ELECTRONIC & RADIO ENGINEER

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In this issue

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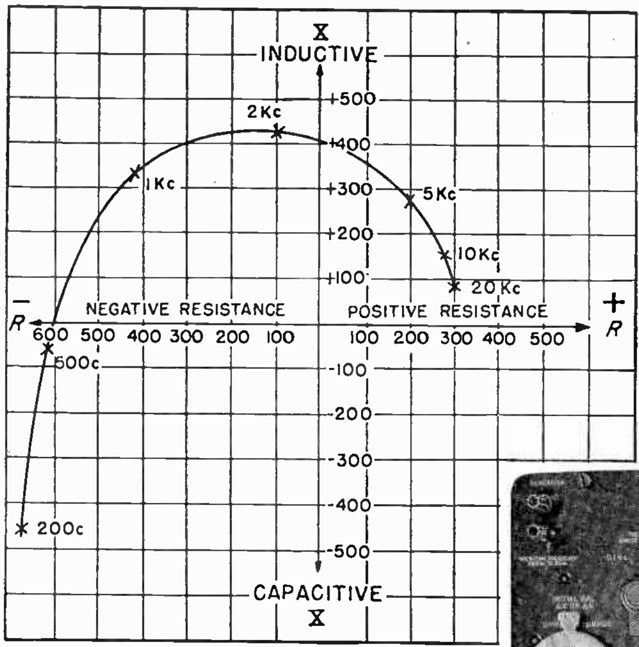
MAY 1958 Vol 35 *new series* No 5



Impedance of Feedback Circuit ... illustrates ability of the Z-Y Bridge to measure any impedance; quadrature components may be positive or negative, real or imaginary.

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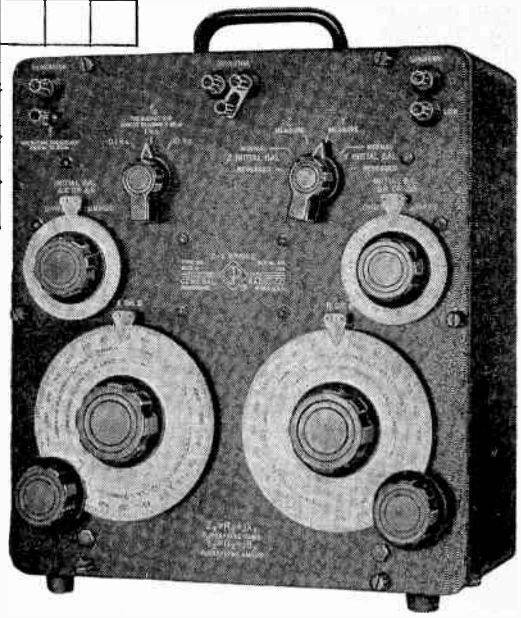
Type 1603-A Z-Y Bridge



Measures Any Impedance...

- From O to ∞ ohms
- Positive or Negative
- At Any Phase Angle
- Over 20-cps to 20-kc Range

The General Radio Z-Y Bridge measures impedances from short circuit to open circuit, at small or large phase angle. Quadrature components, R & X or G & B, are measured directly at calibrated 100 c, 1-kc, and 10-kc bridge positions. Basic accuracy is 1% over most of this range.

The ability to measure impedances of any magnitude accurately with one instrument is an extremely valuable asset in many measurement situations. The Z-Y Bridge can be used for measuring conductivity of liquids, in dielectric cells as readily as it can be used for R-L-C component measurements in the laboratory or production-test department. It will measure open-circuit and short-circuit transformer parameters . . . impedances of batteries and electrolytic capacitors . . . characteristics of audio-transmission networks . . . impedance of electro-acoustic transducers . . . Q and resonant frequency of chokes . . . and impedances of feedback loops, since negative real parameters can be directly measured.

The Bridge also can be used to determine cable-fault locations and circular-arc plots of liquids or solids having lossy polarizations in the audio-frequency range. These are but a few of the countless applications for this unique and versatile device. *You name it — this Z-Y bridge can probably measure it.*

For complete information request a copy of the current "G.R." Catalogue "O" (258 pages), where data is given on pages 34/35.

Impedance and Admittance Range
R: ±1000 ohms G: ±1000 μmhos
X: ±1000 ohms B: ±1000 μmhos

Accuracy
R or G: ±(1% + (2 ohm or 2 μmho))
X or B: $\pm(1\% + (2\frac{f_o}{f}$ ohm or $2\frac{f}{f_o}$ μmho))

f is operating frequency, f_o is frequency setting of panel selector switch

Impedances of less than 100Ω or (100 μmhos) can be measured on "Initial Balance" dials with considerably greater accuracy—
R or G: ±(1% + (0.2 ohm or 0.2 μmho))
X or B: $\pm(1\% + (0.2\frac{f_o}{f}$ ohm or $0.2\frac{f}{f_o}$ μmho))

Frequency Range—20 cycles to 20 kc

Maximum Applied Voltage
130 volts, rms on bridge;
less than 32v on unknown

Accessories Recommended
"G.R." Type 1210-B Unit R-C Oscillator and
"G.R." Type 1212-A Unit Null Detector

Accessories Supplied
2 Shielded Cables for generator and detector

Dimensions—$12\frac{1}{2}$" x $13\frac{1}{2}$" x $8\frac{1}{2}$"

Net Weight—$21\frac{1}{2}$ lbs.

Type 1603-A Z-Y Bridge £222

Claude Lyons Ltd.

76 Oldhall Street Liverpool 3, Lancs.
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Telephone: HODdesdon 3007-8-9

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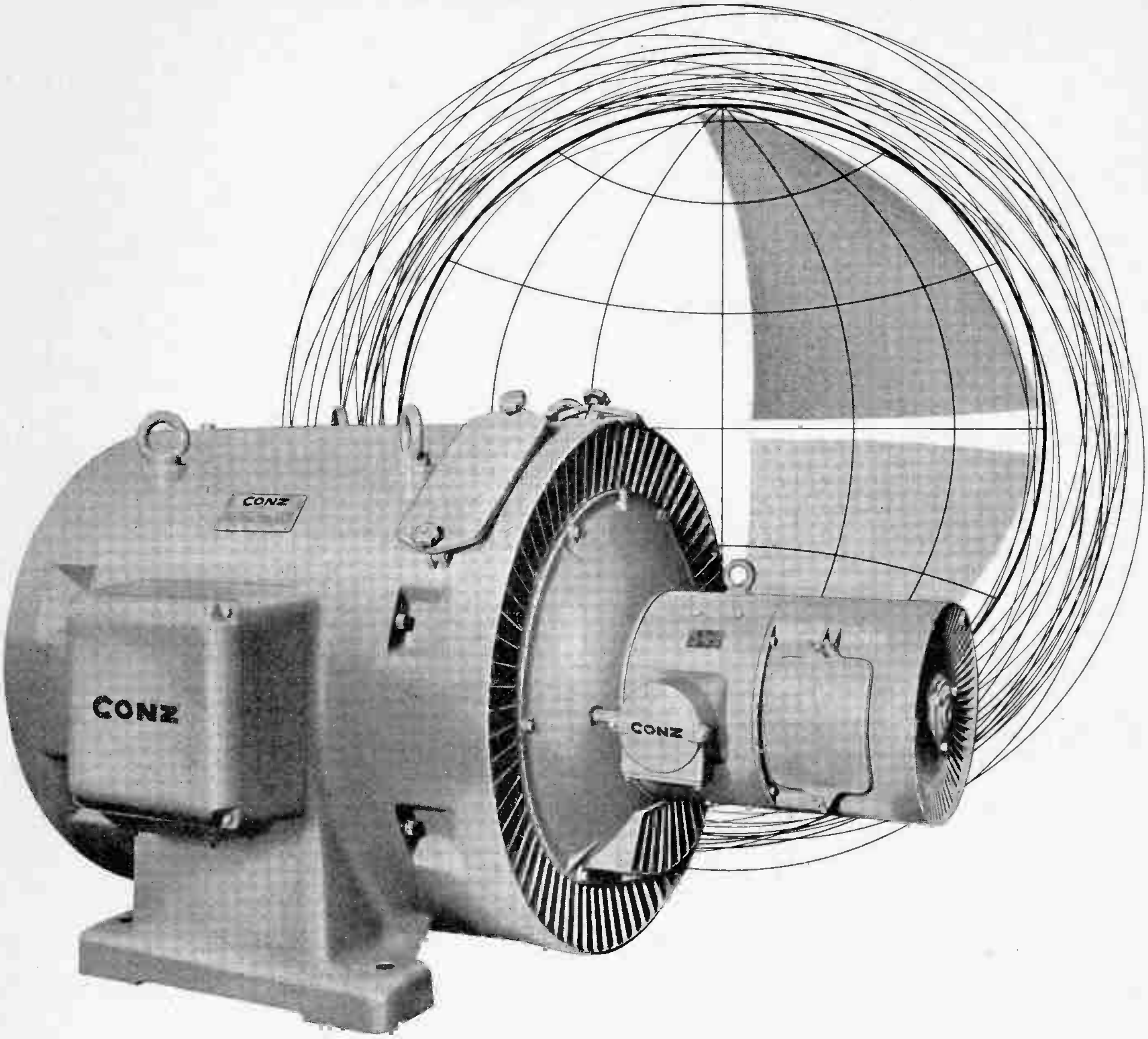
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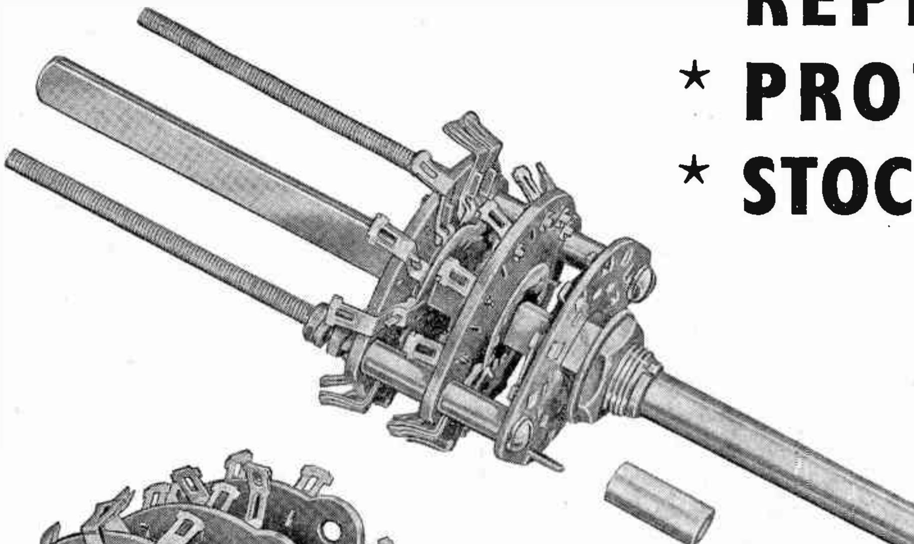

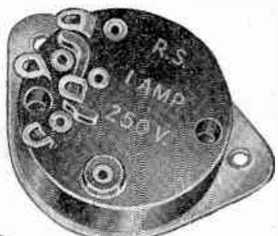

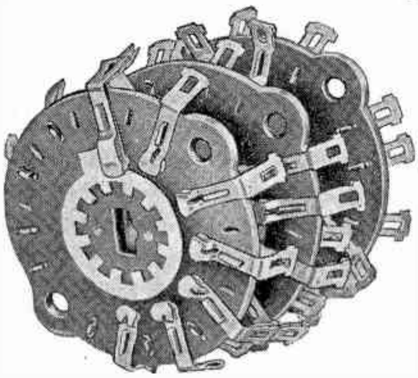

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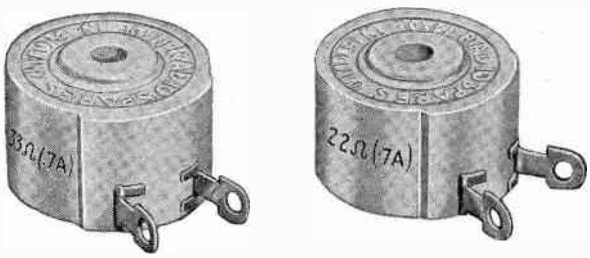

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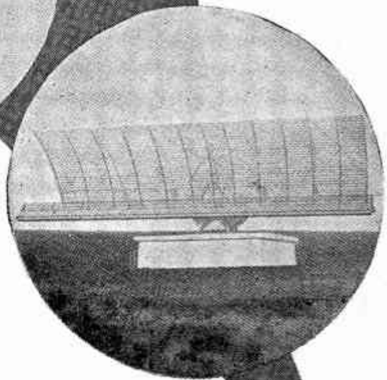

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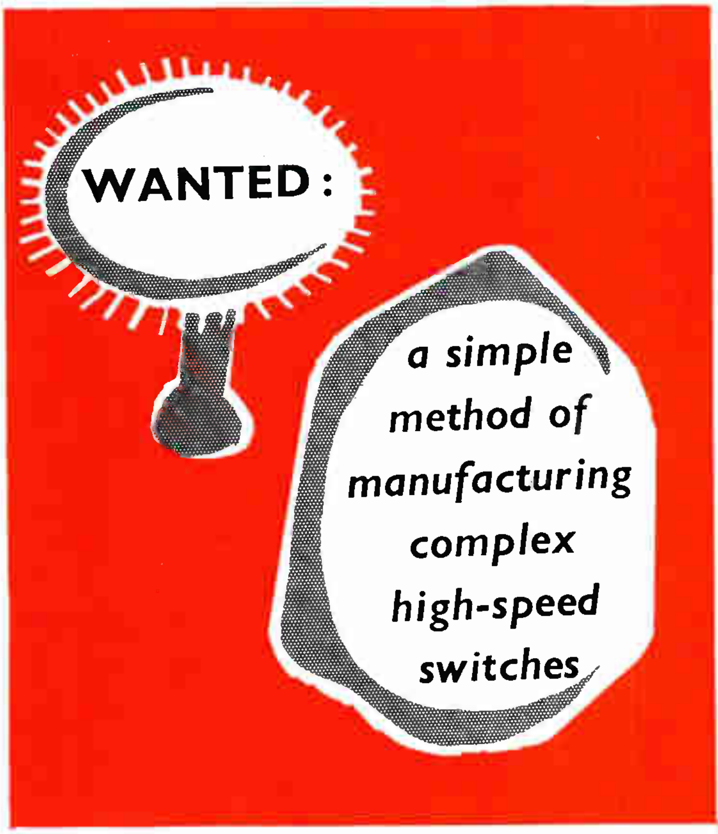

