnal and seasonal characteristics of the disturbances are described. It is suggested that the disturbances are connected with similar geomagnetic disturbances and are due to a narrow stream of solar particles moving into the earth's path.

551.594.13 **2806**

Electric Conductivity and Small-Ion Concentration of the Atmosphere at One Metre above Ground, and Conductivity at Ground Level.—G. A. O'Donnell. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 4, pp. 201–215.) Results of measurements at five locations within 120 miles of New York show that conductivity values at ground level and at 1 m are not equal, nor is their ratio constant. This applies to both polar and total conductivity.

551.594.21 **2807**

Distribution of Electrical Conduction Currents in the Vicinity of Thunderstorms.—R. E. Holzer & D. S. Saxon. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, pp. 207–216.)

551.594.22 **2808**

Thunderbolts: The Electric Phenomena of Thunderstorms.—E. Gold. (*Nature, Lond.*, 5th April 1952, Vol. 169, No. 4301, pp. 561–563.) Report of discussion at the Royal Astronomical Society, January 1952.

551.594.6 : 621.317.35 **2809**

The Waveforms of Atmospherics.—P. G. F. Caton & E. T. Pierce. (*Phil. Mag.*, April 1952, Vol. 43, No. 339, pp. 393–409.) Convenient equipment and technique for recording waveforms of atmospherics are described; a time resolution of 3 μs is achieved on photographs with an exposure time of 20 ms. The results of an extensive series of observations made at Cambridge, England, during the period 1947–1951 are presented and analysed. Both day and night conditions, all seasons of the year, and a wide range of distance of source of atmospheric (100–4 000 km) were covered. A new and more complete classification of atmospheric waveforms is derived and the characteristics of each type are studied in relation to distance of origin. At night, the type of waveform observed depends on the geographical location of the source; for storms to the south-west, a transition in waveform type occurs at a distance of about 1 600 km, but no similar transition is observed for sources to the south-east. A critical discussion is presented of the applicability of the theory of multiple ionospheric reflections to the various types of waveform, and of the accuracy with which the effective height of reflection and the distance of the source can be determined. Only a small proportion of atmospherics recorded, rarely more than 10% on any one night, give reliable values of reflection height and source distance. The reflection height is usually in the range 75–95 km. Photographs showing waveforms of the different types of atmospheric are reproduced.

LOCATION AND AIDS TO NAVIGATION

621.396.9 **2810**

Distance Measurement by Radar Technique.—W. Messerschmidt. (*Arch. tech. Messen*, March 1952, No. 194, pp. 49–52.) Short descriptions of various methods, with discussion of the accuracy attainable.

621.396.9 **2811**

Circular Polarisation for C.W. Radar.—J. F. Ramsay. (*Marconi Rev.*, 2nd Quarter 1952, Vol. 15, No. 105, pp. 71–89.) The simple properties of linearly, circularly and elliptically polarized waves are reviewed. A linearly polarized wave can be converted into a circularly polarized wave by resolving it into two equal orthogonal components and shifting the phase of one by 90°. A phase shift of 180° simply rotates the plane of polarization. Practical devices for these purposes are called 'circularizers' and 'rotators' respectively. Several types are described and illustrated, and their application to microwave aerials discussed. Common T-R operation is achieved by incorporating a circularizer in the aerial and using orthogonal polarizations for transmitter and receiver. Mismatch in a system for circular polarization can result in elliptical polarization. Details of an experimental 10-cm c.w. radar aerial for common T-R operation are given.

621.396.93 : 621.396.671 **2812**

An Investigation of Polarization Errors in an H-Adcock Direction-Finder.—F. Horner. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 229–240. Summary, *ibid.*, Part III, July 1952, Vol. 99, No. 60, pp. 223–225.) The polarization-error characteristics of H-type Adcock direction-finders for the v.h.f. band and the upper part of the h.f. band are controlled to a large extent by resonance phenomena. Investigation of a v.h.f. rotating system shows that the frequencies at which large errors are liable to occur, and the magnitudes of the maximum errors, can be calculated from the physical dimensions of the aerial system. The lowest resonance frequency is that for which the product of aerial length and spacing is $\lambda^2/20$. A second resonance occurs when the spacing is $\lambda/2$, and, if spacing and aerial length are about equal, a third resonance occurs for a spacing of $0{\cdot}8\,\lambda$. Three major causes of polarization errors are discussed and various methods of minimizing errors are considered.

621.396.933 **2813**

A Multichannel Distance Measuring Equipment for Aircraft.—E. B. Mulholland. (*Proc. Instn Radio Engrs, Aust.*, Feb. 1952, Vol. 13, No. 2, pp. 47–58.) Description of radar equipment operating in conjunction with responder beacons at known locations on the ground. The aircraft set transmits pairs of pulses with a selected time interval; each beacon contains a discriminator and responds only to pulses with a certain interval. A 12-channel system operating in the 200–230-Mc/s band has been adopted as a standard for use on Australian airlines.

621.396.933 **2814**

The Civil Aeronautics Administration V.H.F. Omnirange.—H. C. Hurley, S. R. Anderson & H. F. Keary. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, p. 860.) Correction to paper noted in 1000 of April.

621.396.933 **2815**

Anticollision Radar for Commercial Flights.—M. Hobbs. (*Electronics*, June 1952, Vol. 25, No. 6, pp. 110–113.) Description of British equipment installed in high-speed jet aircraft for detecting thunderclouds and mountains. It operates on a 3-cm wavelength with a peak power of 10 kW. The aerial is an 18-in. paraboloid, stabilized gyroscopically, with beam angle 6°; angle of scan on each side of the aircraft is 75°. Tests of the apparatus are described and the principle of the safety-circle technique is illustrated. Details of the receiver circuits are noted.

621.396.9 **2816**

Leitfaden der Funkortung (Manual of Radio Direction Finding). [Book Review]—W. Stanner and collaborators. Publishers: Elektron-Verlag, Garmisch-Partenkirchen, 1952, 164 pp., 8 DM. (*Fernmeldetech. Z.*, April 1952, Vol. 5, No. 4, p. 197.) A general treatment including, in the longest and most interesting section of the book, an account of d.f. developments in Germany and of British and American radar technique.

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.13 **2817**

An Automatically Controlled Knudsen-Type Vacuum Gauge.—C. N. W. Litting & W. K. Taylor. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 241–249.) Description of a gauge in which the pressure-dependent radiometric force is balanced by an e.s. force, the pressure being calculated from a measured voltage and the gauge dimensions. The various units of the instrument are described and also the method of calibration. Experimental results for N and Ar are in close agreement with theoretical values.

534.321.9 : 534.22 : 546.74 **2818**

Magnetically Induced Ultrasonic Velocity Changes in Polycrystalline Nickel.—S. J. Johnson & T. F. Rogers. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 574–577.)

537.226 : 537.228.2 **2819**

Electrostriction Phenomena in Ferroelectric Ceramic Materials.—G. A. Smolenski. (*Zh. tekh. Fiz.*, Sept. 1951, Vol. 21, No. 9, pp. 1045–1049.)

537.311.33 **2820**

Industrial Applications of Semiconductors: Part 1—Semiconductors.—H. K. Henisch. (*Research, Lond.*, March 1952, Vol. 5, No. 3, pp. 101–107.) A simple account of the characteristic properties of these materials, with special reference to the physics of transistor action.

537.311.33 : 546.289 **2821**

Measurement of Diffusion in Semiconductors by a Capacitance Method.—K. B. McAfee, W. Shockley & M. Sparks. (*Phys. Rev.*, 1st April 1952, Vol. 86, No. 1, pp. 137–138.)

537.311.33 : 546.289 **2822**

Diffusion of Donor and Acceptor Elements into Germanium.—C. S. Fuller. (*Phys. Rev.*, 1st April 1952, Vol. 86, No. 1, pp. 136–137.)

538.221 **2823**

The Magnetic and Electrical Properties of Ferroxcube Materials.—J. J. Went & E. W. Gorter. (*Philips tech. Rev.*, Jan. 1952, Vol. 13, No. 7, pp. 181–193.) Aspects discussed include the chemical composition and crystallographic structure in relation to the saturation magnetization; the permeability and magnetic losses in weak and in strong fields; and the remarkable dielectric properties.

538.221 **2824**

Ferroxdure, a Class of New Permanent Magnet Materials.—J. J. Went, G. W. Rathenau, E. W. Gorter & G. W. van Oosterhout. (*Philips tech. Rev.*, Jan. 1952, Vol. 13, No. 7, pp. 194–208.) Ferroxdure is the name given to a class of magnetically hard oxidic ceramics, and especially to one consisting mainly of $BaFe_{12}O_{19}$. This has hexagonal crystal structure with one axis of easy magnetization, resulting in a high value of coercive force together with rather low remanence and saturation magnetization; the relation between structure and magnetic properties is explained. The material is suitable for applications where opposition to demagnetization is required; several such applications are indicated. See also *Phys. Rev.*, 1st May 1952, Vol. 86, No. 3, pp. 424–425.

538.632 : 537.311.1 **2825**

Measurements of the Hall Effect in Zinc Oxide.—K. Intemann & F. Stöckmann. (*Z. Phys.*, Dec. 1951, Vol. 131, No. 1, pp. 10–16.) Values of the order of 10 cm/s per V/cm are obtained for the mobility of electrons in evaporated films of ZnO; this is in satisfactory agreement with values found previously for compact ZnO.

539.234 : 537.29 **2826**

Effect of Electric Field on the Development of Thin Films.—M. Perrot & J. P. David. (*C. R. Acad. Sci., Paris*, 28th April 1952, Vol. 234, No. 18, pp. 1753–1755.) Investigation of thin Ag and Al films evaporated in a high vacuum shows that different resistivities are obtained according to the value of the field applied during deposition.

539.234 : 546.26 : 537.311.32 **2827**

Conductivity and Flicker Effect of Very Thin Carbon Films.—N. Nifontoff. (*C. R. Acad. Sci., Paris*, 28th April 1952, Vol. 234, No. 18, pp. 1755–1757.) Continuation of work previously reported (171 of January and 341 of February), using more sensitive equipment.

539.234 : 546.72 **2828**

Measurements on the Current Sensitivity of the Electrical Resistance of Condensed Iron Films at Low Temperatures.—A. van Itterbeek, R. Lambeir, B. Franken, G. J. van den Berg & D. A. Lockhorst. (*Physica*, March 1952, Vol. 18, No. 3, pp. 137–144.) Measurements were made at temperatures down to those of liquid N_2, H_2 and He of the variation of resistance (*a*) with current, (*b*) in the presence of a magnetic field; the results are related to Kittel's theory (1129 of 1950). The resistance decrease with increasing current is rather less than for sputtered films.

546.811 : 621.3.011 **2829**

On the Electrical Properties of Thin Layers containing Grey Tin.—N. A. Goryunova, I. D. Konozenko & A. P. Obukhov. (*Zh. tekh. Fiz.*, July 1951, Vol. 21, No. 7, pp. 814–817.) The specific resistance of thin layers of white tin containing small amounts of grey tin varies between 10^3 and 10^4 ohm.cm. The thermal coefficient of resistance is negative and of the order of 3–5% per 1°C.