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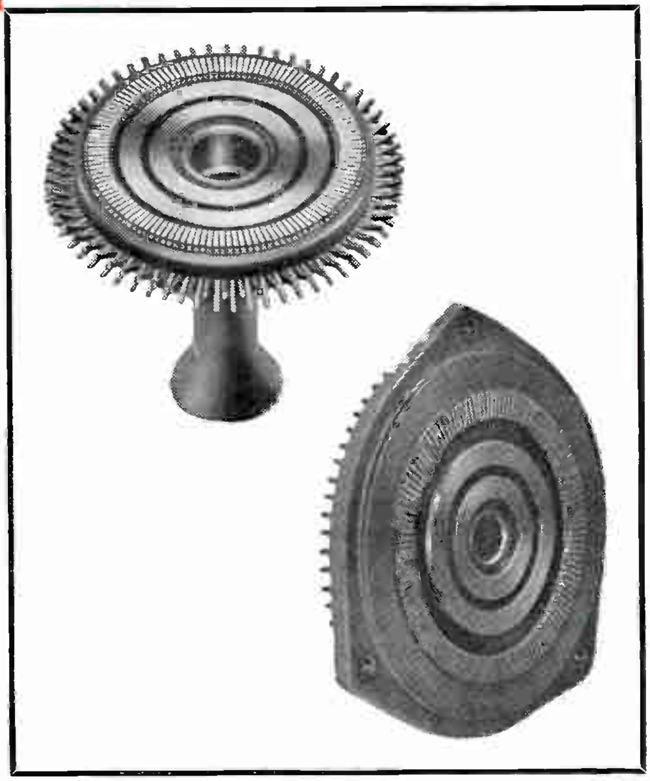

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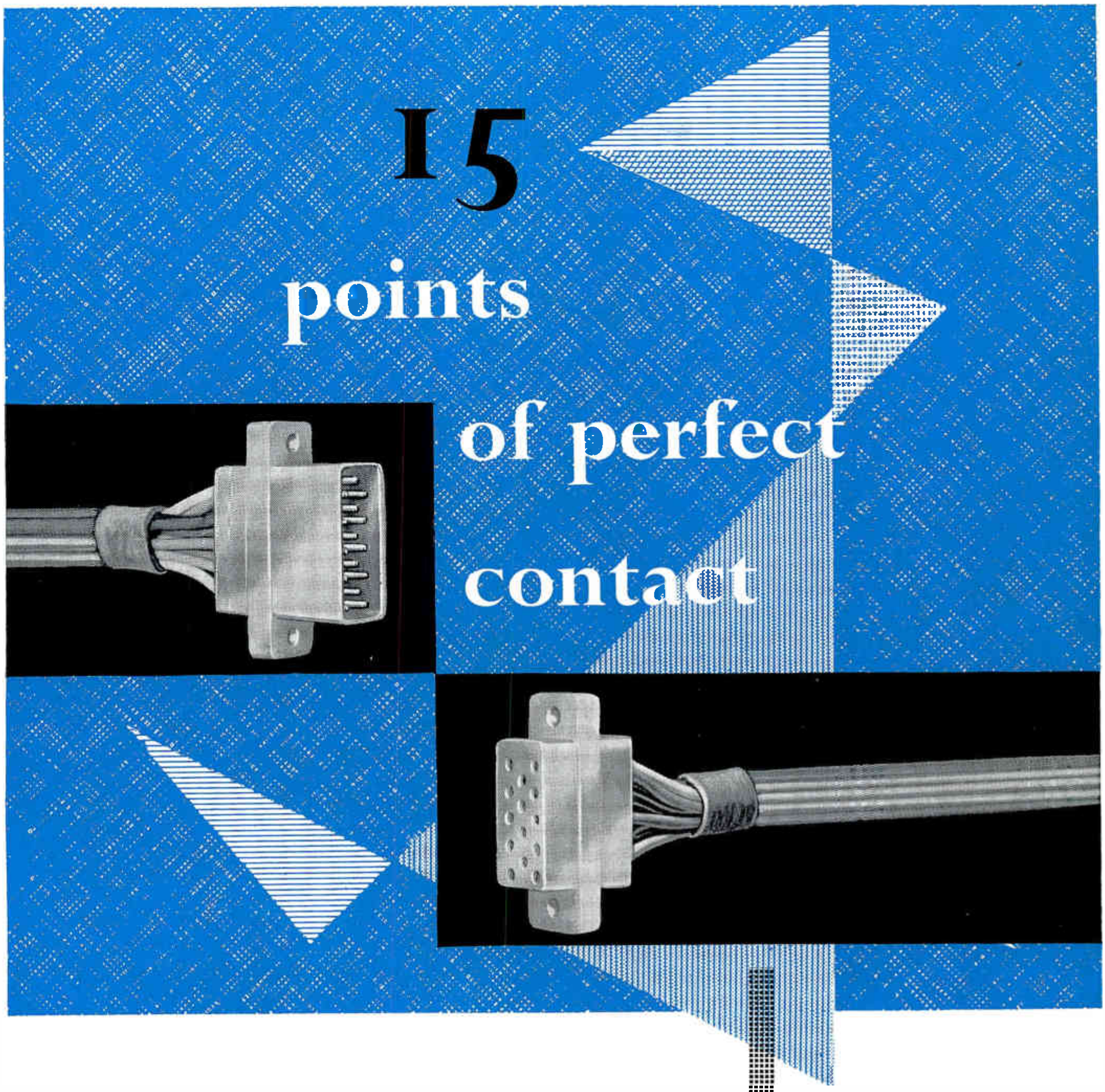
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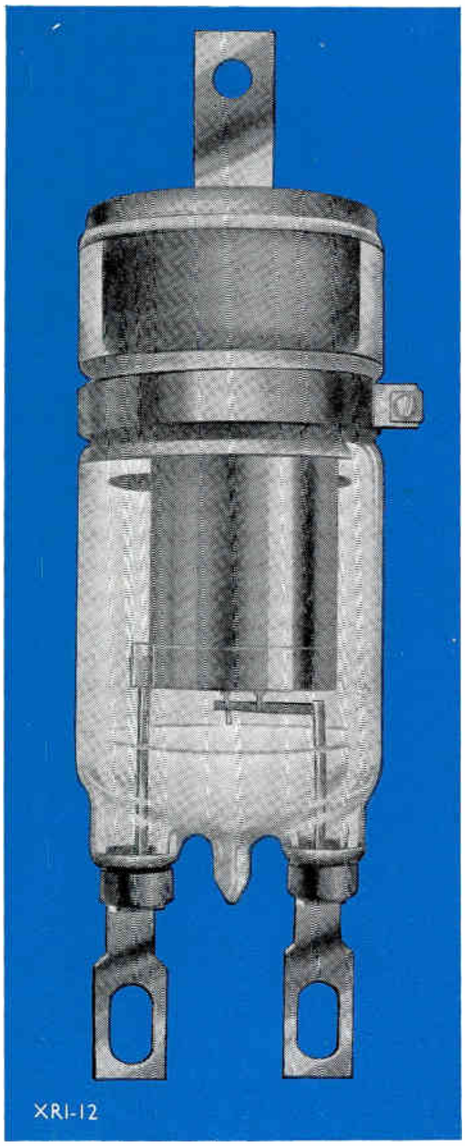

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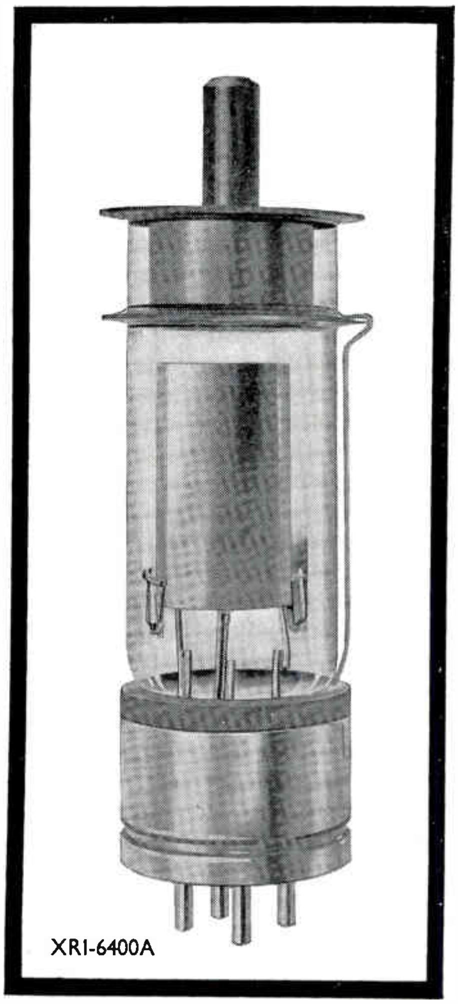

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Their heating-up time is only one minute and they will operate efficiently over a wide range of ambient temperatures.

Both types can be employed with confidence in a variety of power control applications including direct welding control, lighting control, motor control, electronic switches and regulated power supplies. Write to the address below for full data.

Type No.	American Type No.	Vf (V)	If (A)	va(pk) max. (kV)	P.I.V. max. (kV)	ik (pk) max. (A)	ik (av.) max. (A)	Heating-up time (secs)
XR1–6400A	6807	2.5	21	1.5	1.5	80	6.4	60
XR1–12	5855	2.5	34	1.5	1.5	150	12.5	60

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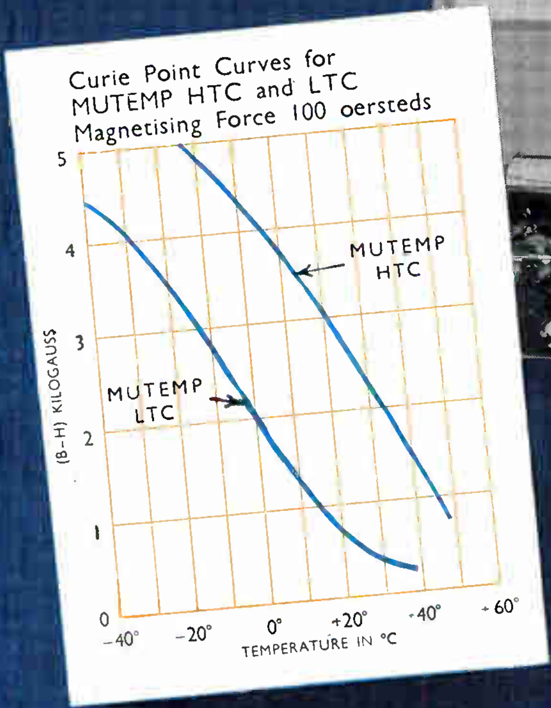
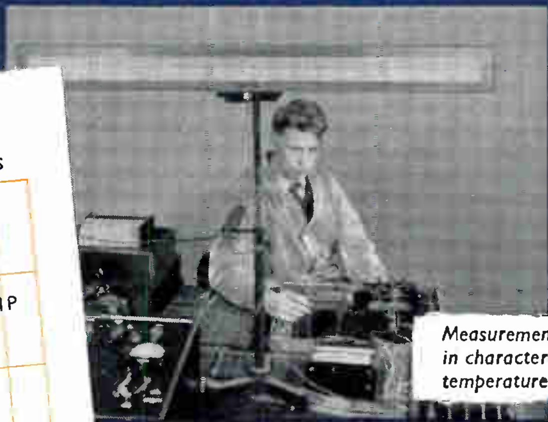
Mullard

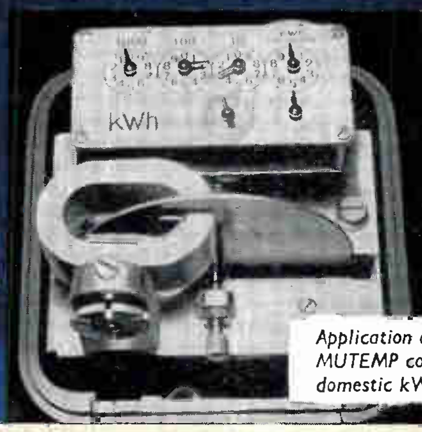
COMMUNICATIONS AND INDUSTRIAL VALVE DEPARTMENT

MVT 333





Measurement of the change in characteristics with temperature.



Application of a MUTEMP compensator to a domestic kWh meter.

MUTEMP: a temperature-compensating alloy

This alloy, for use in electric instruments subject to wide variations in temperature, is now available in two distinct grades. The two grades ensure satisfactory coverage for a wide range of temperature change. It will be seen from the curves that MUTEMP LTC has characteristics suitable for the low temperature and HTC for the higher temperature ranges. MUTEMP is supplied in hot-rolled sheets up to 18 ins. wide and in thicknesses ranging from ·125 ins. to ·020 ins.

Full details may be obtained from our current catalogue, where its temperature characteristics are set out at three standard magnetizing forces, 2, 18 and 100 oersteds.

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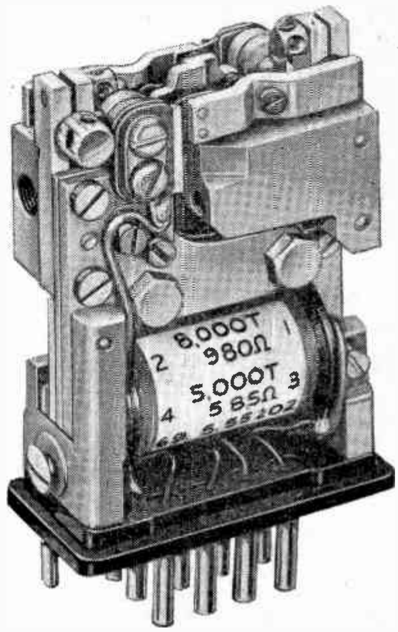

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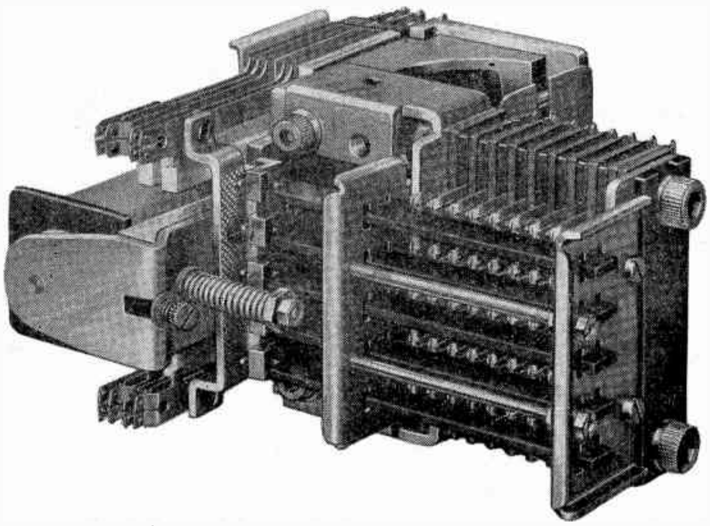
It operates quickly on extremely short, weak or ill-defined impulses of varying polarity — has a close operate/release differential and retains accurate adjustment for long periods in wide variations of temperature, acceleration and vibration. Five basic types are available in a series of specialized versions, with a wide range of single and multiple windings.



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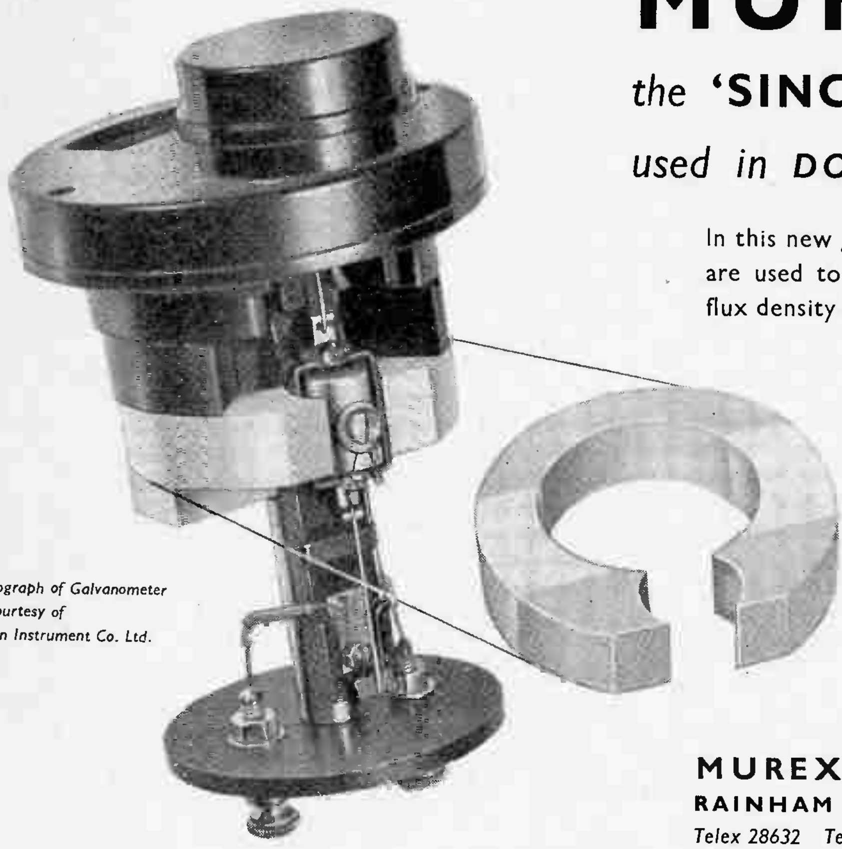

photograph of Galvanometer
by courtesy of
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In this new galvanometer Murex 'Sincomax' Magnets are used to meet the need for low leakage, high-flux density and magnetic stability.

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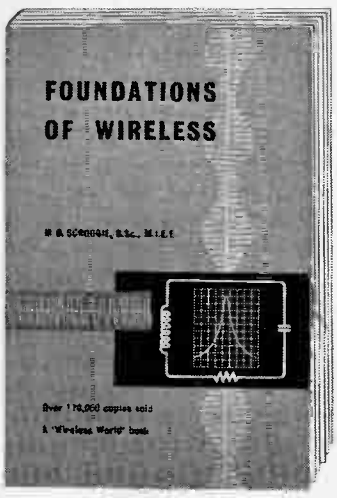

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CONTENTS

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Permanent Magnets

Design Advisory Service

No. 2

Magnetic Circuits

Advertisements in this series deal with general design considerations. If you require more specific information on the use of permanent magnets, please send your enquiry to the address below mentioning the Design Advisory Service.

The fundamental factors governing the design of a magnetic circuit are:—

(*a*) The magnetic field strength required in the air gap.

(*b*) The physical dimensions of the air gap.

(*c*) The leakage flux from the surface of the magnet (and pole pieces, if used).

If the dimensions of the gap and the flux required in it are known, the length of the magnet may be determined with the aid of either of the following simple formulae.

c.g.s. System

Length L_m of magnet in cm.

$$L_m = \frac{H_g \times L_g}{H_d} \times K_l$$

H_g is the field in the air gap in oersteds; L_g is the length of the air gap in cm; H_d is the design value of H from the magnet material characteristic.

M. K. S. System

Length L_m of magnet in metres

$$L_m = \frac{B_g \times L_g}{H_d} \times 4\pi \times 10^{-7} \times K_l$$

B_g is flux density in gap in webers/metre^2; L_g is length of gap in metres; H_d is in ampere-turns/metres.

K_l is a factor which may vary between 1.05 and 1.2. The lower value would apply if iron is of good magnetic quality operating well below saturation; also if joints in the magnetic circuit do not present appreciable reluctance.

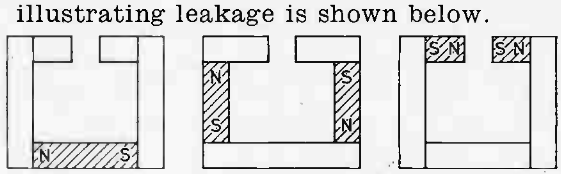
The cross-sectional area of the magnet may be obtained by this formula.

Area A_m of magnet in sq. cm.

$$A_m = \frac{B_g \times A_g}{B_d} \times \text{Leakage Factor}$$

B_g is the flux density required in the air gap ($B_g = H_g$ in air); A_g = area of gap in sq. cm; B_d = design value of flux density of the magnetic material.

Leakage factors vary enormously with different applications and therefore, some experience or information is necessary in order to get a sufficiently close approximation for practical purposes. An example illustrating leakage is shown below.



3%-5% 5%-10% 10%-20%

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Using the M. K. S. System, the same formula still applies with B_g and B_d in webers/metre^2 and the area in square metres.

If you wish to receive reprints of this advertisement and others in this series write to the address below.

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'MAGNADUR' CERAMIC MAGNETS
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MC 262

ELECTRONIC & RADIO ENGINEER

VOLUME 35 NUMBER 5

MAY 1958

incorporating WIRELESS ENGINEER

Jargon

THE use of jargon in technical writing has long been deplored but, in spite of this, it appears to be on the increase. Those who employ it appear to do so for brevity, but they usually succeed only in making themselves unintelligible to all outside a narrow specialized circle. As we shall show later, they do not always even gain in brevity. The dictionary meaning of 'jargon', which we think best describes it, is "mode of speech full of unfamiliar terms". We are, however, often tempted to say that the alternative definition of 'gibberish' is more appropriate.

To non-technical people, all technical writing is naturally jargon, for technical terms must be used and they do not know their meaning. Technical people, however, expect to be able to understand the literature of their field but they cannot when the words employed are jargon; that is, they are not the customary ones of the subject.

We recently met an example in which slang and jargon combine to render a sentence unintelligible to those outside a narrow specialized field. In an instruction manual for a piece of electronic equipment, which is obviously intended for use by those outside that field, we found: "In the interests of high-speed operation, one-half of each valve is used as a cathode follower buffering the strays of the divide down circuit from the anode of the amplifier".

What is half a valve, and how can it be used? The circuit diagram shows that what is meant is one of a pair of triodes contained within a single envelope; that is, half of a double triode.

"Buffering the strays" will probably not puzzle many, but it is inaccurate slang, none the less. In the radio field, 'strays' is a synonym for atmospherics, although it is not one which is much used nowadays. It is used here to mean stray capacitance, but why an adjective should be turned into a plural noun of special meaning defeats us. Stray effects can be inductive, not only capacitive.

"Divide down circuit" will either puzzle the reader or mislead him. The phrase evokes in us the idea of a frequency-dividing circuit, but it is actually nothing but a fancy name for a potential divider!

The sentence can be re-written in precisely the same number of words, not only in a form intelligible to any technical person, but giving a good deal more information than was contained in the original. In plain technical English, instead of the mixture of slang and jargon, we should say "To secure rapid operation, one-half of each double-triode valve is used as a cathode follower, thereby relieving the anode of the amplifier from the stray capacitance of the potential divider".

'Wow' and 'Flutter'

MEASUREMENT IN TAPE RECORDERS

By R. G. T. Bennett* and R. L. Currie*

SUMMARY. *A simple method of measuring wow and flutter is described, which can be made with the aid of a stable oscillator and a triggered oscilloscope with sweep expansion. A sine wave from the oscillator is recorded and subsequently played back, giving a voltage output which triggers the oscilloscope timebase at a particular phase of the waveform. Frequency modulation due to wow or flutter is measured in terms of the relative displacement of the oscilloscope traces at the end of successive sweeps.*

The effects known as wow and flutter, which are caused by variations in frequency brought about by a lack of constancy in the speed that a tape travels across its magnetic head, are usually measured in one of two ways. One method requires the use of complicated limiter–discriminator equipment, which should be calibrated before meaning is given to its results, and the other measures the changes in phase between the recording and reproducing heads when a pure tone is being recorded, but has a very restricted bandwidth because of the time it takes for the tape to travel between the two heads. The method described in this article requires only a stable oscillator and a suitable oscilloscope, and gives the percentage of wow and flutter at any desired bandwidth.

Although it has been developed for use with tape recorders, it can be employed in other requirements as, for instance, to measure the wow due to a turntable. In essence, measurement is achieved by comparing the phase of a recorded sine wave with that of the same wave at some later time.

Suppose that a pure sine wave of constant frequency f is recorded and the recording is then played back and the wave displayed on an oscilloscope. Suppose further that the timebase of this instrument is triggered always at the same part of the cycle, when the instantaneous amplitude of the wave is passing through zero, and that there are displayed on the oscilloscope n complete cycles. There may be a fraction of the next cycle, but this is unimportant.

Each successive trace will start from the same spot (zero, if the triggering delay is ignored; a constant finite value if the triggering delay is small and constant). If the frequency of the sine wave changes from one sine wave to the next, however, successive traces will appear superimposed at their beginnings and will gradually get out of step towards their ends. Their displacement towards the end of the trace is thus a measure of their difference of frequency.

When the recorded wave is frequency-modulated by wow and flutter, the appearance of two successive traces has the form sketched in Fig. 1 (a) for the case $n = 4$. Measurements can be made on the last complete cycle, the nth. In practice, one would use an expanded sweep to display adequately on the screen this nth cycle; alternatively, an oscilloscope with a delayed fast sweep can be used. In either case the nth cycle then has the form shown in Fig. 1 (b).

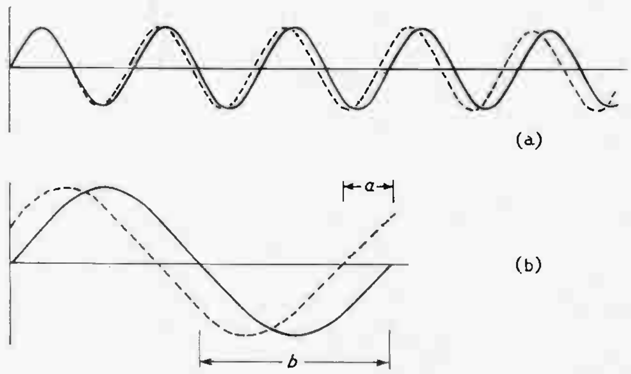

Fig. 1. *Diagram of oscilloscope patterns obtained by superimposing two successive traces showing the played-back signal; (a) two complete sweeps, (b) expanded sweep of last cycle*

The distance b between successive zero crossings of one wave represents the time of one half-cycle of this wave. The distance a between adjacent zero crossings of the two waves represents the time difference in n cycles. The solid curve is considered to be the first reproduced and the dotted the second. If the frequency were constant, the two would be superimposed. The dotted curve is displaced to the left, however, and so the n cycles of the second trace have occupied less time than the n cycles of the first trace. Consequently, the frequency has been higher during the display of the second trace than it was during the display of the first. The difference of timing is $a/2b$ as a fraction of a cycle and, from this, one can work out the change of frequency.

In practice, one does not obtain merely a pair of

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traces like Fig. 1, but a very thick trace similar to that shown by a badly-synchronized oscilloscope. Each successive trace falls at a slightly different position on the screen, but within certain limits imposed by the magnitude of frequency-modulation due to wow and flutter. The trace thus has the form shown by the photograph of Fig. 2, and the thickness of the trace horizontally is a measure of the peak-to-peak amplitude of the frequency-modulation as a fraction of a cycle.

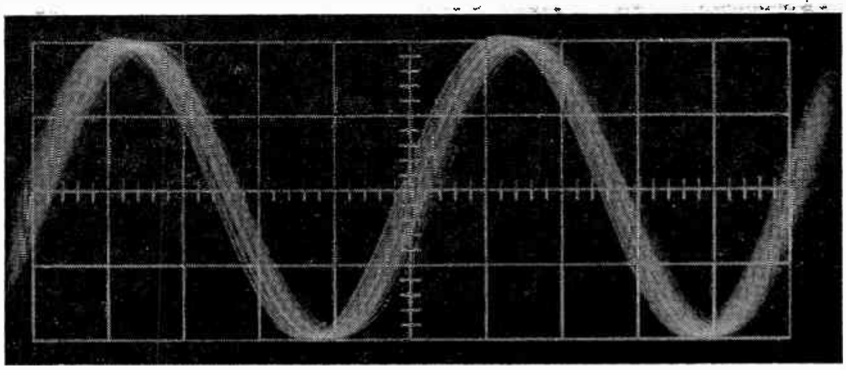


Fig. 2. *Photograph of display obtained in practice*

The mean position for the end of the trace corresponds to the end of the nth cycle of the constant-frequency wave of frequency f, and the time occupied by the n cycles is n/f seconds. At the extremes of amplitude of the modulating wave n cycles occupy $(n \pm a/2b)/f$ seconds, but this time corresponds to n cycles of frequency f_1, or n/f_1 seconds.

Hence $$f_1 = \frac{f}{1 \pm a/2bn}$$

and $\dfrac{\Delta f}{f} = \dfrac{1}{2bn/a \pm 1} \approx \pm a/2bn$ if $a/2bn \ll 1$, which is true in practice.

The percentage of wow and flutter, taken to be peak-to-peak variation, is therefore given by $100\ (2a/2bn)$. Now $2a$ is the total thickness of the trace horizontally, $2b$ the horizontal length of a complete cycle when expanded, and n can be obtained from the unexpanded sweep.

Rather than measure horizontal distances along the time scale of the display, it is sometimes more convenient to measure vertically on the amplitude scale. A sine wave is approximately linear over the range $\pm$ 0·6 of maximum amplitude. 36° being one-tenth of a circle, and sine 36° $\approx$ 0·6, the range $\pm$ 0·6 corresponds to one-fifth of a cycle. Call the length of this range on the amplitude scale R, and the maximum variation of instantaneous amplitude x, then x/R equals the displacement in a horizontal direction as a fraction of one-fifth of a cycle, provided that x/R is less than unity. In other words, $x/R = 5(2a/2b)$, so that the percentage of wow and flutter is given, in this case, by $100(x/5nR)$.