546.817.221 + 546.817.231 + 546.817.241] : 548.55 **2830**

Oxygen-Free Single Crystals of Lead Telluride, Selenide, and Sulfide.—W. D. Lawson. (*J. appl. Phys.*, April 1952, Vol. 23, No. 4, pp. 495–496.) Anomalies in the type of conductivity of crystals of PbSe and PbTe have been found to result from the presence of oxygen. A method of preparation in an atmosphere of hydrogen is described which gives oxygen-free crystals. Single crystals of PbS have also been produced by this method.

549.514.51 : 537.226.2.096 **2831**

Temperature Variation of the Dielectric Constant of Quartz at H.F. between 20° and 700°C. αβ Transformation. Thermal Twinning and Mechanical Detwinning.—J. P. Pérez. (*Ann. Phys., Paris*, March/April 1952, Vol. 7, pp. 238–282.) The quartz plates examined formed the dielectric of capacitors whose capacitance changes were determined from the readings of a calibrated variable capacitor. For plates cut parallel to the optic axis, the capacitance increases continuously with temperature except at the αβ transformation point, where there is usually a discontinuity. Plates cut perpendicular to the optic axis could not be studied beyond about 300°C, the conductivity becoming too great. The results indicate that the αβ transformation is quasi-instantaneous and is characterized by slip at twinning surfaces. 68 references.

621.314.634 **2832**

Positive Current Creep in Selenium Rectifiers.—R. Cooper & J. Harrington. (*Proc. phys. Soc.*, 1st April 1952, Vol. 65, No. 388B, pp. 303–304.) Experiments are described which indicate that although high power dissipation in the barrier layer may be a factor which favours positive current creep, as suggested by Henisch & Ewels (926 of 1951), it is not an essential condition and some other factor must be involved.

621.315.612.6 **2833**

The Electrical Conductivity and Breakdown Strength of Thin Glass Films.—G. Glaser. (*Z. angew. Phys.*, Jan. 1952, Vol. 4, No. 1, pp. 12–16.) Experiments on glass films of thicknesses down to 0·07 μ indicate that there is only an indirect relation between electrical breakdown strength and conductivity. Breakdown strength increases as temperature decreases.

666.22 : 546.244-31 **2834**

Tellurite Glasses.—J. E. Stanworth. (*Nature, Lond.*, 5th April 1952, Vol. 169, No. 4301, pp. 581–582.) A short account of the properties of various glasses with TeO_2 as the principal constituent, the second being PbO or BaO and the third Li_2O, Na_2O, B_2O_3, P_2O_5, GeO_2, V_2O_5, Cb_2O_5 or TiO_2. The expansion coefficients are unusually high for oxide glasses ($10–20 \times 10^{-6}$ per 1°C), refractive indices of the order 1.8–2.2, permittivities about 27 and loss factors about 0.003 from 50 c/s to 1.2 Mc/s. Some of the glasses have very low absorption at any wavelength up to 5.5 μ.

MATHEMATICS

517.564.3 : 621.396.619.13 **2835**

Spectrum of a Frequency-Modulated Wave.—Vaughan. (See 2892.)

517.93 **2836**

A Graphical Analysis for Non-Linear Systems.—Pei-Su Hsia. (*Proc. Instn elect. Engrs*, Part II, April 1952, Vol. 99, No. 68, pp. 125–131. Discussion, pp. 132–134.) Full paper; summary noted in 1945 of July.

519.21 **2837**

Remarks on an Interpolation Theorem.—A. Blanc-Lapierre. (*C. R. Acad. Sci., Paris*, 28th April 1952, Vol. 234, No. 18, pp. 1733–1735.) Discussion of some properties of a class of stationary aleatory functions $X(t)$ such that the values of the function for any values of t are determined from knowledge of the values of $X(t_0 + n\lambda)$ taken by the function $X(t)$ at uniformly distributed intervals on the t axis, n being integral. The theory is related to the theory of communication.

681.142 : 621.318.572 **2838**

Universal High-Speed Digital Computers: Serial Computing Circuits.—F. C. Williams, A. A. Robinson & T. Kilburn. (*Proc. Instn elect. Engrs*, Part II, April 1952, Vol. 99, No. 68, pp. 107–120. Discussion, pp. 120–123.) Circuits designed for the Manchester University computer are described.

681.142 : [621.392.26 + 621.396.611.4 **2839**

The Solution of Waveguide and Cavity-Resonator Problems with the Resistance-Network Analogue.—G. Liebmann. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 260–272.) Description of a resistance-network analogue method which can be considered as an experimental counterpart of Southwell's relaxation technique. The network is the same as that previously described for the solution of certain equations (1954 of 1950), with modifications necessary for carrying out the iteration process.

681.142 : 621.395.625.3 **2840**

Universal High-Speed Digital Computers: a Magnetic Store.—F. C. Williams, T. Kilburn & G. E. Thomas. (*Proc. Instn elect. Engrs*, Part II, April 1952, Vol. 99, No. 68, pp. 94–106. Discussion, pp. 120–123.) An experimental intermediate store is described, comprising a drum coated with a layer of pure Ni as recording medium and rotated in synchronism with the fundamental frequency of the computer. Such a store, with a capacity of 3 000 numbers, each of 40 binary digits, is incorporated in the Manchester University computer.

MEASUREMENTS AND TEST GEAR

531.76 **2841**

A Direct-Reading Mains-Frequency-Cycle Counter.—P. Huggins. (*Electronic Engng*, June 1952, Vol. 24, No. 292, pp. 276–277.) The counter includes three dekatrons [2066 of 1950 (Bacon & Pollard)] to indicate respectively units, tens and hundreds of cycles; a time interval can be read, in terms of mains-frequency cycles, to within 0·02 sec.

531.76 : 621.389 **2842**

A Millisecond Timing Unit.—J. E. Haworth. (*P.O. elect. Engrs' J.*, April 1952, Vol. 45, Part 1, pp. 25–29.) Description of electronic equipment for timing intervals up to 10 sec in 0·5-ms units. The recording meters return to zero at the end of 10 sec and then continue counting the number of cycles of a timing wave that occur in the interval to be measured. The equipment is particularly suitable for timing switching operations.

621.317.3 : 519.271 : 621.396.822 **2843**

Statistical Errors in Measurements on Random Time Functions.—W. B. Davenport, Jr, R. A. Johnson & D. Middleton. (*J. appl. Phys.*, April 1952, Vol. 23, No. 4, pp. 377–388.) Analysis of the dependence of the statistical errors on the averaging interval, the method of averaging, and the statistics of the particular time function considered, with detailed discussion of the measurement of the power of a random-noise voltage of specified bandwidth.

621.317.3 : 537.228.1 **2844**

A New and Quick Method for Detection of Piezoelectricity and Measurement of the Piezoelectric Constants.—K. G. Srivastava. (*Indian J. Phys.*, Jan. 1951, Vol. 25, No. 1, pp. 33–34.) Description of a simple method using a differential transformer.

621.317.321 **2845**

The Measurement of High Alternating Voltages by means of Capacitive Voltage Dividers (C-Measurement): Part 2.—P. Böning. (*Arch. tech. Messen*, March 1952, No. 194, pp. 61–62.) An impedance diagram is constructed for the arrangement previously considered (440 of February), the resistive load being replaced by an instrument transformer. This circuit may be operated so that the voltage across the transformer is in phase with the voltage to be measured.

621.317.35 : 621.397.5 **2846**

A Line Strobe Monitor for Investigating Television Waveforms.—E. Davies. (*J. Televis. Soc.*, Jan./March 1952, Vol. 6, No. 9, pp. 336–342.) Problems in the design of an oscilloscope for television waveforms are discussed generally. Requirements in respect of timebase range, display c.r.o. and associated video amplifier are specified, and diagrams and description are given of a Marconi instrument satisfying these requirements.

621.317.352 : 621.392.52 **2847**

Null-Balance Technique for Filter Measurement.—E. R. Wigan. (*Wireless Engr*, July 1952, Vol. 29, No. 346, pp. 195–196.) Description of a simple and accurate method of determining points on the frequency response curve of a filter, using only laboratory apparatus usually available.

621.317.374 **2848**

An Approximate Method for Deducing Dielectric Loss Factor from Direct-Current Measurements.—B. V. Hamon. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 151–155. Summary, *ibid.*, Part II, June 1952, Vol. 99, No. 69, pp. 291–293.) Description of a method for deducing the approximate loss factor of a solid dielectric from the charging current that flows after the sudden application of a direct voltage. Under certain conditions, the loss factor at a frequency of f c/s can be found from the charging current at a time $0{\cdot}1/f$ sec after application of the voltage. The useful range of the method is discussed and results obtained are compared with a.c. bridge measurements.

621.317.382.029.6 **2849**

Absolute Power Measurement at Microwave Frequencies.—A. L. Cullen. (*Proc. Instn elect. Engrs*, Part IV, April 1952, Monograph No. 23; *ibid.*, Part II, April 1952, Vol. 99, No. 68, pp. 183–186, summary only.) See 1052 of April.

621.317.382.029.6 **2850**

A General Method for the Absolute Measurement of Microwave Power.—A. L. Cullen. (*Proc. Instn elect. Engrs*, Part IV, April 1952, Monograph No. 24; *ibid.*, Part II, April 1952, Vol. 99, No. 68, pp. 186–188, summary only.) Presents the theoretical basis of the method noted in 2849 above, taking as starting point Maclean's 'resonator action' theorem (*Quart. appl. Math.*, 1945, Vol. 2, p. 329.) Any loss-free cavity with input and output waveguides, and containing a movable element, can be used; the force on the movable element can be related to the power flow through the system by subsidiary experiments involving measurements of length only.

621.317.715 : 537.228.1 **2851**

Short Note on a Piezoelectric Vibration Galvanometer.—H. Laporte. (*Z. angew. Phys.*, Jan. 1952, Vol. 4, No. 1, pp. 16–17.) The instrument described is based on Golay's electrometer (3432 of 1937), with a three-stage amplifier incorporated; it will stand heavy overloading.

621.317.729 : 537.291 **2852**

Factors affecting the Design of an Automatic Electron-Trajectory Tracer.—K. F. Sander, C. W. Oatley & J. G. Yates. (*Proc. Instn elect. Engrs*, Part III, July 1952, Vol. 99, No. 60, pp. 169–176. Discussion, pp. 177–179.) Discussion of a method in which information derived from measurements on a model system in an electrolyte tank is passed automatically and continuously to a differential analyser, where the equations of motion of the electron are integrated and its trajectory traced on an output table. Results obtained indicate that a digital computer would be preferable to the differential analyser.

621.317.734 **2853**

Two Electronic Resistance or Conductance Meters.—L. B. Turner. (*Proc. Instn elect. Engrs*, Part II, June 1952, Vol. 99, No. 69, pp. 209–216. Discussion, pp. 216–219.) Description of mains-fed instruments with respective ranges of 10^4–$1{\cdot}2 \times 10^{12}$ Ω and 260–$3{\cdot}3 \times 10^{11}$ Ω. Scale accuracy is not affected by changes of valves.

621.317.755 : 621.385.3/.5 **2854**

A Simple Valve Comparator.—B. C. Foster. (*Electronic Engng*, May 1952, Vol. 24, No. 291, pp. 220–223.) Description of c.r.o. equipment using eight valves and providing simultaneous display of the I_a/V_a characteristics of two valves at a series of grid voltages.

621.317.761 + 621.396.621.54 **2855**

Direct-Reading Frequency Measuring Equipment for the Range of 30 c/s to 30 Mc/s.—L. R. M. Vos de Wael. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 807–813.) English version of paper noted in 743 of March, supplemented by a brief description of a double-heterodyne receiver adapted from that described previously by van der Wijck (2041 of 1949) for use when measuring the frequency of a remote transmitter.

621.317.761 **2856**

Frequency-Deviation Meter plots Drift.—N. C. Hekimian. (*Electronics*, June 1952, Vol. 25, No. 6, pp. 134–135.) The circuit uses two type-6BN6 gated-beam valves [1292 of 1950 (Adler)] in a limiter-discriminator arrangement. Output pulses of variable width are integrated and applied to a bridge circuit containing a microammeter calibrated in kc/s.

621.317.772 **2857**

A Versatile Phase-Angle Meter.—G. N. Patchett. (*Electronic Engng*, May 1952, Vol. 24, No. 291, pp. 224–229.) A direct-reading c.r.o. apparatus with frequency range 20 c/s–20 kc/s, input-voltage range 1–500 V and phase-angle range 90° lag to 90° lead, the accuracy being to within ±2%.

621.317.772 **2858**

Versatile Phase-Angle Meter.—D. S. Gordon: G. N. Patchett. (*Electronic Engng*, July 1952, Vol. 24, No. 293, p. 343.) Comment on 2857 above, and author's reply.

621.317.79 : 621.396.619 **2859**

A New Modulation Meter.—E. Rülker. (*Nachrichtentechnik*, Feb. 1952, Vol. 2, No. 2, pp. 47–51.) Description of an instrument with a logarithmic scale from −50 db to +5 db, suitable for the frequency range 40 c/s–15 kc/s. The logarithmic scale is achieved by using the interelectrode path of a diode, operated in the initial-current region, as one section of the amplitude-dependent voltage divider.

621.317.79 : 621.396.62 **2860**

An Automatic Circuit Checker for Radio Receivers.—V. J. Cox. (*Electronic Engng*, June 1952, Vol. 24, No. 292, pp. 258–263.) Description of test gear for use on a production line. Receivers with incorrect wiring or faulty components are rejected and the location of faults indicated, so that they can be diagnosed and corrected by comparatively unskilled workers. The method is based on comparison with a standard receiver.

621.319.43.089.6 **2861**

Equipment for Alignment of Ganged Variable Capacitors.—J. Schmidt. (*Nachrichtentechnik*, Feb. 1952, Vol. 2, No. 2, pp. 55–57.) Description of apparatus for rapid comparison of the capacitance/angle curve of a variable capacitor with that of a standard or of a ganged unit, with extension to the alignment of three units.

621.396.615.14.029.63/.64 **2862**

A Generator for Measurements at U.H.F.—P. Clostre & R. Wallauschek. (*Ann. Télécommun.*, April 1952, Vol. 7, No. 4, pp. 196–204.) A description is given of equipment for making all the measurements necessary for determining the characteristics of travelling-wave valves and for various measurements on waves in the range 5–12 cm. The equipment comprises (*a*) klystron oscillator in a perfectly screened enclosure, (*b*) screened aperiodic detector, (*c*) screened wavemeter with a coupling system practically aperiodic throughout the range of the klystron, (*d*) direct output with variable coupling, (*e*) calibrated attenuator with input and output impedances matched to external lines, (*f*) modulator. The total range is covered in three sections with adequate overlap, using different klystrons. The direct output power is of the order of 50–100 mW, the attenuator giving outputs variable from 1 mW to 10^{-15} W. Theory of the attenuator is given in an appendix.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

621.38.001.8 : 543/545 **2863**

Recent Developments in Electronic Instrumentation for Chemical Laboratories.—F. Gutmann. (*Proc. Instn Radio Engrs, Aust.*, Jan. 1952, Vol. 13, No. 1, pp. 11–26.) See 2565 of September.

621.383.2 **2864**

Some New Image-Convertor Tubes and their Applications.—J. A. Jenkins & R. A. Chippendale. (*Electronic Engng*, July 1952, Vol. 24, No. 293, pp. 302–307.) Description of the special features of the Mullard tubes, types ME 1200, ME 1201 and ME 1202, and their application in infrared pyrometry and photography, in high-speed photography, in process control for light-sensitive materials, and for brightness intensification in X-ray radiography.

621.385.833 **2865**

The Axial Potential of the Three-Electrode [electron] **Lens.**—P. Grivet & M. Bernard. (*J. Phys. Radium*, Jan. 1952, Vol. 13, No. 1, pp. 47–48.) See also 2000 of July.

621.385.833 **2866**

The Field Ion Microscope.—E. W. Müller. (*Z. Phys.*, Dec. 1951, Vol. 131, No. 1, pp. 136–142.) By reversing the polarity of the voltage in the field electron microscope, adsorbed atoms are torn from the tip of the object as positive ions and form an image of its surface on the luminescent screen. Fields up to 300 MV/cm have been used. Resolution is better than that of the electron-emission microscope because the tangential velocities are lower. The required image intensity is attained by continual reinforcement of the desorption process.

PROPAGATION OF WAVES

621.396.11 **2867**

Polarization of Radio Waves reflected from the Ionosphere.—B. Landmark. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 4, pp. 254–255.) Results of vertical-incidence measurements in Norway are shown. The third magneto-ionic component or *Z* trace was polarized in the same way as the ordinary wave [see also 3090 of 1951 (Hogarth)]. Correlation was found between mean values of absorption at 3·6 Mc/s and the axis ratio ϵ of the polarization ellipse. During magnetic storms and auroral displays the value of ϵ varied considerably.

621.396.11 : 535.515 **2868**

Comparison of Double Refraction in Crystals and in the Ionosphere.—G. Lange-Hesse. (*Arch. elekt. Übertragung*, April 1952, Vol. 6, No. 4, pp. 149–158.) Differences between the double-refraction phenomena of light in crystals and of e.m. waves in the ionosphere are investigated using tensor algebra. Whereas the permittivity tensor for the crystal in the direction of the optic axis is symmetrical, that for the ionosphere in the direction of the earth's magnetic field includes an antisymmetrical term, giving rise to double refraction. Using the concept of normal surfaces, it is shown that there is no direction of propagation in the ionosphere for which double refraction disappears.

621.396.11 : 551.510.535 **2869**

Lunar Variations in F_2-Region Critical Frequency at Singapore.—B. W. Osborne. (*Nature, Lond.*, 19th April 1952, Vol. 169, No. 4303, pp. 661–662.) Results of measurements of f_0F_2 from November 1948 to June 1951 inclusive are analysed and show a definite correlation with the moon's phase, with well-marked maxima at the first and last quarter.

621.396.11.029.45 **2870**

The Ionospheric Propagation of Radio Waves of Frequency 16 kc/s over Distances of about 200 km.—R. N. Bracewell. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 217–228. Summary, *ibid.*, Part III, July 1952, Vol. 99, No. 60, pp. 217–221.) Measurement of phase, the essential feature of the investigations, was effected by comparison with a reference signal sent from the transmitter by land line. The field variations at 200-km range are explicable in terms of a constant ground-wave and multiple reflections from the ionosphere, which are more evident than at 90-km range. The apparent height of reflection varies approximately as $5{\cdot}5 \log_e \sec \chi +$ constant, where χ is the sun's zenith distance. The reflection height for summer noon is 65 km and for the night 82 km.

621.396.11.029.45 **2871**

The Ionospheric Propagation of Radio Waves of Frequency 16 kc/s over Distances of about 540 km.—W. C. Bain, R. N. Bracewell, T. W. Straker & C. H. Westcott. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 250–259. Summary, *ibid.*, Part III, July 1952, Vol. 99, No. 60, pp. 226–228.) An account of investigations, carried out at Aberdeen during 1940–1944 and May–October 1949, of the amplitude and phase of signals from the Rugby transmitter. Diurnal and seasonal effects are noted. The results show that reflection takes place at an apparent height of about 74 km by day and 92 km at night, with effective reflection coefficients of about 0·27 and 0·55 respectively in the summer of 1949. At shorter ranges the downcoming wave is approximately circularly polarized, whereas at 535 km the polarization was almost linear during morning twilight. The results confirm the conclusion of Weekes (1491 of 1950) that there is a marked change in the propagation characteristics of 16-kc/s waves in passing from 300 to 500 km.

621.396.11.029.45 : 551.510.535 **2872**

An Explanation of Radio Propagation at 16 kc/s in Terms of Two Layers below E Layer.—Bracewell & Bain. (See 2804.)

621.396.11.029.45 : 551.510.535 **2873**

The Oblique Reflexion of Long Wireless Waves from the Ionosphere at Places where the Earth's Magnetic Field is regarded as Vertical.—J. Heading & R. T. P. Whipple. (*Philos. Trans. A*, 3rd April 1952, Vol. 244, No. 887, pp. 469–503.) Wilkes's model of the ionosphere, with two distinct regions (2548 of 1947), is used and wave-propagation equations in relatively simple form are derived. For a model in which ion density increases exponentially with height and collision frequency is constant over the range of height of the reflecting region, exact solutions are found for these equations, yielding exact expressions in terms of factorial functions for the reflection coefficients of the two regions separately; the total effect of the ionosphere on an incident wave is obtained by properly combining these coefficients. Apparent height of reflection is defined in terms of the phase of the reflected wave. The results of the theory are presented in graphical form for a model approximating to the 'tail' of a Chapman region, and a comparison is made with experimental observations.

621.396.11.029.51 **2874**

Polarization Measurements of Low Frequency Echoes.—E. L. Kilpatrick. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, pp. 221–226.) Report of National Bureau of Standards investigations at Sterling, Va. Plane-polarized 160-kc/s pulses of about 80-μs duration were transmitted vertically from a rectangular loop in the E-W vertical plane. The elliptical pattern of the polarization of the reflected signals under stable conditions was oriented 60°–70° east of magnetic north, the axis ratio varying from 3 to 5, with left-hand rotation of the polar vector. During unstable periods the duration of the echoes usually increased or the echoes split into separate portions with different polarizations.

621.396.11.029.51 **2875**

A Note on the Polarization of Low Frequency Ionosphere Echoes.—J. M. Watts. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, pp. 287–289.) Report of National Bureau of Standards investigations at Sterling, Va, using circularly polarized 160-kc/s pulses. Continuous records of the height at which reflection occurred were obtained on slowly moving film. Daytime observations confirmed the results obtained with plane-polarized waves [2874 above (Kilpatrick) and 3037 of 1950 (Benner et al.)]. Effects at night were more complex.