The advantage of using the amplitude as a measure is that it is easy to switch in an amplifier of known gain to increase the deflection and so obtain a more accurate measure when the variations are small.

If a delayed sweep is used, it is more convenient to examine the start of the $(n + 1)$th cycle, and the display then takes the form of Fig. 3; n will be given by fT, where f is the recorded frequency as before, and T is just the sweep delay.

Measurements should be made for widely varying delay times and so, in order to keep the variations within suitable limits, it is necessary to use more than one recorded frequency. In obtaining data for the graph illustrated, frequencies of 200, 1,000 and 10,000 c/s were used, with values of n varying from 1 to 10, or 20 in one case.

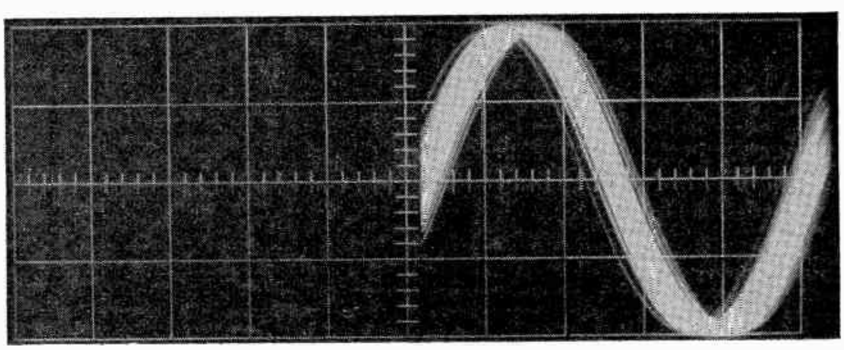
For the longer delays, it will be found in some cases that the spread of the trace varies considerably over a time of half a minute or so. This is because there is inevitably some slip between the tape and the capstan, and sometimes the wow introduced during recording will add to that introduced during playback but, at other times, the two will tend to cancel and the variations will be due to flutter components of frequency modulation only. Hence, if the total wow and flutter is required, the measurements should be made when the variations are maximum; if, however, it is desired to obtain estimates of wow and flutter separately, measurements should be made at both maximum and minimum spread of the trace.

The trace in the photograph of Fig. 4 shows the stability of the oscillator and delay circuit. This trace was produced in the same way as Fig. 3, but with the oscilloscope connected directly to the oscillator. As can be seen, the successive traces are not displaced. This test should be applied to the equipment before making measurements.

The irregularities of tape speed in tape recorders are of two types, and that is why the two names, 'wow' and 'flutter' are used to describe them. The wow is periodic, arising mainly out of eccentricities of the capstan, and having its frequency of rotation which is usually a few cycles per second. Flutter, on the other hand, is random in character, and has components of frequency completely covering a very wide audio band.

The system of measurement described in this article

Fig. 3. *Pattern obtained with delayed sweep*



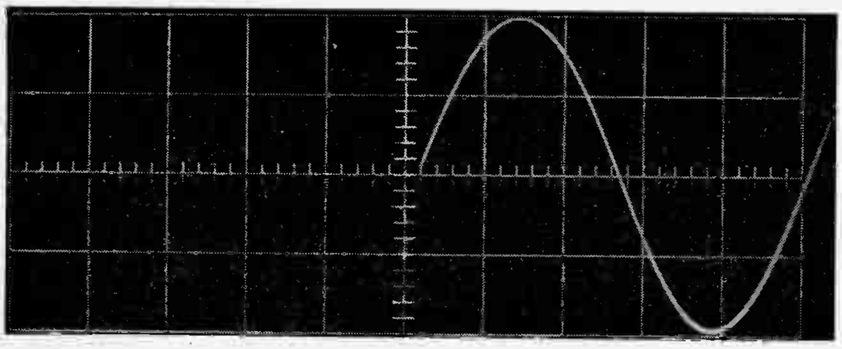
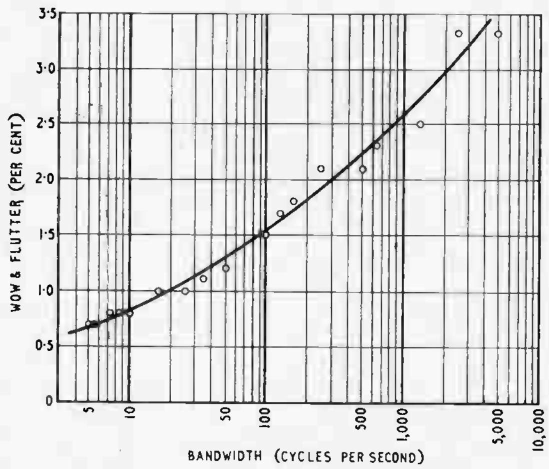


Fig. 4. *Oscillator output*

Fig. 5 (*below*). *Wow and flutter of a particular tape recorder*



does not respond equally to all wow-and-flutter frequencies; it has a response similar to a low-pass filter. This response is shown in the appendix to be proportional to $(\sin \pi f'T)/\pi f'$ where f' is the wow or flutter frequency.

This can be understood more readily by considering a particular instance, that in which the component of frequency modulation has the same period as the delay. The frequency is (say) higher during the first part of the delay period and lower during the second part; hence, the wave comes into phase again at the nth cycle and would not appear to be displaced.

Since flutter components up to very high frequencies are present, it is necessary to specify a bandwidth if tape recorders are to be compared adequately.

For the purpose of determining the bandwidth of this measuring system, we imagine a 'white noise' signal to be applied to the input (white noise has components of all frequencies and all at the same intensity). The bandwidth of the system is defined as the bandwidth of the ideal filter which will give the same output power under these conditions. A constant of proportionality is included to make the response of the two systems equal at the frequency of maximum transmission. The result is that the bandwidth is $1/2T$, where T is the delay. It is, hence, a simple matter to obtain the bandwidth associated with each measurement of wow and flutter.

The graph (Fig. 5) shows the total wow and flutter, plotted against bandwidth for a particular tape recorder, obtained with delays varying from 100 milliseconds to 100 microseconds.

APPENDIX

1. *Wow*

Suppose the velocity of the tape is

$$V = V_0(1 + m \cos 2\pi f't)$$

where f' is the wow frequency.

The wavelength on the tape at any instant is

$$\lambda = V_0(1 + m \cos 2\pi f't)/f.$$

When played back, the phase change in time T is

$$\theta = 2\pi \int_0^T (v/\lambda)\, dt$$

$$= 2\pi f \int_0^T [\{1 + m \cos (2\pi f't + \beta)\}/\{1 + m \cos (2\pi f't + \alpha)\}]\, dt$$

where α and β are the phase angles of record and playback respectively and may have any values.

If

$$m \ll 1$$

$$\theta = 2\pi f \int_0^T [1 + m\{\cos (2\pi f't + \beta) - \cos (2\pi f't + \alpha)\}]\, dt$$

and

$$\Delta\theta = \frac{4mf}{f'} \sin \left\{\frac{\alpha - \beta}{2}\right\} \sin (\pi f'T + \alpha + \beta) \sin (\pi f'T)$$

disregarding the fundamental phase change πfT. When $\alpha - \beta = \pi$ the first sine factor equals 1, the second takes values between 1 and -1 on successive sweeps so that $\Delta\theta$ lies between $\pm\, 4\pi mf \dfrac{\sin \pi f'T}{\pi f'}$ which are the maximum values referred to above.

2. *Flutter*

(*a*) The random component of tape-velocity variation may be supposed to be the sum of the contributions from a large number of different frequencies. Any frequency component may be resolved into a wave which has $\alpha - \beta = \pi$ and gives the maximum excursion, and another for which $\alpha - \beta = 0$ which gives no result. Each is equally likely, hence on the average, the root-mean-square flutter (calculated from the excursions) produced by all the frequency components is $p/\sqrt{2}$ where p is the actual r.m.s. flutter.

(*b*) The response of the system is proportional to

$$\frac{\sin \pi f'T}{\pi f'},$$

hence the root mean square output for 'white noise' input is proportional to

$$\sqrt{\left[\int_0^\infty \left\{\frac{\sin \pi f'T}{\pi f'}\right\}^2 df\right]} = \sqrt{\frac{T}{2.}}$$

An ideal low-pass filter of bandwidth B with the same low-frequency response

$$T = \lim_{f' \to 0} \frac{\sin \pi f'T}{\pi f'}$$

would have a mean square output of

$$\sqrt{\left(\int_0^B T^2\, df\right)} = \sqrt{T^2 B}$$

Hence $B = 1/2T$.

By using a large delay, it is possible to render negligible the flutter response and measure low-frequency wow components.

Analysis of Current Pulses

APPLICATION TO RECTIFIERS AND CLASS C AMPLIFIERS

By F. G. Heymann, M.Sc.(Eng.)*

SUMMARY. *Current pulses are analysed by an approximate method which gives results in which the errors are not more than about 5%. The resulting relations are applied to class C amplifiers and lead to simple expressions for various amplifier quantities.*

An approximate method has been used to analyse the current pulse in a circuit containing a rectifier with a linear characteristic[1]. This method is now extended to include non-linear characteristics and its application to the class C amplifier is indicated. It is assumed that all alternating voltages are sinusoidal and that the cosine function may be approximately represented by the first two terms of its expansion.

The current–voltage characteristic of the rectifier or amplifying device is assumed to be

$$i = kv^{\alpha}$$

where k and α are constants for a particular device.

It is possible to derive simple relations between the peak current, the average current and the various harmonic components of the current pulse. These relations may be used in class C amplifier design.

A similar approximation has been made by Kosa[2] assuming linear characteristics but, in general, this is not accurate enough.

The results which follow indicate that the ratio between average current and peak current varies appreciably with the exponent α but that the ratio between the fundamental current component and the average current is not greatly affected by the value of α.

Average Current

The basic circuit is shown in Fig. 1 (a), assuming that each source has zero internal impedance. Fig. 1 (b) shows the voltage and current waveforms during the positive half-cycle of the alternating voltage.

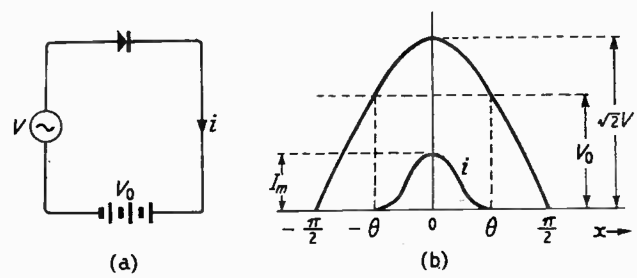


Fig. 1. *(a) Basic circuit; (b) current and voltage waveforms*

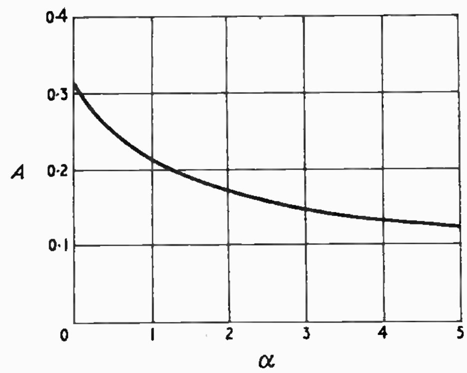


Fig. 2. *Dependence of factor A on the exponent α*

The instantaneous voltage during conduction is:

$$v = \sqrt{2}V\cos x - V_0$$

In the appendix it is shown that the approximate instantaneous current will be given by the following expression:

$$i \approx I_m\{1 - (x/\theta)^2\}^{\alpha}$$

The average current may be found by integration:

$$I_D = \frac{1}{2\pi}\int_{-\theta}^{\theta} i \, . \, dx$$

$$\approx A\theta I_m \quad \dots \quad (1)$$

The factor A, which may be readily determined for integral values of 2α, is plotted as a function of α in Fig. 2. The curve may be used to determine A for any value of α.

The average current therefore varies approximately linearly with angle of flow when expressed in terms of the peak current. The approximation gives a value in which the error is not more than 6% when $\theta = \pi/2$ and $\alpha = 2$. For lower values of α the approximation is closer.

Harmonic Components

The effective value of the nth harmonic component

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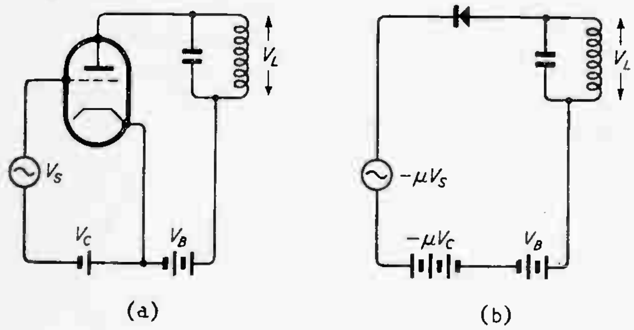

Fig. 3. *Class C amplifier; (a) normal circuit, (b) equivalent circuit*

may be found by evaluating the following integral:

$$I_n = \frac{1}{\sqrt{2}\pi}\int_{-\theta}^{\theta} i \, . \cos nx \, . \, dx$$

$$\approx \sqrt{2}\, I_m A\theta(1 - Bn^2\theta^2) \quad \ldots \quad (2)$$

$$\approx \sqrt{2}\, I_D(1 - Bn^2\theta^2) \quad \ldots \quad (3)$$

$$\text{where } B = \frac{1}{4\alpha + 6}$$

This approximate expression holds very well for values of $n\theta$ up to about $\pi/2$, the error being not more than 5% when $\alpha = 2$ and $n\theta = \pi/2$. For higher values of $n\theta$ the error tends to increase.

Unmodulated Class C Amplifier

It is usual to operate an unmodulated class C amplifier in the region where the anode voltage exceeds the grid voltage. Under these conditions the anode current pulse is of the form considered in the previous sections.

The anode circuit of the amplifier shown in Fig. 3 (a) may be represented by the equivalent circuit in Fig. 3 (b). The equivalent rectifier has a characteristic of the form $i = kv^\alpha$, where $v = \mu v_g + v_a$ and current only flows while v is positive.

The circuit of Fig. 3 (b) reduces to that of Fig. 1 (a) if $V = \mu V_s - V_L$ and $V_0 = \mu V_c - V_B$

Therefore, the current pulses may be analysed as in the foregoing sections.

If a design procedure similar to that proposed by Terman[3] is used, the maximum allowable peak anode current I_m is first determined and a suitable combination of minimum anode voltage and maximum grid voltage selected to produce this current. It is usual to ensure that the minimum anode voltage V_{min} exceeds the maximum grid voltage so that no dip appears in the current pulse.