621.396.11.029.6 : 551.594.5 **2876**

The Fading Rate of Ionospheric Reflections from the Aurora Borealis at 50 Mc/s.—K. Bowles. (*J. geophys. Res.*, June 1952, Vol. 57, No. 2, pp. 191–196.) Measurements have been made of the rapid flutter type of fading associated with auroral propagation (2002 of 1951). The observed fading rates are about ten times greater than might be expected from normal ionospheric drift velocities. For communication by auroral reflection to be effected, in most cases both transmitting and receiving aerials must have the same polarization and be pointed approximately in the direction of the visible aurora. Speech transmission on a.m. 50-Mc/s waves is occasionally possible.

RECEPTION

621.396.621 **2877**

Twelve Years' Progress in the Design of Domestic Broadcast Sound Receivers.—F. T. Lett. (*J. Brit. Instn Radio Engrs*, April 1952, Vol. 12, No. 4, pp. 254–265.) A review of receiver-design trends, particularly in the post-war period, and of progress in the design of components resulting in the production of small portable receivers with good performance.

621.396.621 **2878**

The Marconi Single-Sideband Receivers — Types HR92 and HR93.—C. P. Beanland & F. I. Rickaby. (*Marconi Rev.*, 2nd Quarter 1952, Vol. 15, No. 105, pp. 60–70.) Special features and performance data for (*a*) Type-HR92, a double-diversity, dual-channel s.s.b. receiver pre-tuned to any three spot frequencies in the range 3–27·5 Mc/s, (*b*) Type-HR93, a single-channel version with six spot frequencies.

621.396.621 : 517.432.1 **2879**

Theory of the Impulse Response of Receivers. Application of Heaviside Operators and the Duhamel Integral.—R. Kitai. (*Proc. Instn elect. Engrs*, Part III, July 1952, Vol. 99, No. 60, pp. 221–222.) Summary only. The response of a simple superheterodyne receiver to a step-voltage input is analysed by application of operational analysis, the voltage/time responses being determined at the grid of the converter valve, at the grid of the i.f. amplifier valve, and at the detector output. The indicial-response equations given can also be used, together with the Duhamel integral, when the input differs from a step voltage. The theory was verified by measurements on a receiver.

621.396.621 : 621.317.79 **2880**

An Automatic Circuit Checker for Radio Receivers.—Cox. (See 2860.)

621.396.621.018.12 : 621.3.018.783 **2881**

Low-Frequency Distortion due to H.F. Phase Shift.—J. Zakheim. (*Radio franç.*, April 1952, No. 4, pp. 22–24.) If the oscillating circuit of a receiver is exactly tuned to the frequency of a modulated carrier, the phase advance of the modulation voltage, resulting from the equal and opposite phase shifts of the two h.f. sidebands, produces no nonlinear distortion and is of secondary importance in the transmission of speech or music. If, however, the receiver circuit is mistuned, the phase shifts of the two sidebands are not equal and distortion is produced which depends on the difference (τ) between the phase shifts of the sidebands and on the depth of modulation (m). Curves are given showing the distortion as a function of τ for $m = 30\%$, 60% and 90%. For receivers with more than one tuned circuit, the phase shift introduced by each circuit may result in a total distortion too great to be tolerable.

621.396.621.54 + 621.317.761 **2882**

Direct-Reading Frequency Measuring Equipment for the Range of 30 c/s to 30 Mc/s.—Vos de Wael. (See 2855.)

621.396.622 + 621.396.621 : 621.396.619.11 **2883**

The Synchrodyne and Coherent Detectors.—D. G. Tucker. (*Wireless Engr*, July 1952, Vol. 29, No. 346, pp. 184–188.) The performance of the synchrodyne and the coherent detector with respect to signal/noise ratio, when the input signal is accompanied by noise in its own allotted frequency band, is compared with that of the ordinary so-called 'linear' detector in which the received signal is subjected to plain rectification. There is a very considerable difference in the output noise spectra when the signal is absent or very small, and in the 'linear' detector the noise produces a d.c. output which is absent in the case of the coherent detector. Thus although there is little difference in performance on continuous or envelope-modulated signals, the coherent detector is much the better on pulse or intermittent signals. The synchrodyne has basically the same performance in these respects as the coherent detector, but may be slightly inferior, due to noise appearing in the output of its local oscillator.

621.396.622.7.029.64 : 621.396.615.142 **2884**

Velocity-Modulated Detector.—F. N. H. Robinson. (*Wireless Engr*, Aug. 1952, Vol. 29, No. 347, pp. 200–202.) An explanation is given of the action of a microwave detector in which the r.f. signal is fed to a helix through which an electron beam passes. If the beam velocity is approximately the same as the wave propagation velocity along the helix, the beam emerges from the helix with v.m. and the presence of the signal results in a change of the current picked up by a collector on which the beam impinges. The sensitivity of such a device is estimated, taking account of possible noise sources, and is found to be some hundred times better than that for a video crystal. Experiments at wavelengths of 10 cm and 3 cm were carried out with a simple type of structure having an inefficient collector. Sensitivities of 10^{-9} W at 10 cm and 10^{-8} W at 3 cm with a video bandwidth of 1 Mc/s were obtained, and 10^{-11} W at 10 cm, using a higher load resistance, with a video bandwidth of 1 kc/s. The sensitivity could be greatly improved by a better design of collector.

621.396.81 **2885**

On the Theory of Measurement of Weak Signals having a Continuous Spectrum.—V. S. Troitski. (*Zh. tekh. Fiz.*, Aug. 1951, Vol. 21, No. 8, pp. 994–1003.) Weak signals are defined as signals the spectral density of which is lower than that of the noise fluctuations in the measuring apparatus. Two methods are available for measuring such signals, viz. the compensation method and the modulation method. The theory of these methods is discussed and a comparison between the two is made. The following main conclusions are reached: (*a*) the sensitivity of both methods can be made as high as desired by narrowing the bandwidth of the filter; (*b*) the advantage of the modulation method is that it eliminates the effect of slow random modulation of the noise level.

621.396.82 : 621.396.619.13 **2886**

Interference in F.M. Reception caused by Strong Interfering Transmitters.—M. Kulp. (*Arch. elekt. Übertragung*, April 1952, Vol. 6, No. 4, pp. 143–148.) The intensity of the interference at the receiver output depends on the ratio q between the amplitudes of the unwanted and wanted signals at the limiter input, and changes suddenly as this ratio varies through unity. Formulae are derived and tabulated for the interference caused by an unwanted f.m. signal of frequency equal to or different from that of the wanted signal, and for the interference caused by an unwanted a.m. signal of different frequency, for $q<1$. The modifications to the formulae required to meet the case $q>1$ are indicated.

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11 : 519.272 **2887**

The Mathematical Treatment of Random Phenomena in the Study of Oscillations (Norbert Wiener's Theory).—F. A. Fischer. (*Fernmeldetech. Z.*, April 1952, Vol. 5, No. 4, pp. 151–158.) An outline of the essentials of Wiener's theory of harmonic analysis, with examples of its application.

621.39.001.11 : 621.394.14.004.15 **2888**

Efficient Coding.—B. M. Oliver. (*Bell Syst. tech. J.*, July 1952, Vol. 31, No. 4, pp. 724–750.) "This paper reviews briefly a few of the simpler aspects of communication theory, especially those parts which relate to the information rate of and channel capacity required for sampled, quantized messages. Two methods are then discussed, whereby such messages can be converted to a 'reduced' form in which the successive samples are more nearly independent and for which the simple amplitude distribution is more peaked than in the original message. This reduced signal can then be encoded into binary digits with good efficiency using a Shannon-Fano code on a symbol-by-symbol (or pair-by-pair) basis. The usual inefficiency which results from ignoring the correlation between message segments is lessened because this correlation is less in the reduced message."

621.391 : 621.396.619.16 **2889**

A Recent Development in Communication Technique.—C. W. Earp. (*Proc. Instn elect. Engrs*, Part III, July 1952, Vol. 99, No. 60, pp. 181–186.) A description is given of a proposed new system of communication, tentatively termed the 'ambiguous-index system', which has been evolved as a logical development of earlier systems. The system has certain practical advantages, and it is suggested that one variant, which is very nearly equivalent to the theoretical 2-digit multiple-level p.c.m. system, could be of great value when the available frequency bandwidth is insufficient for binary coding by as many as six digits. The new system permits a satisfactory classification of the system commonly known as 'pulsed f.m.', which represents a special case of the 'ambiguous-index system', which is very closely related to signal coding systems. A modification of the 'pulsed f.m.' system probably represents an almost ideal system of transmission for the case where the available bandwidth is only about twice that required for s.s.b. working.

621.396.619.018.782.4 **2890**

Harmonic Distortion of Modulation.—E. G. Hamer. (*Wireless Engr*, Aug. 1952, Vol. 29, No. 347, pp. 212–216.) Discussion of distortion due to echoes in radio systems, in particular, that due to echoes in aerial feeders. The distortion of a.m. and of f.m. signals is calculated and the results are presented in the form of abacs from which the amount of distortion can be readily determined for a wide range of modulation frequencies and depths of modulation. The equations and abacs show that a f.m. system is much more vulnerable to the effects of echo signals than an a.m. system.

621.396.619.11/.14 : 621.396.822 **2891**

On the Distribution of Energy in Noise- and Signal-Modulated Waves: Part 2—Simultaneous Amplitude and Angle Modulation.—D. Middleton. (*Quart. appl. Math.*, April 1952, Vol. 10, No. 1, pp. 35–56.) The energy distribution is determined for a carrier modulated simultaneously in amplitude and phase (or frequency) by a pair of random-noise waves, one of which is delayed relatively to the other, coherence between the two modulations being assumed. Mean power and spectral distribution are derived from the autocorrelation functions and shown as graphs. The angle modulation results in a redistribution of energy without changing the total power. Cross-correlation terms are responsible for the spectral asymmetry not previously found. As the relative delay increases, spectral maxima oscillate about the carrier frequency in decreasing swings, so that symmetrical spectra are still obtained for particular delay values. Clipping due to over-modulation causes little spreading of the spectra, the shapes of which are mainly controlled by the degree of angle modulation. Special cases considered are those of no coherence and of coherence without over-modulation. The latter has applications to the noise output of magnetrons. Part 1: 2333 of August.

621.396.619.13 : 517.564.3 **2892**

Spectrum of a Frequency-Modulated Wave.—W. C. Vaughan. (*Wireless Engr*, Aug. 1952, Vol. 29, No. 347, pp. 217–222.) Expressions involving Bessel functions are derived for the frequency spectrum of a f.m. wave and for the sideband pattern. Simple arithmetical methods of evaluating Bessel functions to an accuracy adequate for most practical requirements are described in detail. A graphical construction showing the relation between $J_{n-1}(m)$, $J_n(m)$ and $J_{n+1}(m)$ forms the basis of a method for determining a limiting value for the ratio between two coefficients of adjacent orders. This is illustrated numerically for $J_4(5)/J_5(5)$, and the values of $J_n(5)$ are then computed for values of n from 1 to 8 and compared with the values given in standard tables. A second method, with numerical example, for evaluating Bessel coefficients is also given, and the spectrum of a f.m. wave with a modulation index of 5 is shown on a graph which also demonstrates the geometrical relation between the magnitudes of alternate components.

621.396.619.16 : 621.394.3 **2893**

A System for the Transmission of Teleprinter Signals through Narrow Frequency Bands.—A. F. Boff. (*Marconi Rev.*, 2nd Quarter 1952, Vol. 15, No. 105, pp. 49–59.) Modern communication theory is applied in the experimental equipment described. The use of multi-level pulse coding in place of the conventional binary digits of the telegraph code reduces the working bandwidth to only 10 c/s per channel, but the signal/noise ratio for satisfactory operation is higher than that for normal telegraphy.

621.396.65 : 621.385.029.6 **2894**

Travelling-Wave Valves in Radio Beam Links.—G. Goudet. (*Ann. Télécommun.*, April 1952, Vol. 7, No. 4, pp. 152–154.) The use of travelling-wave valves enables amplification to be effected directly at relay stations, without recourse to an i.f. Bandwidth and gain requirements can easily be met and a relay station for a 200-channel telephony system could have only three valves, the first a low-noise type with a gain of about 20 db, receiving a signal of 10^{-8} W and furnishing 10^{-6} W, the second with a gain of 35 db giving an output signal of 3 mW, at which level a crystal mixer could be used for frequency changing, the third valve, also with a gain of 35 db, giving a final output of 1 W. Suitable valves have been designed in the Centre National d'Études des Télécommunications (see 2936–2938 below).

621.396.65 : 621.396.615.142.2 **2895**

Operating Klystrons in F.M. Microwave Links.—J. Cohn. (*Electronics*, June 1952, Vol. 25, No. 6, pp. 124–127.) Discussion of methods of evaluating and correcting the distortion due to long transmission lines and mismatches. The analysis is based on graphical solutions of the equation derived from consideration of the equivalent circuit of a reflex klystron and its load.

621.396.65.029.63/.64 **2896**

Decimetre- and Centimetre-Wave Beam Links, with reference to C.C.I.F. Requirements.—K. O. Schmidt. (*Funk u. Ton*, April 1952, Vol. 6, No. 4, pp. 176–190.) Discussion in particular of noise, signal level, and power requirements for telephony and television multichannel links, with a few technical data for (*a*) a p.ph.m. 24-channel telephony system using a wavelength of 15 cm, (*b*) a f.m. wide-band (6 Mc/s) television system, also on 15 cm, (*c*) a f.m. multichannel telephony system providing 480 channels on 15 cm, (*d*) a similar system providing 1 440 channels on 7·5 cm.

621.396.712.3 **2897**

The New Broadcasting Studios for the Laibach Transmitter.—V. Dušan. (*Radio Tech., Vienna*, April 1952, Vol. 28, No. 4, pp. 173–176.) General description of the arrangement and acoustic properties of the various studios. An illustration shows the special treatment of the walls of the large studio.

621.396.721 **2898**

Portable Field Radio Equipment SUF-21K.—K. Behr & H. Norrby. (*Ericsson Rev.*, 1952, No. 1, pp. 22–28.) Description of Swedish-made telephony apparatus mainly designed for military use. The frequency range is about 8 Mc/s in the band 30–50 Mc/s; f.m. is used. Power transmitted is up to 4 W, giving an effective range of 15–25 km.

621.396.97.029.62 : 621.396.619.13 **2899**

V.H.F. Broadcasting.—J. R. Brinkley. (*Wireless World*, July 1952, Vol. 58, No. 7, p. 279.) Brief report based on a survey carried out in the U.S.A. early in 1952, and relevant to current British plans. Fifteen years after the establishment of the first f.m. stations, only 5% of radio sets and 2% of television sets are for f.m. sound broadcasting. F.m. receivers cost much more than a.m. receivers and many manufacturers have given up f.m. models; the number of f.m. stations has also dropped. F.m. seems likely to be successful for filling gaps in the a.m. service rather than for supplanting it.

SUBSIDIARY APPARATUS

621-526 **2900**

A System utilizing Coarse and Fine Position-Measuring Elements Simultaneously in Remote-Position-Control Servo Mechanisms.—J. C. West. (*Proc. Instn elect. Engrs*, Part II, April 1952, Vol. 99, No. 68, pp. 135–141.)

621.316.722.078.3 **2901**

The Design of Series-Parallel Voltage Stabilizers.—S. N. Pocock : F. A. Benson. (*Electronic Engng*, July 1952, Vol. 24, No. 293, p. 343.) Comment on 2045 of July and author's reply.

TELEVISION AND PHOTOTELEGRAPHY

621.397.24/.26 **2902**

Television from Paris.—(*Wireless World*, Aug. 1952, Vol. 58, No. 8, pp. 298–300.) Outline description of the recent Paris-London relay. From Lille, the end of the existing French relay system, the ordinary broadcast and a second transmission of the programme by a 9-kMc/s portable set were received at Cassel, 28 miles away. Here a 405-line image orthicon was focused on the long-persistence screen of a 15-in. c.r. tube presenting the 819-line picture. A special land line conveyed the 50-c/s mains frequency of the British grid to Cassel for frame-scan locking. Subsequent links were Cassel–Alembon, 7 kMc/s; thence Swingate–Wrotham–London, 4·5 kMc/s. A v.h.f. communication system linked repeater stations from Cassel to London. A land line direct from Paris to London transmitted the programme sound.

621.397.242 **2903**

Carrier-Frequency Transmission on Television Cables.—R. Hoffmann & J. Müller. (*Fernmeldetech. Z.*, April 1952, Vol. 5, No. 4, pp. 173–177.) Various possible methods were considered for the transmission of television signals over distances up to 25 km between studio and transmitter or points in the telephone network. For 625-line signals, 21-Mc/s carrier-frequency transmission on coaxial cables was adopted, equalizers (range 15–27 Mc/s) and amplifiers being fitted at intervals of 6–7 km. Equipment used on a 14-km link between Berlin-Tempelhof and the exhibition hall at Witzleben is described, the quality of the transmission being illustrated by oscillograms of square-wave signals with frequencies of 0·3 and 0·5 Mc/s. A diagram shows the overall amplitude and phase characteristics of the system.

621.397.5 : 519.24 **2904**

Statistics of Television Signals.—E. R. Kretzmer. (*Bell Syst. tech. J.*, July 1952, Vol. 31, No. 4, pp. 751–763.) "Measurements have been made of some basic statistical quantities characterizing picture signals. These include various amplitude distributions, autocorrelation, and correlation among successive frames. The methods of measurement are described, and the results are used to estimate the amount by which the channel capacity required for television transmission may be reduced through exploitation of the statistics measured."

621.397.5 : 519.272.1 **2905**

Experiments with Linear Prediction in Television.—C. W. Harrison. (*Bell Syst. tech. J.*, July 1952, Vol. 31, No. 4, pp. 764–783.) The correlation between the elements of a signal makes possible the prediction of the future of the signal in terms of the past and present. A method of prediction is described which does not make full use of the past, but is effective with certain signals and is relatively simple. In this method the prediction for the next signal sample is simply the sum of previous signal samples each multiplied by an appropriate weighting factor which depends on the statistics of the signal. The relatively simple apparatus required for experiments on linear prediction of television signals is described and results obtained with it are illustrated and discussed.

621.397.5 : 535.623/.624 **2906**

Progress in Colour Television.—R. L. Smith-Rose. (*Nature, Lond.*, 5th April 1952, Vol. 169, No. 4301, pp. 563–566.) A review of the development of the art, principally in the U.S.A.

621.397.5 : 535.623 **2907**

Image-Orthicon Color-Television Camera Optical System.—L. T. Sachtleben, D. J. Parker, G. L. Allee & E. Kornstein. (*RCA Rev.*, March 1952, Vol. 13, No. 1, pp. 27–33.) A relay lens system and cross-shaped dichroic image divider provide three separated images. The green light is focused directly and the red and blue beams are reflected on to their respective image orthicons. Astigmatism introduced by the divider is corrected by means of two mutually perpendicular plates between the field lens and the relay lens system. The aperture of the system may be remotely controlled by a motor-driven iris.

621.397.5 : 535.623 **2908**

The R.C.A. Color-Television Camera Chain.—J. D. Spradlin. (*RCA Rev.*, March 1952, Vol. 13, No. 1, pp. 11–26.) Description of features of the system developed for commercial operation, particularly the construction, operation and adjustments of the camera, the target-scanning circuit, the three channel amplifiers and the monochrome and colour monitoring arrangements.

621.397.5 : 535.623 : 621.317.2 **2909**

The N.B.C. New York Color-Television Field-Test Studio.—J. R. DeBaun, R. A. Monfort & A. A. Walsh. (*RCA Rev.*, March 1952, Vol. 13, No. 1, pp. 107–124.) Description of the studio arrangement, apparatus and operation for standard tests and adjustment of equipment.

621.397.5 : 621.317.35 **2910**

A Line Strobe Monitor for Investigating Television Waveforms.—Davies. (See 2846.)

621.397.5 : 621.396.73 **2911**

A Developmental Portable Television Pickup Station.—L. E. Flory, W. S. Pike, J. E. Dilley & J. M. Morgan. (*RCA Rev.*, March 1952, Vol. 13, No. 1, pp. 58–70.) Illustrated description of the unit which consists of a 50-lb pack and an 8-lb vidicon camera. Video and sound channels operate on a common u.h.f. carrier; the range is up to $\frac{1}{2}$ mile. See also *Electronics*, June 1952, Vol. 25, No. 6, pp. 98–101.

621.397.5(083.74) **2912**

International Television Standards.—(*Wireless World*, Aug. 1952 ,Vol. 58, No. 8, pp. 296–297.) Details of the 405-, 525-, 625- and 819-line systems approved by C.C.I.R. in 1951.

621.397.61 : 621.3.018.41.016.352 **2913**

Frequency Stability for Television Offset-Carrier Operation.—P. J. Herbst & E. M. Washburn. (*RCA*

Rev., March 1952, Vol. 13, No. 1, pp. 95–106.) For successful offset-carrier operation at u.h.f. (1798 and 2653 of 1950) the stability requirements of a local monitor are such that single checks against a standard-frequency transmission may be inadequate. A highly stable crystal oscillator is described which can safely be used in areas where a primary standard is not readily available. Details are given of the treatment and mounting of the crystal, and of the performance of the unit on protracted tests. It meets the monitor tolerance of a frequency deviation $< \pm 5$ parts in 10^7 in a 30-day period.