For a particular anode supply voltage V_B and angle of flow 2θ it is possible to write down the following simple expressions:

Input power: $P_D = V_B I_D = V_B I_m A\theta$

Output power: $P_L = V_L I_1$

$$= (V_B - V_{min})\, I_m A\theta\, (1 - B\theta^2)$$

Efficiency:

$$\eta = (1 - V_{min}/V_B)\,(1 - B\theta^2)$$

Tank impedance:

$$Z_L = \frac{V_B - V_{min}}{2I_m A\theta\,(1 - B\theta^2)}$$

These relations show clearly what part each factor plays in determining the operation of a class C amplifier.

Input power increases continuously with angle of flow, whereas output power reaches a maximum at some value of θ greater than $\pi/2$. This means that the amplifier does not reach this point while it is still operating under class C conditions.

The efficiency is seen to fall with increasing angle of flow and the effect of the minimum anode voltage is clearly brought out. It is also evident that the tank impedance is roughly inversely proportional to the output power.

Since average valve characteristics are usually consulted in designing amplifiers, the errors which arise in consequence may be large compared with the errors introduced by the above approximate method and therefore the use of the approximate theory in place of more exact sets of curves is justified.

Harmonic Amplifiers

The above analysis of current pulses may also be applied to harmonic amplifiers if it is assumed that the alternating component of the anode voltage does not have much effect on the anode current; i.e., if a high value of μ is assumed. The approximate theory becomes increasingly inaccurate as the angle of flow rises beyond a certain value but, on the whole, the results are sufficiently accurate for most purposes.

If 2θ is the angle of flow relative to the driving voltage and the frequency is multiplied n times, the following relations hold approximately

Input power: $P_D = V_B I_m A\theta$

Output power:

$$P_L = (V_B - V_{min})\, I_m A\theta\,(1 - Bn^2\theta^2)$$

Efficiency:

$$\eta = (1 - V_{min}/V_B)\,(1 - Bn^2\theta^2)$$

Tank impedance:

$$Z_L = \frac{V_B - V_{min}}{2I_m A\theta\,(1 - Bn^2\theta^2)}$$

In the case of harmonic amplifiers it is probably advantageous to operate near maximum power output; i.e., at

$$n\theta \approx \sqrt{1{\cdot}33\alpha + 2} \text{ (see appendix).}$$

APPENDIX

List of Symbols

x = $2\pi ft$
f = frequency
t = time
v = instantaneous voltage across equivalent rectifier
V = effective (r.m.s.) value of a sinusoidal voltage
i = instantaneous current
I_m = peak current
I_D = average current
I_n = effective (r.m.s.) value of the nth harmonic component of current
2θ = phase angle during which current flows
$\cos x \approx 1 - 0{\cdot}5x^2$

1. *Instantaneous Current*

The resultant voltage during conduction is

$$v = \sqrt{2}\,V \cos x - V_0$$
$$= \sqrt{2}\,V (\cos x - \cos\theta)$$
$$\approx V(\theta^2 - x^2)/\sqrt{2}$$

Peak current flows when $x = 0$

$$\therefore I_m = k\,(V\theta^2/\sqrt{2})^\alpha$$

The instantaneous current may be expressed in terms of I_m

$$i = kv^\alpha = I_m\,(1 - x^2/\theta^2)^\alpha$$

2. *Average Current*

$$I_D = \frac{1}{2\pi}\int_{-\theta}^{\theta} i\,.\,dx$$

$$\approx \frac{\theta I_m}{\pi}\int_0^1 (1 - x^2/\theta^2)^\alpha\,.\,d(x/\theta)$$

$$= A\theta I_m$$

Let $x/\theta = \sin y$; $d(x/\theta) = \cos y\,.\,dy$

$$\therefore A = \frac{1}{\pi}\int_0^{\pi/2} \cos^{2\alpha+1} y\,.\,dy$$

$$= \frac{2\alpha}{\pi(2\alpha+1)}\int_0^{\pi/2} \cos^{2\alpha-1} y\,.\,dy$$

This reduction formula makes it possible to evaluate A for all integral values of 2α once A has been found for $\alpha = 0$ and $\alpha = \frac{1}{2}$. Calculated values of A are listed in Table 1.

TABLE 1

α	0	0·5	1·0	1·5	2·0	3·0	4·0	5·0
A	0·318	0·25	0·212	0·188	0·170	0·146	0·129	0·117

The value $\alpha = 0$ corresponds to a rectangular current pulse.

3. *Harmonic Components*

$$I_n = \frac{1}{\sqrt{2}\,\pi}\int_{-\theta}^{\theta} i\,(\cos nx)\,dx$$

$$\approx \frac{\sqrt{2}\theta I_m}{\pi}\int_0^1 (1 - x^2/\theta^2)^\alpha\,(1 - 0{\cdot}5n^2x^2)\,d(x/\theta)$$

$$= \sqrt{2}\,I_m A\theta\,(1 - Bn^2\theta^2)$$

Where $B = \dfrac{1}{2\pi A}\displaystyle\int_0^{\pi/2} \sin^2 y\,.\,\cos^{2\alpha+1} y\,.\,dy$

$$= \frac{1}{2\pi A}\int_0^{\pi/2} \cos^{2\alpha+1} y\,.\,dy - \frac{1}{2\pi A}\int_0^{\pi/2} \cos^{2\alpha+3} y\,.\,dy$$

$$= \frac{1}{2}\left(1 - \frac{2\alpha+2}{2\alpha+3}\right)$$

$$= \frac{1}{4\alpha+6}$$

4. *Maximum Power Output of Class C Amplifier*

$$P_L \approx (V_B - V_{min})\,I_m A\theta\,(1 - Bn^2\theta^2)$$

Let $\dfrac{\delta P_L}{\delta\theta} = 0$

$$\therefore 1 - Bn^2\theta^2 = 2Bn^2\theta^2$$

For a maximum value of P_L, $n\theta \approx 1/\sqrt{3B}$

$$= \sqrt{1{\cdot}33\alpha + 2}$$

Thus maximum output power is:

$$P_{Lmax} \approx (V_B - V_{min})\,I_m\,(2A/3n)\,\sqrt{1{\cdot}33\alpha + 2}$$

and the efficiency at this output will be

$$\eta = 0{\cdot}667\,(1 - V_{min}/V_B)$$

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[1] F. G. Heymann, *Wireless Engineer*, June 1955. Vol. 32, p. 147.
[2] F. M. Kosa, *Wireless Engineer*, December 1937. Vol. 14, p. 647.
[3] F. E. Terman, "Radio Engineers' Handbook", p. 444, McGraw-Hill, 1945.

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ARTIFICIAL AURORA

Recent reports of the production of an artificial Aurora Borealis may have stimulated thoughts about the possibility of using it for illumination. That is very much a thing of the, probably far, future and here I simply want to discuss what lies behind the Luxembourg Effect and, more particularly, the theoretical and experimental work that has been done on its possible use to produce an artificial Aurora Borealis. Two things should be made clear at the start, however. The first is that, although some such expression as "Light from the Luxembourg Effect" has been used, the only way in which this could conceivably be realized is in the special case of the effect which occurs at one particular frequency, called the gyrofrequency. The second is that, although the production of a luminous discharge *in the E-layer itself* would be well within the scope of any really high-power transmitter using this frequency, provided it had a suitable aerial array, (which would be rather a large affair) the main object of research has been to study conditions in the ionosphere and not to develop new and fancy lighting techniques!

The February 1957 number of *Radio Industria Televisione* had an article describing experiments by Professor M. Cutolo of the University of Naples, in which he had reproduced E-layer ionosphere conditions *in a glass vessel*, and had excited an auroral glow in it at a distance of some 800 metres from a radio transmitter. A summary of this article appeared in the *European Broadcasting Union Review* for June of last year. The account was not by Cutolo himself, a very distinguished worker for a quarter of a century in this field, but by an author whom I suppose to be "Quantum's" opposite number in the Italian journal. I could not understand it, because he had left some essential details out. However, the references were there and it was, I thought, well worth while to try to follow some of them up. I expect that by now the work has been fully published; but I haven't come across it in that form yet, so I don't suppose you have either.

The Luxembourg Effect

B. D. H. Tellegen reported in *Nature* (10th June 1933) that the programme from Radio Luxembourg (150 kW, 1190 m) was received at Eindhoven on a set tuned in to Beromunster (460 m). Radio Luxembourg is in a direct line between transmitter and receiver, and it was realized that a cross-modulation effect was occurring in the E-layer of the ionosphere; that is, the modulation of the Luxembourg programme was being impressed on the reflecting region, and thence transferred to the reflected 'wanted' signal (Fig. 1). The terms 'wanted' and 'unwanted' refer to the tuning of the receiver, and not to any listener-research rating. Tellegen also observed the effect with many other 'wanted' transmissions passing over the high-powered Luxembourg station, ranging from Radio Paris, 1725 m to Frankfurt, 259 m. Subsequent progress in the study of this effect is signposted by a number of communications to *Nature* between the years 1933 and 1951, from L. G. H. Huxley, J. A. Ratcliffe, V. A. Bailey and M. Cutolo.

Conditions in the E-layer of the ionosphere, at which medium-wave radiation is reflected, are fairly well understood. The average height is about 120 km, and the lower limit about 90 km. The pressure is a fraction of a millimetre of mercury, ionization (chiefly due to solar ultra-violet radiation) gives about 10^5 free electrons per cc, and the mean free path of an electron between its thermal-agitation collisions with other particles is of the order of a centimetre or so. The value of the total intensity of the earth's magnetic field, which of course varies from place to place and is less than at the earth's surface, can be taken as about 0·48 oersted. The E-layer was pretty well explored over thirty years ago by Appleton and Barnett, but the only way in which the magnetic field entered into their echo-sounding work was in the polarization of the reflected waves. Indeed, it does not have much to do with the Luxembourg Effect either in the ordinary way, for this is simply a matter of sheer power. Even at E-level distances, a station radiating at between 100 kW and 200 kW can convey sufficient energy to individual free electrons to modify their paths between collisions, and cross-modulation occurs because the radiation of the wanted station is being reflected

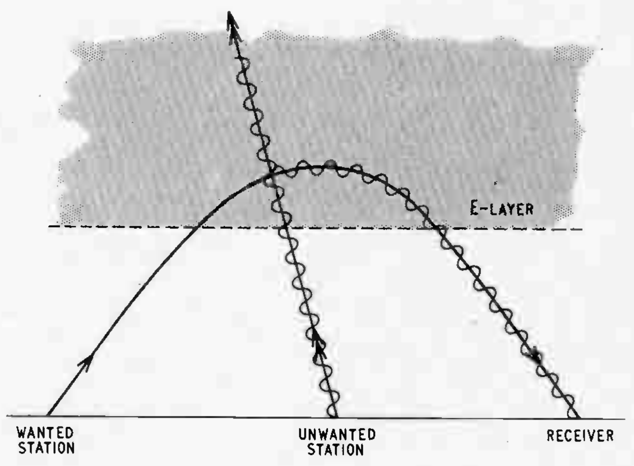

Fig. 1. *Illustrating the Luxembourg Effect. Transmission from the wanted station to the receiver is modulated during reflection at the E-layer of the ionosphere. The wavy line represents the modulation of the unwanted station*

through the agency of electrons which are dancing to a modulated pattern instead of being really free. This is *not* a resonance effect, and occurs with any 'unwanted' station of any wavelength provided it is sufficiently powerful. But there is one particular frequency, which depends on the local value of the magnetic field, at which electron cyclotron resonance can occur; this resonance frequency is called *gyrofrequency*, and it turns out to be about four times the frequency of Radio Luxembourg. This is a completely different kind of effect, for it means that resonance absorption of power on a large scale should be possible if only it can be got up to the E-layer.

The Gyrofrequency

In space, an electron of mass m and charge e moving with speed v at right angles to a field of strength H will describe a circular path of radius r, where

$$\frac{mv^2}{r} = \mu_0 Hev,$$

if all quantities are measured in the same consistent unit system. Usually, one finds this written in c.g.s. terms, with H in oersteds, μ_0 equalling 1, and e expressed in absolute electrostatic units, when the velocity of light c is needed as a conversion factor. With these replacements, then,

$$\frac{mv^2}{r} = \frac{Hev}{c}$$

Now, if the electron goes on describing its circular path, the angular frequency ω is v/r, so that $\omega = He/mc$; and the frequency of revolution f is $\omega/2\pi$, whence

$$f = \frac{He}{2\pi mc}$$

Taking H to be 0·48 oersted, and using the other values $e = 4{\cdot}8 \times 10^{10}$ e.s.u., $m = 9 \times 10^{-28}$ gm, $c = 3 \times 10^{10}$ cm/sec, then f works out to be nearly $1{\cdot}2 \times 10^6$ c/s, and the corresponding wavelength about 250 metres. The value of f varies from place to place.

In 1937, V. A. Bailey calculated that an 'unwanted' station operating at or near the local gyrofrequency should give a cross-modulation many times stronger than would normally be expected, due to resonance absorption; and experiments showed that resonance did indeed occur, and suggested that powers as low as 1 or 2 kW might suffice to give detectable cross-modulation. Cutolo was able to confirm this experimentally in 1947.

Bailey's 1938 Paper

"On Some Effects caused in the Ionosphere by Electric Waves—Part II" is the formal title of V. A. Bailey's very sprightly contribution to *Phil. Mag.*, March 1938. First, he develops the mathematical theory of the absorption of energy by free electrons from radio waves at frequencies round about the local gyrofrequency, and calculates an "index of interaction" expressed as $N\,\nu\,\bar{w}$, where N is the number of free electrons per cc, ν the collision frequency, and $\bar{w}$ the average energy lost by an electron at each collision. The calculated results for various depths of penetration into the E-layer are shown in Fig. 2. For a 5-km penetration, to use his own words, "the resonance curve changes from the dromedarian type to the bactrian type". In 1949, using a 3·3-kW transmitter of Radio Italiana at Florence as the 'unwanted' station, Cutolo was able to obtain results of this type, thus confirming Bailey's calculations.