621.397.611.2 **2914**

Performance of the Vidicon, a Small Developmental Television Camera Tube.—B. H. Vine, R. B. Janes & F. S. Veith. (*RCA Rev.*, March 1952, Vol. 13, No. 1, pp. 3–10.) The vidicon developed is 1 in. in diameter and about 6¼ in. long. Gamma, sensitivity, spectral response, persistence and life of three types of photoconductive layer, viz., amorphous Se, Sb_2S_3 and a modification of Sb_2S_3, are discussed. Sensitivities in the three cases are respectively 100, 300 and 50 mA per lumen.

621.397.62 **2915**

The First British Multi-Channel Television Receiver.—W. D. Asbury, K. M. B. Wright & W. M. Lloyd. (*J. Televis. Soc.*, Jan./March 1952, Vol. 6, No. 9, pp. 343–351.) A full description of the design is given, with circuit details and response curves. The receiver is a superheterodyne with the oscillator frequency on the high side and intermediate frequencies of 19·5 Mc/s for sound and 16·0 Mc/s for the picture. A single r.f. stage is used, and the pentode oscillator-mixer is designed to eliminate interaction between signal and oscillator circuits. The user can tune quickly to any one of the five channels.

621.397.621 **2916**

Simple Line-Scan Circuit.—W. T. Cocking. (*Wireless World*, Aug. 1952, Vol. 58, No. 8, pp. 305–309.) The directly fed deflector-coil circuit (527 of February) can be adapted to provide h.v. by including an extra inductance which compensates the energy loss in the deflector coil during flyback. The operation and design of the circuit, including the waveform-correction element, are discussed. The complete circuit has proved noncritical in adjustment and satisfactory for operating a 53° tube at 10 kV.

621.397.621 **2917**

The Required Figure of Merit of Frame Deflector Coils.—E. T. Emms. (*Electronic Engng*, May 1952, Vol. 24, No. 291, pp. 238–239.) A method is indicated for estimating the required 'electrical goodness' for frame deflector coils to be used with a particular output pentode operated at given line voltage, to scan a c.r. tube operated at given high voltage. Worked examples make use of results obtained previously (2060 of July).

621.397.621 **2918**

Faulty Interlacing.—G. N. Patchett. (*Wireless World*, July & Aug. 1952, Vol. 58, Nos. 7 & 8, pp. 250–254 & 315–319.) Experiments are described using integrator- and differentiator-type frame-synchronizing-signal separator circuits in conjunction with blocking-oscillator and thyratron timebase circuits to investigate the influence of the shape of the synchronizing pulse on the accuracy of interlacing. For correct interlacing, the pulse from the separator must have a sharp leading edge, with a fixed time delay with respect to the first frame pulse, and must be identical in all respects for odd and even frames. A separator circuit satisfying these requirements is described, with illustrations of waveforms obtained; a 6F32 or 6F33 valve is used.

621.397.621.2 **2919**

Self-Focusing Picture Tube.—A. Y. Bentley, K. A. Hoagland & H. W. Grossbohlin. (*Electronics*, June 1952, Vol. 25, No. 6, pp. 107–109.) Description of an electrostatically focused electron gun designed for mass production. The focusing electrode is a cylinder at cathode potential and of larger diameter than the adjacent high-potential cylindrical cups. Supply-voltage variations have no significant effect on the focusing. The guns are manufactured as two separate units which are welded together after checking.

621.397.8 **2920**

The Evaluation of Picture Quality with Special Reference to Television Systems.—L. C. Jesty & N. R. Phelp. (*J. Brit. Instn Radio Engrs*, April 1952, Vol. 12, No. 4, pp. 211–253.) Reprint. See 275 of January and 1127 of April.

621.397.8 **2921**

A Method of Measuring Television Picture Detail.—G. G. Gouriet. (*Electronic Engng*, July 1952, Vol. 24, No. 293, pp. 308–311.) The 'picture detail' over a given length of scan is defined as "the modulus slope of the brightness variation integrated over that length." Experimental equipment for measuring this quantity is described, and its applications to service monitoring and for comparison of the performances of picture-producing equipment are discussed.

TRANSMISSION

621.396.61 **2922**

A Multichannel Single-Sideband Radio Transmitter.—L. M. Klenk, A. J. Munn & J. Nedelka. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 783–790.) Description of a transmitter designed for transoceanic communications and operating over the frequency band 4–23 Mc/s; four telephone channels are available. The main feature is the use of a servo system permitting push-button tuning to any one of ten preselected operating frequencies in about 15 sec.

621.396.61 : 621.396.645 **2923**

Amplifiers for Multichannel Single-Sideband Radio Transmitters.—N. Lund, C. F. P. Rose & L. G. Young. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 790–796.) Design requirements for h.f. amplifiers with low interchannel modulation and adjacent-band radiation are discussed. The speech rating of the amplifier is most significant, but the tone rating is the basis of valve selection; a method for determining the relation between the two ratings is presented. Unbalanced circuits are preferred for low- and medium-power amplifiers, while balanced circuits may have advantages for some high-power amplifiers. See also 2922 above.

621.396.61 : 621.396.97 **2924**

Remote Control of High-Power Transmitters.—(*J. Brit. Instn Radio Engrs*, April 1952, Vol. 12, No. 4, p. 268.) The new 150-kW transmitter at Daventry for the B.B.C. third programme has been working unattended since 13th January 1952. The transmitter comprises two identical units, whose outputs are combined in a circuit that ensures no transfer of power between the two sections. The switching on of the various power supplies in the correct sequence and at the correct time intervals is effected automatically by a system of interlocked relays. Automatic monitors [1491 of 1951 (Rantzen et al.)] continuously monitor the outputs from the two sections and shut down either half which develops a fault, special arrangements preventing complete stoppage of transmissions as a result of a comparatively minor fault.

621.396.619.24 **2925**

Single-Sideband Transmission by Envelope Elimination and Restoration.—L. R. Kahn. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 803–806.) The system described eliminates the need for costly linear r.f. amplifiers in the transmitter. The ph.m. component of the s.s.b. signal is amplified by means of class-C amplifiers, while the a.f. envelope is separately detected and amplified and recombined with the r.f. signal at the final stage. Experiments indicate that the performance of the system is equal to or better than that of the conventional transmitter with linear r.f. amplifier.

621.396.619.24 **2926**

Design of Modulation Equipment for Modern Single-Sideband Transmitters.—A. E. Kerwien. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 797–803.) The transmitters considered are of the type using filters to suppress the unwanted sidebands. Factors discussed include balance requirements, frequency stability, choice of i.f., and methods of avoiding transmission of spurious signals. See also 2922 above.

VALVES AND THERMIONICS

621.314.65 **2927**

A High-Voltage, Cold-Cathode Rectifier.—E. G. Linder, J. H. Coleman & E. G. Apgar. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 818–828.) Description and theory are given of a mercury-vapour glow-discharge rectifier operating with an external magnetic field; the electron paths are similar to those in a cylindrical magnetron, but are modified by the use of end plates on the cathode. This rectifier has withstood peak inverse voltages up to 40 kV, and has been run at a peak inverse voltage of 30 kV for 3 000 hours. Operation at temperatures between 20° and 80°C has been satisfactory. The upper frequency limit lies between 120 and 240 kc/s. See also *Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 64–72.

621.314.7 : 621.396.822 **2928**

Barrier-Layer Interaction and Statistical Fluctuations in the Three-Electrode Crystal.—H. F. Mataré. (*Z. Phys.*, Dec. 1951, Vol. 131, No. 1, pp. 82–97.) Noise in semiconductors is discussed. A particular problem arising in transistor operation is the increase of noise resulting from the control mechanism. This is effective over the whole frequency spectrum, but is conveniently measured at h.f. The interaction of the streams of charge carriers originating at the emitter and collector barrier layers leads to a large increase of the statistical fluctuations in the effective resistances. A theoretical treatment similar to Richardson's (1391 of 1950) is used. Interaction phenomena of a similar nature are probably present in interstellar noise sources.

621.383.5 : 546.28 **2929**

Photoelectric Properties of Ionically Bombarded Silicon.—E. F. Kingsbury & R. S. Ohl. (*Bell Syst. tech. J.*, July 1952, Vol. 31, No. 4, pp. 802–815.) The first Si photocells were cut from bulk Si containing a natural potential barrier between *n*-type and *p*-type material. Later cells were produced by subjecting the polished face of wafers about 0·025 in. thick to bombardment by positive ions of He of energy from 100 eV to 30 keV, the Si being kept at about 395°C. Typical spectral-response curves are illustrated and the photon efficiency as a function of wavelength is shown for a particular cell.

621.384.5 : 621.316.722 : 621.396.822 **2930**

Peak-Noise Characteristics of Glow-Discharge Voltage-Regulator Tubes.—H. Bache & F. A. Benson. (*Electronic Engng*, June 1952, Vol. 24, No. 292, pp. 278–279.) Measurements have been made on tubes of 15 different types to obtain information about the dependence of noise on design and operational factors. Results are tabulated and shown in graphs. In all cases noise increases as tube current decreases. Tube specifications should state approximate limits for both peak and mean values of noise voltage throughout the current range.

621.384.5 : 621.316.722 : 621.396.822 **2931**

Mean-Noise Characteristics of Glow-Discharge Voltage-Regulator Tubes.—H. Bache & F. A. Benson. (*Electronic Engng*, July 1952, Vol. 24, No. 293, pp. 328–329.) Results of measurements on six different types of voltage-regulator tube are shown graphically. The curves have the same general shape as in the case of peak-noise measurements (2930 above), the noise increasing with decreasing tube current, the increase becoming very rapid as the region of minimum current is approached. The relation between peak noise and mean noise is discussed briefly.

621.384.5 : 621.385.5 : 621.318.572 **2932**

The Development of a Multi-Cathode Decade Gas-Tube Counter.—G. H. Hough. (*Proc. Instn elect. Engrs*, Part IV, July 1952, Vol. 99, No. 3, pp. 177–186.) Full paper. See 2657 of September.

621.384.5 : 621.385.5 : 621.318.572 **2933**

Some Recently Developed Cold-Cathode Glow-Discharge Tubes and Associated Circuits.—G. H. Hough & D. S. Ridler. (*Electronic Engng*, April–June 1952, Vol. 24, Nos. 290–292, pp. 152–157, 230–235 & 272–277.) Construction and applications are described of the G1/370 K high-speed trigger tube and the multielectrode G10/240 E counting tube. See also 784 of 1951 and 2932 above.

621.385.029.6 **2934**

Effect of Thermal-Velocity Spread on the Noise Figure in Traveling-Wave Tubes.—P. Parzen. (*J. appl. Phys.*, April 1952, Vol. 23, No. 4, pp. 394–406.) A method of Hahn (3521 of 1939 and 537 of 1940) is extended by working out a new theory for the diode drift valve and travelling-wave valve to include the effect of the thermal-velocity spread at v.h.f. Some computations of gain and noise figure for a travelling-wave valve amplifier are given for conditions met in practice.

621.385.029.6 : 621.396.65 **2935**

Two Travelling-Wave Valves for Radio Beam Links.—(*Ann. Télécommun.*, April 1952, Vol. 7, No. 4, pp. 150–204.) A symposium of seven papers, abstracts of which are given in 2936–2940 below, 2862 and 2894 above. 40 references.