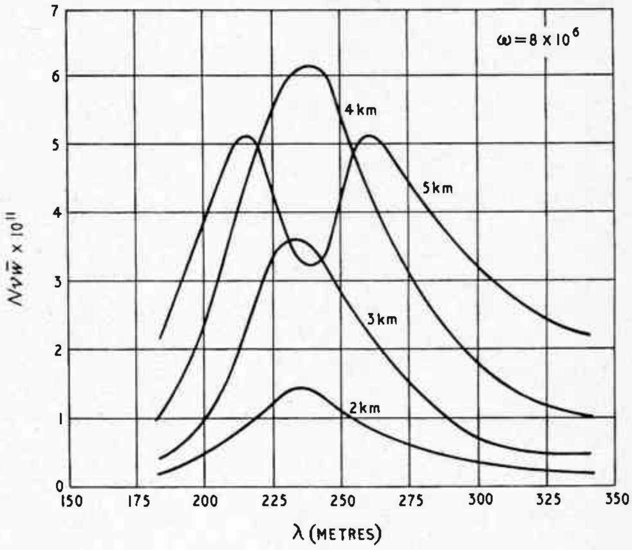

Fig. 2. *Resonance curves calculated for the index of gyro-interaction at frequencies in the region of the gyrofrequency, taken from V. A. Bailey's* 1938 Phil. Mag. *paper*

But the part of the paper that is most relevant to the present article is at the end, where he speculates on the possibility of generating light in the E-layer. The gyro-interaction, if it supplies *sufficient* energy between collisions to the electrons, should enable them to cause the molecules they strike to emit light, or fresh electrons, or both. In some ways this resembles Townsend's electrodeless discharge, and there is some good solid Townsend stuff behind the calculations. He finds that it would take 2×10^5 kW to give general illumination in the E-layer by gyrofrequency radiation broadcast generally. But, if beamed using an array of 800 half-wave aerials, the Moscow 500-kW station should be able to manage it. Droitwich with 150 kW and a mere 2,700 aerials could also do it. The resulting brightness, over an area 20 km × 9 km would be about 4×10^{-7} candles per sq. cm, which is 50 times as bright as the night sky, and would be easily visible. The illumination at ground level would be 4×10^{-5} lux, which is much smaller than the minimum of 0·22 lux needed to light roadways. Coming down to this practical application, stepping up the power by a factor of 10 would indeed give 0·22 lux over an area of 10,000 sq. km. Expensive, no doubt, but possibly a good deal pleasanter than the odds and sodiums we collide by nowadays. Remembering again that all this was in 1938, and that in the succeeding years radio research was concentrated in completely different channels, it is interesting to speculate what might have happened. Should we by now be buying a combined radio, television, and night-driving licence from the Postmaster-General?

Conclusion

I said at the start that I could not quite follow the account of Cutolo's recent experiment. It is true that this explains quite clearly what has happened—the production of a Bailey glow in a closed vessel; and it is helpful in the references provided. But it does not say how the ionization was done (though this would be a relatively simple matter), and it does not say anything about the magnetic field surrounding the vessel.

Apparently, the 250-m range was deserted and v.h.f. radiation in the one to ten-metre range used; the photograph of the 7-kW transmitter certainly shows that kind of aerial set-up. In this case, to get a gyrofrequency in the v.h.f. region, there must have been a magnetic field of the order of 10 to 100 oersteds. You may feel that it is unwise, and almost unprofessional, to comment on an incomplete account of work in progress; but I felt I could not let this rest until I had found out a little more about it, and sorted out the general background of the work.

Parallel-Plate Transmission Lines and Equivalent Radiators

By A. B. Hillan, M.Eng., A.M.I.E.E.*

SUMMARY. *The connection between parallel-plate transmission lines and equivalent radiators which have at least one infinite dimension is discussed. Calculation establishes that there is an exact correlation and demonstrates that in the case of an infinite plane irrotational current sheet there are no induction field terms, the radiated field being a faithful reproduction of the current density in the sheet.*

This article arose from a desire to resolve an apparent anomaly in the connection between the behaviour of parallel-plate transmission lines when working in the TEM mode and their equivalent radiators.

When a plane TEM wave propagates along a parallel-plate transmission line, it is clear from considerations involving the method of images that the wave is a slice from an infinite plane wave, the depth of the slice being determined by the separation of the parallel plates. The source of the wave propagated along this transmission line can be regarded as a current sheet across the line with an applied electric field of appropriate magnitude. The same arguments as before lead to the proposition that the infinite plane wave is the radiation field from an infinite current sheet which has the property that the current density in the sheet at any instant is irrotational.

The apparent anomaly arises from the fact that the parallel-plate transmission line will propagate TEM waves which are an arbitrary function of time and, in particular, will propagate a step-function faithfully. On this basis, the above argument leads to the assertion that an infinite current sheet, in which the current density at any moment is constant over the sheet, will radiate a TEM wave having a waveform which is the time variation of the current density in the infinite sheet. In particular, if the time variation of the current density is a step function, the radiation field should be a step-function TEM wave.

The common radiation formulae lead to a usual supposition that radiation fields depend essentially on a time rate of change of current in the radiator. For example, the usual formulae for the field of a current element can be readily extended from the particular case of a sinusoidal time variation to that of an arbitrary time function to give the following results:

$$\left.\begin{aligned} H_\phi &= \frac{Idl\sin\theta}{4\pi}\left[\frac{Df(t')}{rc}+\frac{f(t')}{r^2}\right] \\ H_\theta &= H_r = 0 \\ E_\phi &= 0 \\ E_\theta &= \frac{Idl\sin\theta}{4\pi\epsilon_0}\left[\frac{Df(t')}{rc^2}+\frac{f(t')}{r^2c}+\frac{D^{-1}f(t')}{r^3}\right] \\ E_r &= \frac{2Idl\cos\theta}{4\pi\epsilon_0}\left[\frac{f(t')}{r^2c}+\frac{D^{-1}f(t')}{r^3}\right] \end{aligned}\right\} \quad (1)$$

where $If(t)$ represents the current in the element dl,

$$t' = \left(t-\frac{r}{c}\right),$$

$$Df(t') = \frac{d}{dt}f(t'),$$

and $D^{-1}f(t') = \int f(t')dt.$

It will be noted that the radiation-field term involves the time differential of the arbitrary waveform. From this, it may be argued that it is difficult to see how any conceivable radiator could radiate a waveform such as a step function faithfully.

Moullin[1] has previously briefly considered the radia-

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tion from such a current sheet for the case of a sinusoidal time-variation, as an extrapolation from an earlier calculation of the field from an infinite wire. This treatment does not bring out clearly the relevant property of an infinite current sheet, so it was decided to make a direct calculation of the radiation field from the sheet when a current having a non-sinusoidal time variation is impressed. For the purpose of the calculation, a step-function of current was chosen for two reasons:

(a) The calculation for this particular case is particularly simple.

(b) The consideration of the field at a time t approaching infinity gives the radiation under quasi-static conditions.

This article sets out the calculation and also includes the corresponding calculation for the case of an infinitely long current filament in which the current at any moment does not vary along the length of the wire.

The Radiation Field of an Infinite Current Sheet

The concept of an infinite plane current sheet in which the (finite) current is irrotational does not violate fundamental physical concepts. The effect of the end of the sheet can be neglected since the accumulated charge, being finite at a finite time, has a negligible influence. The electric field is most easily calculated from the usual formula

$$E = -\mu_0 \frac{\partial A}{\partial t} - \text{grad. } V \qquad (2)$$

where, in this case, grad. V is zero because of the considerations outlined above.

The current in the sheet is taken to start suddenly at time $t = 0$ and to persist indefinitely thereafter at a surface density of J amperes per metre. In order to calculate the magnitude of the electric vector E at an arbitrary point P in space, it is necessary to derive the rate of change of the delayed vector potential A. From Fig. 1 it will be seen that at an arbitrary time t, the magnitude of A will be determined by the contributions of the current moments within a circle of radius z. In a further time interval δt, the magnitude of A will be increased by the contributions of the current moments in the annulus

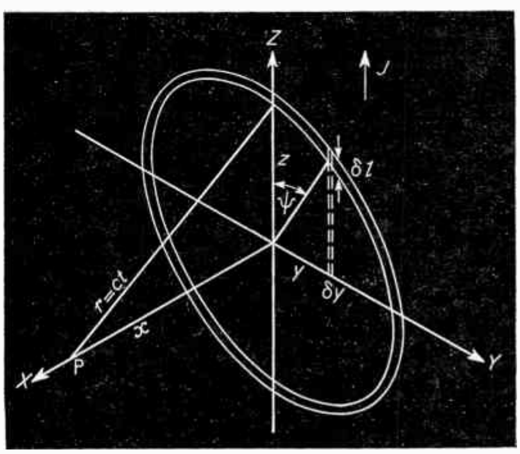

Fig. 1. *Elementary annulus of infinite plane irrotational current sheet*

of radial width δz. Taking the plane of the current sheet to contain the Z and Y axes of a co-ordinate system, as shown in Fig. 1, consider the contribution from that part of the elementary annulus at a distance y. This contribution is

$$2\left(\frac{1}{4\pi}\frac{I\delta y \delta l}{r}\right)$$

Since $\delta l = \dfrac{\delta z}{\cos\psi}$ and $\delta y = z \cos\psi\, \delta\psi$, the contribution from the annulus is

$$\delta A = \frac{1}{2\pi}\frac{Jz\delta z}{r}\int_{-\pi/2}^{+\pi/2} d\psi = \frac{Jz\delta z}{2r} \qquad (3)$$

Since $\delta z = \dfrac{r}{z}\,\delta r = \dfrac{r}{z}c\delta t$, it follows that

$$\delta A = \frac{Jc\delta t}{2} \qquad (4)$$

$$E_z = -\mu_0 \frac{Jc}{2}$$

$$= -\frac{\eta_0 J}{2} \qquad (5)$$

where η_0 is the intrinsic impedance of free space.

From equation (4),

$$A = \frac{Jct}{2} + \text{constant} \qquad (6)$$

Since, at a distance x from the sheet, A must be zero when $ct \leqslant x$ the constant is readily evaluated and Equ. (6) becomes

$$A = \frac{J(ct - x)}{2} \qquad (7)$$

$$H_y = \text{curl}_y\, A$$

$$= \tfrac{1}{2} J \qquad (8)$$

From equations (5) and (8) it is clear that a time-independent electromagnetic field, starting at time $t = 0$, propagates into the semi-infinite volume on each side of the sheet. Because of this fact the Poynting power density $\left(\dfrac{\eta_0 J^2}{4}\right)$ is half the power density in the sheet $\left(\dfrac{\eta_0 J^2}{2}\right)$.

The radiation resistance of the sheet is $\dfrac{\eta_0}{2} = 60\pi$ ohms.

The Radiation Field of an Infinite Wire

It is of interest to calculate the radiation from an infinite wire carrying a current which at any moment is constant along its length, since this is the equivalent radiator for a disc transmission line carrying a cylindrical wave.

The time variation of current in the wire is taken to be a step function commencing at $t = 0$. As before, the electric vector is calculated from the formula

$$E = -\mu_0 \frac{\partial A}{\partial t} \qquad (9)$$

Referring to Fig. 2, in a time interval δt the increase in A at a point P is due to the contribution from two current elements of length δz.

$$\delta A = 2\left(\frac{1}{4\pi}\frac{I\delta z}{r}\right) \quad \cdots \quad (10)$$

Since $r = ct$ and $z = \sqrt{r^2 - \rho^2}$, Equ. (10) can be re-written as

$$\frac{\delta A}{\delta t} = \frac{1}{2\pi}\frac{Ic}{\sqrt{c^2t^2 - \rho^2}} \quad \cdots \quad (11)$$

$$E_z = \frac{-\eta_0}{2\pi}\frac{I}{\sqrt{c^2t^2 - \rho^2}} \quad \cdots \quad (12)$$

From equation (11),

$$A = \frac{Ic}{2\pi}\int\frac{dt}{\sqrt{c^2t^2 - \rho^2}}$$

$$= \frac{I}{2\pi}\log_e\left\{ct + \sqrt{c^2t^2 - \rho^2}\right\} + \text{constant} \quad (13)$$

As before, the constant is evaluated by the condition that $A = 0$ when $ct \leqslant \rho$, giving

$$A = \frac{I}{2\pi}\log_e\left\{\frac{ct + \sqrt{c^2t^2 - \rho^2}}{\rho}\right\} \quad \cdots \quad (14)$$

$$H_\phi = \text{curl}_\phi\, A$$

$$= \frac{I}{2\pi\rho}\frac{ct}{\sqrt{c^2t^2 - \rho^2}} \quad \cdots \quad (15)$$

Equations (12) and (15) show that as t approaches infinity, the field vectors decay to the values normally derived in the static case; i.e.,

$$E = 0$$

$$H_\phi = \frac{I}{2\pi\rho}$$

If attention is fixed on the vectors at a particular distance d behind the wave front, their values are given by the condition

$$(ct - \rho) = d \quad \cdots \quad (16)$$

In this case E_z and H_ϕ may be rewritten as

$$\left.\begin{aligned} E_z &= \frac{-\eta_0 I}{2\pi\sqrt{d(2\rho + d)}} \\ H_\phi &= \frac{I}{2\pi\rho}\frac{(\rho + d)}{\sqrt{d(2\rho + d)}} \end{aligned}\right\} \quad \cdots \quad (17)$$

When $\rho \gg d$ (and hence $ct \gg d$),

$$\left.\begin{aligned} E_z &= \frac{-\eta_0 I}{2\pi\sqrt{2\rho d}} \\ H_\phi &= \frac{I}{2\pi\sqrt{2\rho d}} \end{aligned}\right\} \text{approximately} \quad \cdots \quad (18)$$

The radiated power from a length z of the wire is obtained from Equ. (18).

$$\text{Radiated power} = \frac{\eta_0 I^2}{4\pi^2 2\rho d} \times 2\pi\rho z$$

$$= \frac{\eta_0 I^2 z}{4\pi d} \quad \cdots \quad (19)$$

Radiation resistance per unit length of wire

$$= \frac{\eta_0}{4\pi d} = \frac{30}{d}\ \text{ohms/metre} \quad \cdots \quad (20)$$

From equation (17), when $\rho = 0$

$$E_z = \frac{-\eta_0 I}{2\pi d} \quad \cdots \quad (21)$$

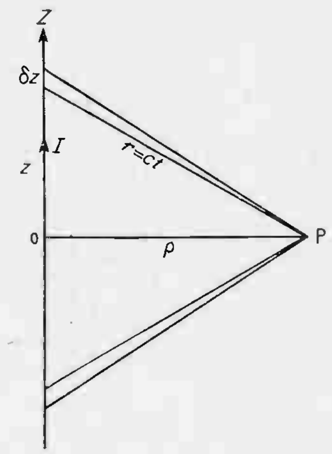

Fig. 2. *Part of infinite-wire radiator*

This means that the power leaving a length z of the wire is twice that calculated as the radiated power [Equ. (19)]. This difference in power is stored in the energy of the induction field, in this case the magneto-static field which remains as time t approaches infinity.

The Disc Transmission Line

The disc transmission line is formed by placing two parallel conducting plates perpendicular to the Z axis of Fig. 2 and energizing it by the intercept of the current filament along this axis.

If the separation between the plates is z, the parameters of the transmission line are as follows:

$$\left.\begin{aligned} &\text{Distributed capacitance} = \frac{\epsilon_0 2\pi\rho}{z} \\ &\text{Distributed inductance} = \frac{\mu_0 z}{2\pi\rho} \end{aligned}\right\} \quad \cdots \quad (22)$$

Writing equations (12) and (15) in terms of the line voltage v and current i gives

$$\left.\begin{aligned} v &= \frac{\eta_0 z}{2\pi} \times \frac{I}{\sqrt{c^2t^2 - \rho^2}} \\ i &= I\frac{ct}{\sqrt{c^2t^2 - \rho^2}} \end{aligned}\right\} \quad \cdots \quad (23)$$

The differential equations governing the lossless disc transmission line may be written as follows:

$$\left.\begin{aligned} \frac{\partial i}{\partial \rho} &= \frac{-\epsilon_0 2\pi\rho}{z}\frac{\partial v}{\partial t} \\ \frac{\partial v}{\partial \rho} &= \frac{-\mu_0 z}{2\pi\rho}\frac{\partial i}{\partial t} \end{aligned}\right\} \quad \cdots \quad (24)$$

It can be verified readily that the formulae from Equ. (23), which were derived from the equivalent radiator, satisfy the disc transmission line equations (24).

Conclusion

It is deduced that an infinite plane irrotational current sheet has the ability to radiate a plane TEM wave which is a faithful reproduction of the time variation of current in the sheet. This has been demonstrated for the particular case of a step function, but can be taken as applicable to an arbitrary time function since the latter can be regarded as the superposition of a suitable series of step functions. Thus there is no anomaly in the behaviour of a parallel-plate transmission line carrying a plane TEM wave as compared with the behaviour of its equivalent radiator.

As an additional exercise, the equivalence between a disc transmission line and the radiation from an infinite current filament has been demonstrated. It is noted that this radiator is unable to radiate a faithful reproduction of an impressed step function of current.

REFERENCE

[1] E. B. Moullin. *J. Instn elect. Engrs*, 1944, Vol. 91, p. 23 and p. 14.

MATHEMATICAL TOOLS **By Computer**

Relative Merits of Alternative Methods of Extracting Roots and Solving Equations

In the March issue of *Electronic & Radio Engineer*, Mr. D. T. Broadbent drew attention to an alternative method of extracting roots based upon a note by Mr. W. B. Jordan in *Mathematical Tables and Aids to Computation* (July 1951, Vol. 5, p. 183). He rightly pointed out that in some respects Jordan's method was superior to that given in "Mathematical Tools" of January 1958.

If we wish to understand the essential nature of an object or an abstract idea, comparison with something similar but not identical is often extremely helpful. Similarities and differences are easily seen, whereas much of the essential nature of a single object or idea is taken for granted. In this article, we therefore compare Jordan's method with those given in earlier "Mathematical Tools", both for extracting roots and more generally for solving equations. But first, Mr. Broadbent ought to be warmly thanked for providing the basis of comparison. It is very much to be hoped that he will be the first of many who, by bringing alternative methods to the notice of readers of *Electronic & Radio Engineer*, will significantly add to their knowledge and understanding.

In choosing a method for inclusion in "Mathematical Tools" where alternatives are available, it has been assumed that simplicity is the prime consideration, rather than speed. The object has been to enable an engineer to carry out a necessary computation which he could not otherwise carry out at all, to bring to his notice obvious and widely-applicable labour-saving devices, and to increase his self-confidence where computation is concerned. If an engineer is spending say 5% of his time computing, and takes twice as long as he need, the loss is not serious ; the position is quite different in the case of anyone whose main occupation is computing. In the latter case, where a calculation may have to be repeated hundreds of times, any process which saves time on each step is worth serious consideration.

Mr. Jordan's method amounts (as pointed out by Mr. Broadbent) to saying that if y_1 is an approximation to a root of an equation $F(y) = 0$, then

$$y_2 = y_1 - \frac{2\,F(y_1)\,F'(y_1)}{2\,\{F'(y_1)\}^2 - F(y_1)\,F''(y_1)} \quad \ldots \quad \ldots \quad (1)$$

is a much better approximation. In (1) $F'(y_1)$ means the derivative of $F(y)$ when $y = y_1$ and $F''(y_1)$ means the second derivative, also with y replaced by y_1 after differentiation. There is little restriction upon the nature of $F(y)$, except that it must be continuous, and differentiable at least twice, in the neighbourhood of its zeros. If (1) is used for finding $\sqrt[n]{N}$, $F(y)$ is $y^n - N$, but (1) can be used also when $F(y)$ is any polynomial. It can even be used when we are seeking complex roots of algebraic equations, for $F(y)\;F'(y)$, $\{F'(y)\}^2$ and $F(y)\;F''(y)$ are then all polynomials in y. If we require their value when $y = a + bj$, we divide by $(y^2 - 2ay + a^2 + b^2)$ and put $y = a + bj$ in the (linear) remainder, as mentioned in last May's "Mathematical Tools".

The reason why y_2 is a better approximation than y_1 is fundamentally geometrical, when y_1 and y_2 are real. Equation (1) is essentially an improvement of Newton's

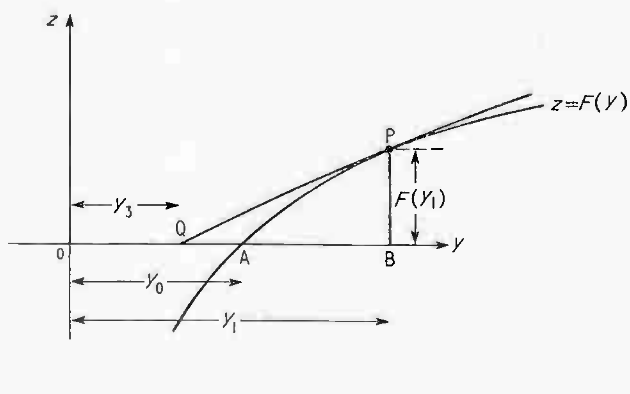

Fig. 1. *The geometry of Newton's approximation*

method of saying that a better approximation than y_1 to the zero y_0 of $F(y)$ is

$$y_3 = y_1 - \frac{F(y_1)}{F'(y_1)} \quad \ldots \quad (2)$$

In Fig. 1, 0 is the origin and $0y$, $0z$ are rectangular axes; the curve is $z = F(y)$. The true zero of $F(y)$ is represented by the point A with co-ordinates $(y_0, 0)$ where the curve crosses the y-axis. The improved approximation y_3 is obtained by finding where the tangent PQ to the curve at the point P meets $0y$; P is the point whose co-ordinates are $[y_1, F(y_1)]$, associated with the initial approximation y_1. Now the main error, represented by AQ in Fig. 1, introduced by Equ. (2) is due to the curvature of $z = F(y)$. The object of Equ. (1) is to "straighten out" this curvature. Equ. (1) is obtained from Equ. (2) by replacing $F(y)$ by $G(y)$ where

$$G(y) = F(y)/\{F'(y)\}^{\frac{1}{2}} \quad \ldots \quad (3)$$

$G(y)$ in (3) has the same zeros as $F(y)$, but has zero curvature at each of them.

Clearly, if the slope of the line PQ is small, it will be difficult to determine Q accurately and QA may be large. (1) will therefore not be very satisfactory for an equation which has equal or nearly equal roots. Such roots are not common in practical equations of degree not exceeding 7, though in equations of high degree, say 12 or more, they often do occur. Hence, for the equations likely to occur in electrical engineering, (1) must be regarded as obviously worth trying. Once y_1 is close to y_0, y_2 obtained from (1) will be very close indeed when $F'(y_1)$ is not unduly small.

A disadvantage of (1) for a general equation of degree n is that the numerator and denominator are respectively of degrees $(2n-1)$ and $(2n-2)$ whereas, with the Lin method, given in "Mathematical Tools" of February and March 1957, all manipulations consist of divisions of the original polynomial of degree n by a linear or quadratic expression. This disadvantage, however, does not apply in the case of square-root extraction cited by Mr. Broadbent, for then $F(y)$, $F'(y)$ and $F''(y)$ are all very simple expressions, as they are when a cube or higher root is extracted.

On the other hand, it is sometimes necessary to derive a square root to accuracy only slightly greater than that easily obtainable by means of slide rule or tables. If a is the approximation and it is divided into N whose square root we require, the result N/a of the division is on one register of the calculating machine, while a is on another; their averaging to obtain a better approximation to $\sqrt{N}$ can be done mentally, whereas the application of Equ. (1), though straightforward, does involve a separate calculation. This will give $\sqrt{N}$ to an unnecessarily high degree of accuracy, and no advantage can be gained with the excessive accuracy.

We shall now consider a number of examples which have already appeared in "Mathematical Tools", and apply (1). Comment will be purely explanatory, so that the reader is left free to choose the method he prefers. This choice is partly subjective—a matter of temperament.

Example 1. Extraction of $\sqrt{2}$ with $1\cdot4$ as starting approximation. This was discussed in "Mathematical Tools" of January 1958. Two applications of the averaging process there used gave $1\cdot414213565$, whose square is $2 + 7 \times 10^{-9}$. The first application of (1) gives (using Broadbent's simplification)

$$y_2 = y_1 \times \frac{y_1^2 + 3N}{3y_1^2 + N} = 1\cdot4 \times \frac{7\cdot96}{7\cdot88} = 1\cdot4142132$$

the square of which is $2 - 1 \times 10^{-6}$.

Example 2. Extraction of $\sqrt[6]{800}$ starting with 3. A result $3\cdot046834$, in error by about 1 in 10^6, was obtained from two applications of the process given in the January 1958 "Mathematical Tools". The first application of (1) with $y_1 = 3$ gives

$$y_2 = y_1 \left[1 - \frac{2\,(y_1^6 - 800)}{7y_1^6 + 5 \times 800}\right] = 3\left[1 + \frac{142}{9103}\right] = 3\cdot046798.$$

Example 3. Solving the cubic equation

$$F(y) = (y+1\cdot5)\,(y+4\cdot5)\,(y+12)$$
$$= y^3 + 18y^2 + 78\cdot75y + 81 = 0$$

starting with $y_1 = -1\cdot7$. This was discussed in the February 1957 "Mathematical Tools". We find from Equ. (1)

$$y_2 = -1\cdot7 - \frac{2 \times (-5\cdot768) \times (26\cdot22)}{2 \times 687\cdot4884 - (-5\cdot768) \times (25\cdot8)} = -1\cdot5015$$

Example 4. Solving the equation $F_4(y) = 0$ where $F_4(y) = y^4 + 3y^3 + 12y^2 + 11y + 9 = (y^2+y+1)\,(y^2+2y+9)$ starting with the quadratic-factor approximation

$$y^2 + 0\cdot92y + 0\cdot75$$

This was discussed in the March 1957 "Mathematical Tools". Using (1) with $y_1 = -0\cdot46 + j\sqrt{0\cdot5384} = -0\cdot46 + 0\cdot733757j$, we have

$$F_4(y) = (y^2 + 0\cdot92y + 0\cdot75)\,(y^2 + 2\cdot08y + 9\cdot3364) + 0\cdot850512y + 1\cdot9977$$
$$F_4(y_1) = 1\cdot9977 + 0\cdot850512\,(-0\cdot46 + 0\cdot733757j) = 1\cdot606464 + 0\cdot624069j$$
$$F'_4(y) = (y^2 + 0\cdot92y + 0\cdot75)\,(4y + 5\cdot32) + 16\cdot1056y + 7\cdot01$$
$$F'_4(y_1) = 7\cdot01 + 16\cdot1056\,(-0\cdot46 + 0\cdot733757j) = -0\cdot398576 + 11\cdot817597j$$
$$F''_4(y) = 12\,(y^2 + 0\cdot92y + 0\cdot75) + 6\cdot96y + 15$$
$$F''_4(y_1) = 15 + 6\cdot96\,(-0\cdot46 + 0\cdot733757j) = 11\cdot7984 + 5\cdot106949j$$

so that

$$y_2 = y_1 - \frac{2\,(1\cdot606464 + 0\cdot624069j)\,(-0\cdot398576 + 11\cdot817597j)}{2\{-139\cdot496736 - 9\cdot420421j\} - \{1\cdot606464 + 0\cdot624069j\}\{11\cdot7984 + 5\cdot106949j\}}$$
$$= -0\cdot49901 + 0\cdot86544j$$

and the corresponding quadratic factor is

$$y^2 + 0\cdot99802y + 0\cdot99800$$

which has errors only in the third significant figure.

Example 5. Solving the equation

$$F_5(y) = y^4 + 4y^3 + 8y^2 + 8y + 3\cdot99 = 0$$

which was discussed in the "Mathematical Tools" of March 1957. If the number term is raised to 4, $F_5(y)$ would become $(y^2 + 2y + 2)^2$, so we are dealing with a case of nearly equal roots. In the March 1957 "Mathematical Tools", it was suggested that the presence of equal or nearly equal roots can be suspected by applying the "H.C.F. process" to $F_5(y)$ and $F_5'(y)$, and that this indicates that $(y^2 + 2y + 1{\cdot}99)$ is nearly a repeated factor of $F_5(y)$. We therefore apply (1) with $y_1 = -1 + j\sqrt{0{\cdot}99}$ or $-1 + 0{\cdot}994987j$ in an exploratory manner. We find, proceeding as in Example 4,

$$F_5(y) = (y^2 + 2y + 2)^2 - 0{\cdot}01$$
$$F'_5(y) = 4(y + 1)(y^2 + 2y + 2)$$
$$F''_5(y) = 12(y + 1)^2 + 4$$

and $y_1 + 1 = 0{\cdot}994987j$; $y_1^2 + 2y_1 = -1{\cdot}99$, so that $F_5(y_1) = -0{\cdot}0099$; $F'_5(y_1) = 0.0397995j$; $F''(y_1) = -7{\cdot}88$ whence, from equation (1), $y_2 = -1 + 0{\cdot}98728j$. Continuing the process defined by equation (1) with y_2 instead of y_1, we obtain as our next approximation $y_3 = -1 + 0{\cdot}96696j$, and repeating the process twice more gives $y_4 = -1 + 0{\cdot}94968j$ and $y_5 = -1 + 0{\cdot}948683j$, the last being a root of $F_5(y) = 0$ correct to six places.

It thus seems to be roughly true that two applications of the root-extraction process suggested in the January 1958 "Mathematical Tools" are equivalent to one of the Jordan process [Equ. (1)], and the same two-to-one ratio seems also to hold when equations have to be solved. The "Mathematical Tools" processes for solving equations, however, are confined to algebraic operations on the original polynomial, and it is not normally necessary to obtain its derivatives or their numerical values at particular points. Example 5, however, was deliberately chosen to be unfavourable to the Jordan process, which has given an accurate result after four applications. Any process for solving equations with equal or nearly equal roots involves consideration of $F'(y)$ as well as $F(y)$, and we took as our starting-point the factor $y^2 + 2y + 1{\cdot}99$ in Example 5, derived by using the "H.C.F. process". Without this favourable start, a solution would have been difficult to obtain by any method.

Stagger-Tuned Band-Pass Amplifiers

DESIGN FOR PRESCRIBED OVERSHOOT

By Yona Peless*, M.S.E.E.