621.385.029.6 : 621.396.65 **2936**

Two Travelling-Wave Valves for Radio Beam Links: General Results and Technology.—M. Kuhner & P. Lapostolle. (*Ann. Télécommun.*, April 1952, Vol. 7, No. 4, pp. 155–168.) A detailed account is given of the investigations resulting in the production of Type-M8 and Type-M11 valves, starting from the experimental valves previously described [2060 of 1950 (Blanc-Lapierre & Kuhner)]. The two valves are of similar construction, but the envelope of the Type-M8 is provided with an extra seal assuring a direct contact between the output cone and the external circuit. The values of the gain and the pass band of both valves are particularly high, 35–40 db and 800–1 000 Mc/s for the M8 (8 cm wavelength) and 30 db and 150–200 Mc/s for the M11 (11 cm wavelength), the noise factors being 20 db and 17 db respectively. Simple mounting and matching arrangements facilitate valve changing.

621.385.029.6 : 621.396.65 **2937**

Two Travelling-Wave Valves for Radio Beam Links: Measurements and Characteristics.—P. Clostre & R. Wallauschek. (*Ann. Télécommun.*, April 1952, Vol. 7, No. 4, pp. 169–172.) Results of measurements of gain, output power and bandwidth of Type-M8 and Type-M11 valves are presented graphically. Measurements of the phase difference between input and output are described and curves are given for a Type-M11 valve showing gain and phase shift as functions of (*a*) helix voltage (target current constant), (*b*) target current (helix voltage constant.) Normal operating voltages and currents are tabulated.

621.385.029.6 : 621.396.65 **2938**

Electron Guns for Travelling-Wave Valves [Types M8 and M11].—J. E. Picquendar. (*Ann. Télécommun.*, April 1952, Vol. 7, No. 4, pp. 173–180.) Electron guns giving a cylindrical beam were first studied. In order to improve their efficiency, an investigation was made of the effect of the axial magnetic field applied; a simple method was developed for tracing the electron trajectories under the influence of a variable electric field and of a constant axial magnetic field. Magnetic screening was found necessary to reduce the deleterious effect of the magnetic field. With parallel-beam guns, the very high current density required at the cathode resulted in short valve life. To remedy this, electron guns giving convergent beams were adopted and means provided for preventing ion bombardment of the cathode. A method was devised for tracing approximately the electron trajectories for convergent-beam guns, taking account of space-charge effects. Tests of the M86 electron gun in a series of valves gave efficiencies of the order of 98%. The efficiency of a later type, M88, was satisfactory for a wide range of currents (1–9 mA).

621.385.029.6 : 621.396.65 : 621.392.43 **2939**

Impedance Matching of Travelling-Wave Valves [Types M8 and M11] **to Coaxial Lines.**—P. Clostre & R. Wallauschek. (*Ann. Télécommun.*, April 1952, Vol. 7, No. 4, pp. 181–190.) An account is given of investigations of coupling arrangements, with a detailed description of the capacitive type of matching unit finally adopted, which, in the case of the M8 valve, has a bandwidth of the order of 1–1·25 kMc/s for a s.w.r. $< 1\cdot5$. Coupling of the core of the 70-Ω coaxial cables to the cylindro-conical fittings soldered to the two ends of the helix is effected for the M11 valve by rings surrounding the glass envelope. For the M8 valve a series-parallel type of capacitive coupling is used. For a distance of a few centimetres from the ends, the pitch of the helix is progressively decreased to the value selected for the central section. Sectional diagrams of the coupling units are given and also input-impedance diagrams for both types of valve.

621.385.029.6 : 621.396.65 : 621.392.43 **2940**

Impedance Matching of a Travelling-Wave Valve [Type M8] **to a Waveguide.**—P. Chavance & L. Moutte. (*Ann. Télécommun.*, April 1952, Vol. 7, No. 4, pp. 191–195.) Use is made of the properties of ridge waveguides in a matching unit with bandwidth $>$ 600 Mc/s for a s.w.r. $< 1\cdot7$. A second arrangement permits accurate matching of a series of valves over two bands, each 20 Mc/s wide, centred on 3 640 and 3 920 Mc/s, the s.w.r. being $< 1\cdot1$, a variable matching unit in conjunction with specially designed fittings for locating the valve in the fixed matching unit enabling the required s.w.r. to be quickly achieved when one valve is replaced by another.

621.385.032.24 : 621.94 **2941**

Grid-Winding Lathe.—(*Electronics*, June 1952, Vol. 25, No. 6, pp. 238 . . 242.) Description of the process developed by Standard Telephones & Cables by which 1 000 valve grids are wound per hour on the new Brimar notch-and-swage lathe.

621.385.13 : 621.396.822 **2942**

Low-Frequency Noise Spectra of Hot-Filament Low-Pressure Discharge Tubes.—H. Martin & H. A. Woods. (*Proc. phys. Soc.*, 1st April 1952, Vol. 65, No. 388B, pp. 281–286.) Measurements on hot-cathode discharges in Hg vapour confirm that, as previously reported by Cobine & Gallagher (2400 of 1947), the noise spectrum is continuous, with superposed peaks. The upper limit of the spectrum is in some cases above 10 Mc/s. The peaks can be partly attributed to harmonic components of ionic relaxation oscillations. Most of the noise from the tubes investigated originated near the cathode.

621.385.2 : 546.289 **2943**

Temperature-Independent Crystal Diodes.—R. Rost. (*Fernmeldetech. Z.*, April 1952, Vol. 5, No. 4, pp. 177–178.) Tests carried out on Ge-W diodes, mass produced by a process involving temperatures of about 200°C, show that during cooling to room temperature the rectification factor in most cases becomes constant below about 80°C, this property depending on the use of a particular method of construction which results in diodes with rectification-factor variations $< 1\%$ over the range $-$ 20° to $+$ 70°C.

621.385.832 **2944**

Elementary Theory of the Generation of Electron Beams by means of Triode Systems: Part 2 — Intensity and Structure of the Electron Beam.—M. Ploke. (*Z. angew. Phys.*, Jan. 1952, Vol. 4, No. 1, pp. 1–12.) Langmuir's space-charge formula is used to develop formulae for the beam intensity and the current density at different cross-sections. Closed expressions are found relating aperture angle and crossover area with the dimensions and operating voltages of the system. Part 1: 2087 of July.

621.385.832 **2945**

Improved Cathode-Ray Tube for Application in Williams Memory System.—W. E. Mutter. (*Elect. Engng, N.Y.*, April 1952, Vol. 71, No. 4, pp. 352–356.) Description of the IBM-79, a 3-in. c.r. tube of storage type. See also 2258 of 1949 (Williams & Kilburn).

621.396.615.14 **2946**

Generation of Oscillations at Centimetre Wavelengths.—H. Severin. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Dec. 1951, Vol. 29, No. 12, pp. 466–476. In German.) Review of the physical principles and the performance of disk-seal, retarding-field, magnetron, klystron and travelling-wave valves.

621.396.615.141 **2947**

Space-Charge Reactance Tube.—L. E. Williams. (*Electronics*, June 1952, Vol. 25, No. 6, pp. 166 . . 182.) A method of measuring the variation of grid-cathode and grid-anode capacitance as a function of operating voltage is outlined. Applications based on the linear nature of this variation are described. These include frequency modulation of a Hartley oscillator by varying the grid bias of a reactance valve, and electronic tuning of h.f. filters.

621.396.615.141.1 **2948**

A Wide-Range Oscillator in the Range from 8 000 to 15 000 Mc/s.—R. W. Wilmarth & J. L. Moll. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 813–817.) In retarding-field valves of the general type described by

Heil & Ebers (2677 of 1950), losses may be experienced in extracting the energy. Modifications are here described in which the energy is extracted by causing the repeller, which is part of the resonant circuit, to radiate into a waveguide. Either inductive or capacitive tuning may be used; in the latter case the efficiency of the oscillator is 2–4% over the frequency range, with maximum efficiency occurring near the highest frequency. Inductive tuning appears to have certain intrinsic advantages which can be realized after certain mechanical and electrical difficulties have been overcome.

621.396.615.141.1 **2949**

Experimental Investigation of the Theory of Retarding-Field Oscillations.—H. G. Unger. (*Frequenz*, April 1952, Vol. 6, No. 4, pp. 89–98.) Measurements of the dynamic admittance of the grid-anode path of a cylindrical retarding-field valve were made by a resonance method, using external excitation at a frequency of about 500 Mc/s, damping being applied to prevent self excitation. The results are presented graphically and compared with the theory of Gundlach & Kleinsteuber (2389 of 1941 and 1866 of 1943). Discrepancies between the results and the theory for planar electrode systems are discussed.

621.396.615.141.2 **2950**

An Experimental Study of Low-Power C.W. Magnetrons having Few Segments.—E. B. Callick. (*Proc. Inst. Radio Engrs*, July 1952, Vol. 40, No. 7, pp. 836–843.) Measurements on two- and four-segment magnetrons are reported. The characteristics differ very little from those of multi-segment valves having the same ratio between cathode and anode diameters, except that the efficiency is lower and varies as a function of that ratio. High efficiency can be obtained if the cathode diameter is relatively small. Possible explanations are discussed.

621.396.615.141.2 **2951**

Note on the History of the Development of the Magnetron in Germany up to 1945.—K. Fritz. (*Arch. elekt. Übertragung*, May 1952, Vol. 6, No. 5, pp. 209–210.)

621.396.615.141.2 : 621.385.029.6 **2952**

Potentials and Electron Paths in Multisegment Magnetrons.—K. Fritz. (*Arch. elekt. Übertragung*, May 1952, Vol. 6, No. 5, pp. 211–215.) Theory is developed for the multisegment magnetron considered as a travelling-wave valve. A formula is derived for the threshold voltage, i.e. the lowest direct voltage for which electrons can reach a point in the interaction space in the absence of alternating voltage. Good agreement is obtained with the value found experimentally for the lowest anode voltage at which electrons reach the anode of a type-725A magnetron. The anode alternating voltage is expressed as a function of direct anode voltage and travelling-wave potential. The electrical and mechanical components of energy are evaluated, and a first-order second-degree differential equation is derived for the mean electron path; this can be solved in terms of a sine function.

621.396.615.142 **2953**

Velocity-Modulation Valves for 100 to 1 000 Watts Continuous Output.—B. B. van Iperen. (*Philips tech. Rev.*, Feb. 1952, Vol. 13, No. 8, pp. 209–222.) In designing v.m. valves for the generation of cm waves, account must be taken of effects which may be disregarded in the elementary theory, such as the mutual repulsion of the beam electrons, damping due to finite transit time through the gaps, and deflection of electrons by the h.f. field at the input gap. Details are given of four experimental valves incorporating guns, cavities and gaps designed to reduce these effects.

621.396.615.142 : 621.396.622.7.029.64 **2954**

Velocity-Modulated Detector.—Robinson. (See 2884.)

621.385.032.216 **2955**

The Oxide-Coated Cathode. Vol. 1: Manufacture. [Book Review]—G. Herrmann & S. Wagener. Publishers: Chapman & Hall, London, 1951, 148 pp., 21s. (*Proc. phys. Soc.*, 1st Feb. 1952, Vol. 65, No. 386B, p. 165.) "The book is well produced and illustrated and the information is authoritative and up-to-date."

621.385.032.216 **2956**

The Oxide-Coated Cathode. Vol. 2: Physics. [Book Review]—G. Herrmann & S. Wagener. Publishers: Chapman & Hall, London, 1951, 302 pp., 42s. (*Proc. phys. Soc.*, 1st Feb. 1952, Vol. 65, No. 386B, pp. 165–166.) "The publication of an extensive and lucid review which brings the subject back into the sphere of more general discussions . . . will be generally appreciated. The present volume is based on work first published in Germany in 1944. It has since been brought up to date. . . and the literature has been covered up to the beginning of 1950." See also 2603 of 1951. Vol. 1: 2955 above.

MISCELLANEOUS

001.891 : 538.569.4.029.64 **2957**

University Research in Physics: Part 3 — Research in Physics at Oxford University.—J. A. Teegan. (*Beama J.*, March 1952, Vol. 59, No. 177, pp. 81–87.) A short account of work on s.w. absorption spectroscopy.

025.45 : 621.3 **2958**

Work of the Electrical Engineering Commission for Universal Decimal Classification at the Rome Meeting.—C. Frachebourg. (*Tech. Mitt. schweiz. Telegr.-Teleph-Verw.*, 1st Dec. 1951, Vol. 29, No. 12, pp. 476–478.) A brief account of discussions on proposed modifications to various portions of the 621.3 classification, with emphasis on the proposals for a new main section 621.37 dealing with the technique of electric waves, oscillations and pulses.

621.38 : 001.891 : 359.4(41) **2959**

Electronics in Naval Research.—(*Electronic Engng*, July 1952, Vol. 24, No. 293, pp. 322–323.) A short account of the organization of the Royal Naval Scientific Service, with particular mention of the activities of the Admiralty Signal and Radar Establishment, H.M. Underwater Detection Establishment, and the Services Electronics Research Laboratory.

621.39.001.11 : 025.3/.4 **2960**

Information Theory and its Application to Taxonomy.—D. K. C. MacDonald. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 529–531.) A possible source of confusion between the concept of information content and entropy in the theory of information is discussed and resolved. Information theory is then applied to taxonomy (classification of data) and several models are considered, representing various possible methods of filing, with the object of determining the optimum size of filing unit in relation to the available data.

621.396 : 061.3 **2961**

I.R.E. - U.R.S.I. Spring Meeting, Washington, D.C. April 21-24, 1952.—(*Proc. Inst. Radio Engrs*, June 1952, Vol. 40, No. 6, pp. 738–748.) Summaries are given of 71 technical papers presented at the meeting.

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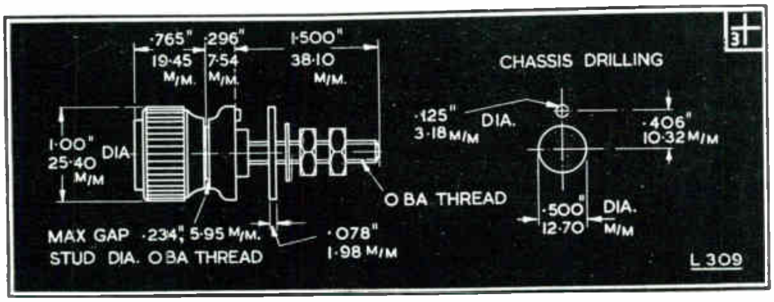

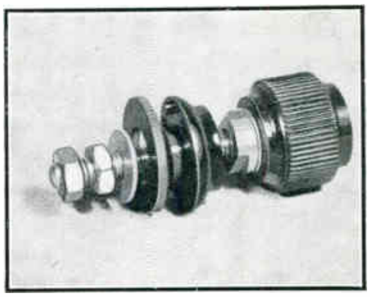

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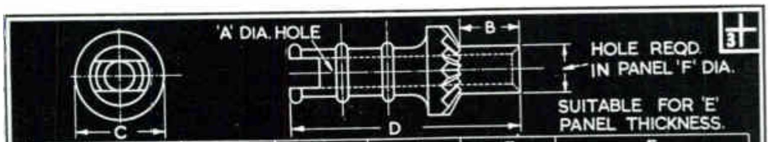

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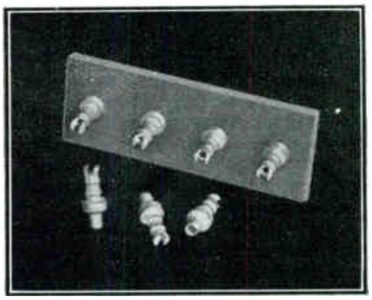

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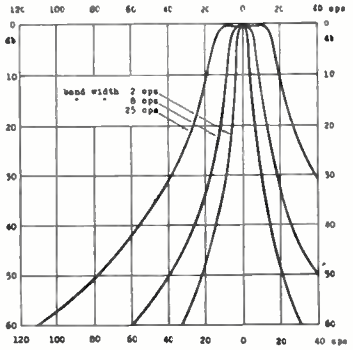

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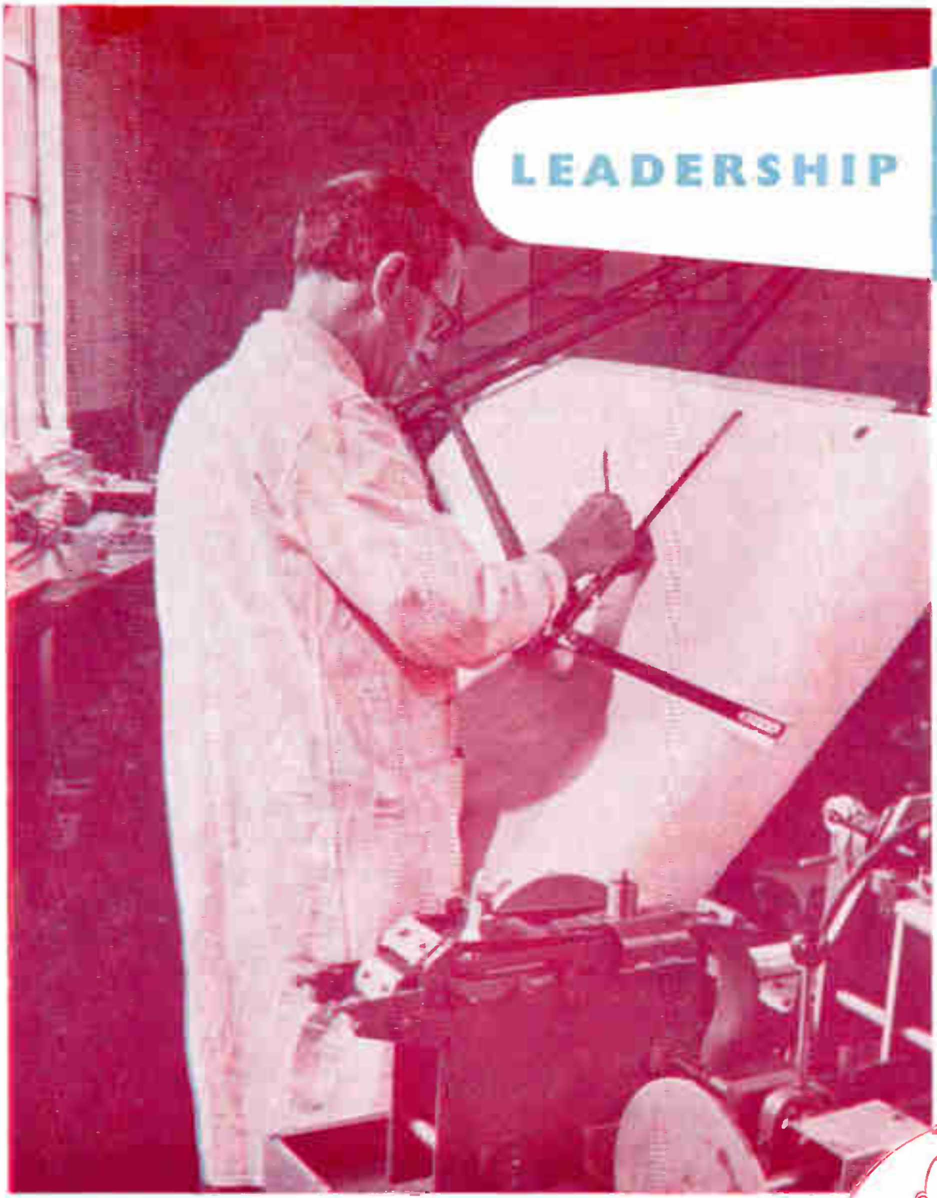

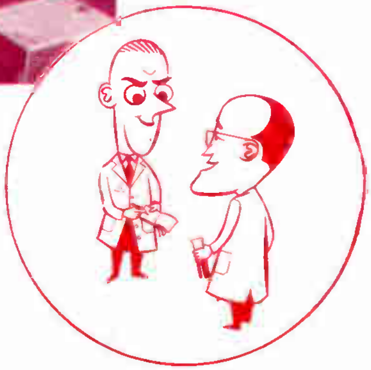

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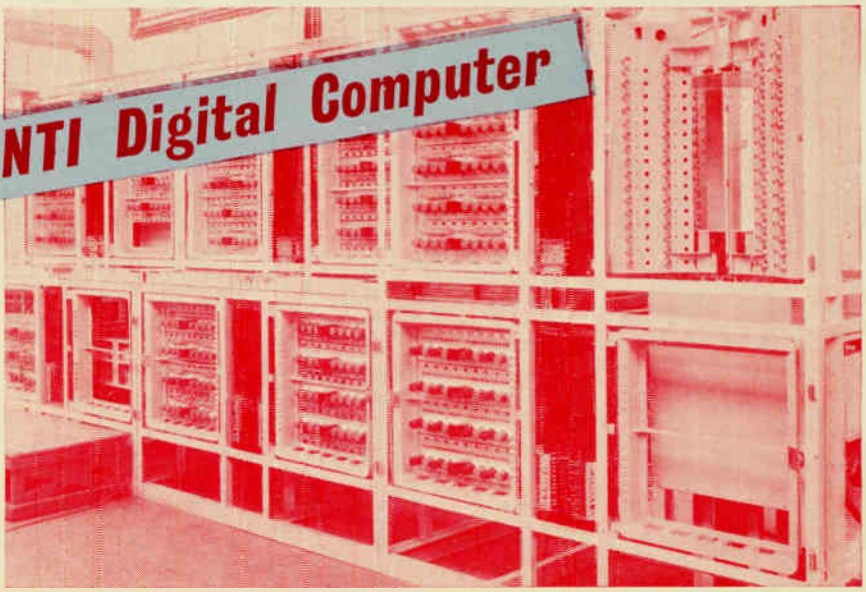


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