SUMMARY. *A procedure for designing band-pass amplifiers having specified gain, overshoot and either bandwidth or rise time is given. The design is limited to the narrow-band case and is based on the theory of transitional Butterworth-Thomson networks developed in an earlier paper. Detailed data covering single-tuned cascades consisting of five stages or less is included.*

In a recent paper[1] the theory of transitional Butterworth-Thomson (t.b.t.) filters and band-pass amplifiers was established. It was there pointed out that the maximally-flat amplitude (m.f.a.) network has a step response with a relatively fast rise but substantial overshoot ; the maximally-flat envelope delay (m.f.e.d.) network on the other hand has a slower rise coupled with smaller overshoots. The t.b.t. network was shown to have steady state and transient characteristics which may be made to lie between, or beyond, those of the m.f.a. and m.f.e.d. networks. This leads to the possibility of a systematic procedure for exchanging bandwidth for overshoot. The purpose of this paper is to present such a straight-forward procedure for the design of band-pass amplifiers for specified gain, maximum permissible overshoot, and either a specified bandwidth or rise time.

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Design for Specified Bandwidth

It was shown in reference 1 that the gain-bandwidth factor[2] (g.b.f.) of a t.b.t. band-pass amplifier is equal to $2\pi B'$ where B' is the 3-dB normalized bandwidth, and the normalization is carried out so that $2\pi B' = 1$ for m.f.a. networks. Hence

$$(\text{g.b.f.}) = \frac{G^{1/n}B}{g_m/2\pi C} = 2\pi B' \qquad \ldots \quad (1)$$

now define the 'bandwidth factor' as

$$\beta = \frac{B}{g_m/2\pi C} \qquad \ldots \quad (2)$$

We therefore have

$$20 \log_{10} G = G_{\text{dB}} = 20n \log_{10}(2\pi B') - 20n \log_{10}\beta \quad (3)$$

where n is the number of stages, g_m and C the mutual conductance of the valve and the interstage capacitance. G and B are the total gain and overall 3-dB bandwidth of the amplifier respectively.

Equation (3), plotted on a logarithmic scale for β and

TABLE 1

Normalized Bandwidth, Rise-Time and Overshoots of T.B.T. Networks

n		$m = -0{\cdot}2$	0	0·2	0·4	0·6	0·8	1·0	1·2
2	$2\pi B'$	1·054	1	0·949	0·902	0·859	0·820	0·786	0·756
	τ'	2·04	2·15	2·27	2·39	2·50	2·62	2·73	2·84
	$\gamma\%$	5·91	4·3	3·04	2·07	1·32	0·79	0·43	0·21
3	$2\pi B'$	1·064	1	0·933	0·868	0·810	0·756	0·712	0·671
	τ'	2·16	2·29	2·44	2·59	2·74	2·90	3·07	3·23
	$\gamma\%$	11·1	8·15	5·74	3·87	2·45	1·43	0·75	0·30
4	$2\pi B'$	1·064	1	0·924	0·845	0·774	0·712	0·659	0·617
	τ'	2·29	2·43	2·59	2·77	2·95	3·14	3·36	3·53
	$\gamma\%$	14·9	10·9	7·58	5·01	3·12	1·75	0·83	0·29
5	$2\pi B'$	1·064	1	0·916	0·824	0·740	0·671	0·617	0·572
	τ'	2·40	2·56	2·74	2·94	3·15	3·36	3·58	3·81
	$\gamma\%$	17·6	12·8	8·82	5·71	3·46	1·83	0·75	0·18

linear scale for G measured in dB is a straight line.* Using the values for $2\pi B'$ given in table 1 the curves for $n = 2$, 3, 4 and 5 were plotted in Fig. 1, the parameter being the percentage of overshoot γ. The parameter m indicated on the lines varies the location of the poles of the transfer function. For the m.f.a. filter $m = 0$ and for the m.f.e.d. filter $m = 1$. Given the overall desired bandwidth B we may find β for the chosen valve. The values of G and β determine a point on Fig. 1. If the overshoot corresponding to a line that passes near this point is too large, a line corresponding to a greater number of stages and less overshoot may be found in its vicinity. By the use of Table 2 the location of the poles of the transfer function corresponding to the selected m and n may be found.

The elements of the tuned circuits may then be computed by the use of the following equations[1]:

$$p'_k = 2\pi \frac{B}{2} (\sigma_k + j\omega_k) \frac{1}{2\pi B'} + j\, 2\pi f_0 \quad \ldots \quad (4)$$

$$f'_k = f_0 + \frac{B}{2}\, \omega_k \cdot \frac{1}{2\pi B'} \quad \ldots \quad (5)$$

$$b_k = \frac{B}{2\pi B'} (-\sigma_k) \quad \ldots \quad (6)$$

$$L_k = \frac{1}{(2\pi f'_k)^2 C} \quad \ldots \quad (7)$$

and

$$R_k = \frac{B'}{C\,(-\sigma_k)\, B} \quad \ldots \quad (8)$$

where

p'_k is the location of the kth pole of the amplifier's transfer function.

σ_k and ω_k are the real and imaginary parts of p_k given in Table 2.

* This graph is similar to one used for m.f.a. by B. A. Wightman[3].

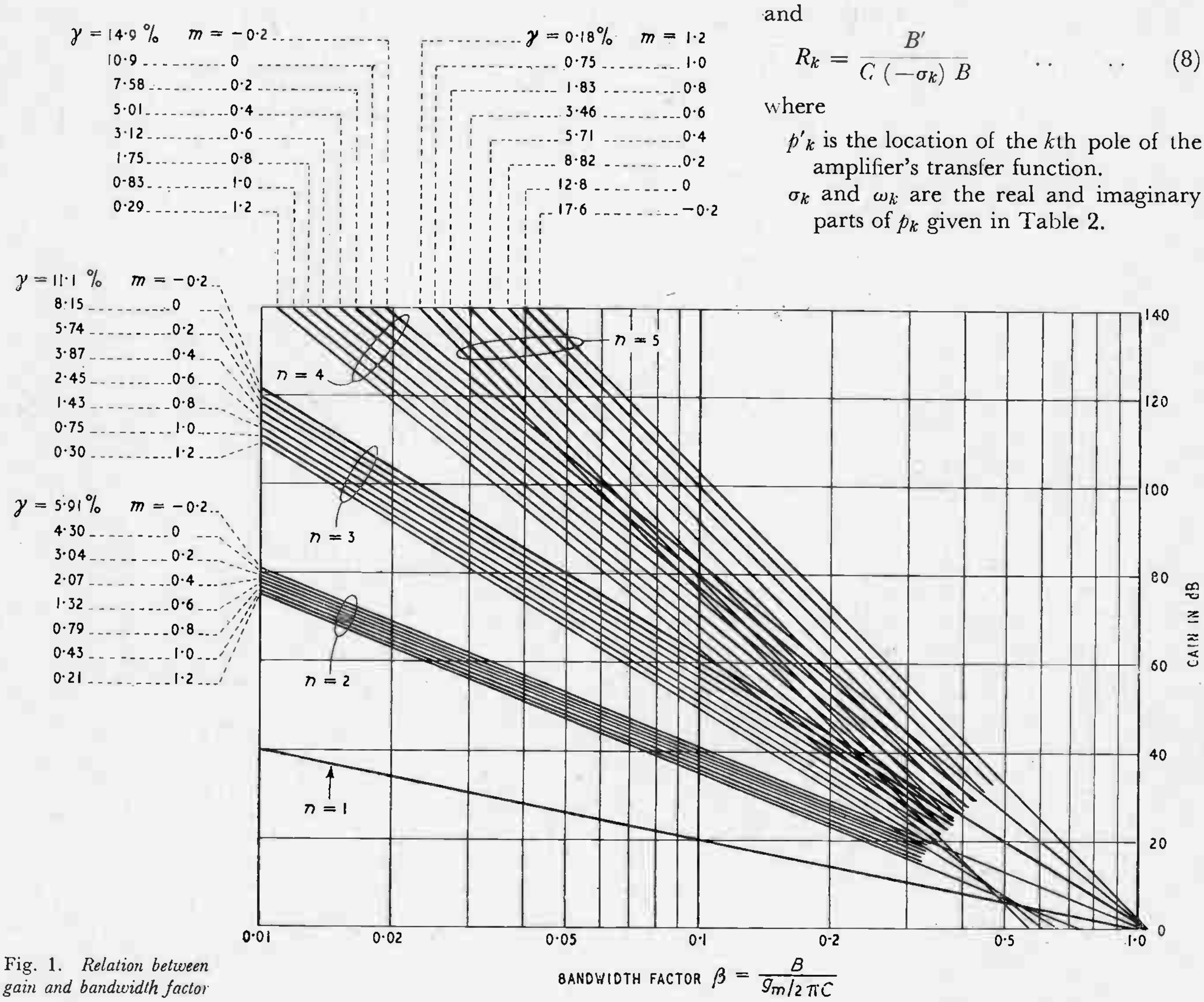
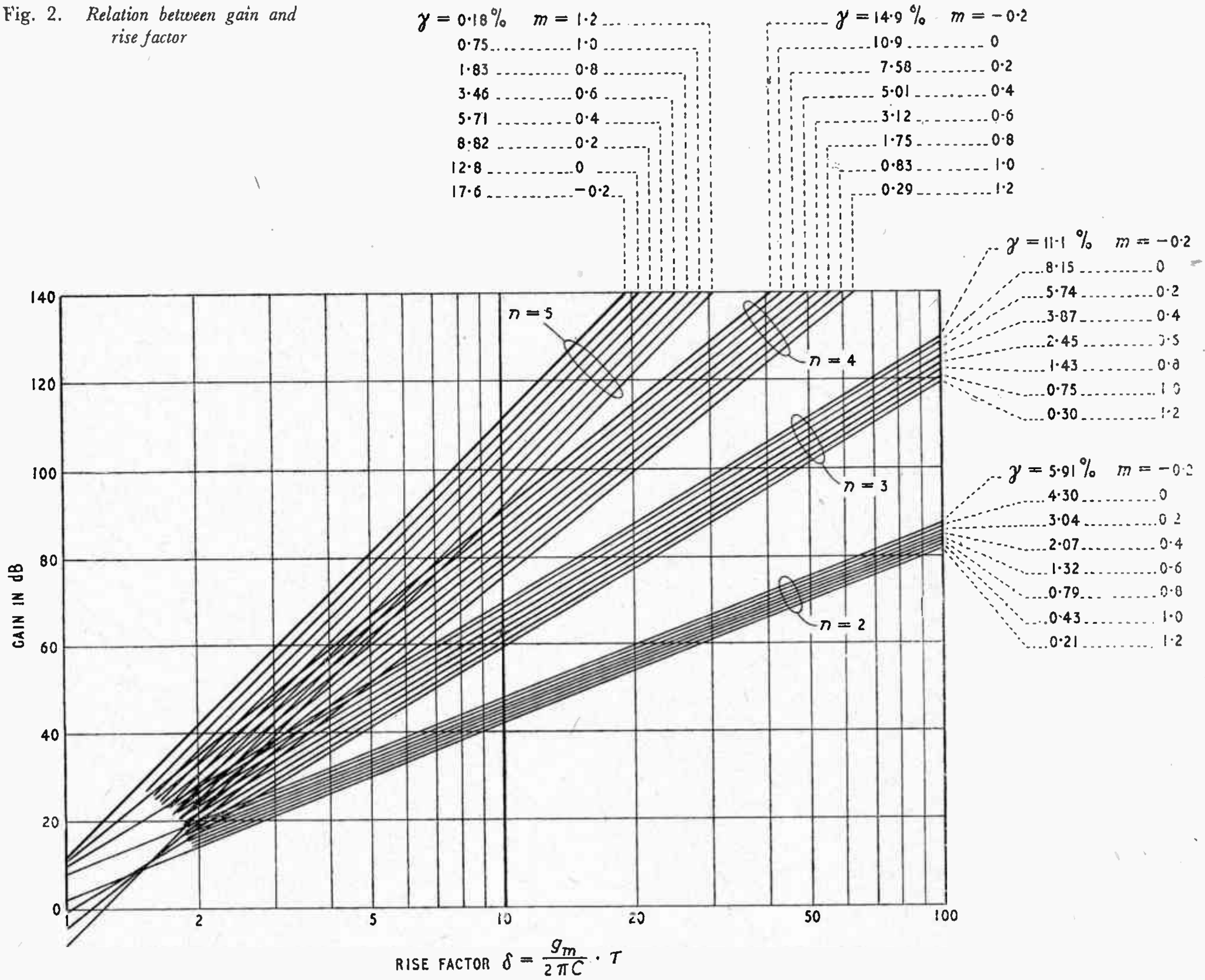


Fig. 1. *Relation between gain and bandwidth factor*

Fig. 2. *Relation between gain and rise factor*



f_0 is the centre frequency of the amplifier.
b_k is the 3-dB bandwidth of the kth stage.
$\omega_k = 2\pi f_k$.
L_k, R_k are the inductance and resistance of a parallel-tuned interstage network.
C is the total interstage capacitance.

Design for Specified Rise Time

The normalization used in reference 1 leads to the following relationship for the low-pass filter:

$$\tau' B' = \tau B$$

where τ' is the normalized 10 to 90 per cent rise time.
τ is the actual rise time in seconds.

TABLE 2

Location of Poles of T.B.T. Networks

n		$m = -0{\cdot}2$	0	0·2	0·4	0·6	0·8	1·0	1·2
2	p_1, p_2	−0·6691 ±j0·7431	−0·7071 ±j0·7071	−0·7431 ±j0·6691	−0·7771 ±j0·6293	−0·8090 ±j0·5878	−0·8387 ±j0·5446	−0·8660 ±j0·5000	−0·8910 ±j0·4540
3	p_1 p_2, p_3	−1·0121 −0·4471 ±j0·8877	−1·0000 −0·5000 ±j0·8660	−0·9880 −0·5519 ±j0·8411	−0·9764 −0·6026 ±j0·8131	−0·9645 −0·6515 ±j0·7823	−0·9530 −0·6997 ±j0·7481	−0·9416 −0·7456 ±j0·7114	−0·9304 −0·7899 ±j0·6717
4	p_1, p_2 p_3, p_4	−0·3273 ±j0·9328 −0·9264 ±j0·4060	−0·3827 ±j0·9239 −0·9239 ±j0·3827	−0·4381 ±j0·9117 −0·9209 ±j0·3596	−0·4937 ±j0·8961 −0·9175 ±j0·3369	−0·5488 ±j0·8775 −0·9136 ±j0·3146	−0·6034 ±j0·8553 −0·9094 ±j0·2925	−0·6572 ±j0·8301 −0·9047 ±j0·2709	−0·7101 ±j0·8017 −0·8998 ±j0·2495
5	p_1 p_2, p_3 p_4, p_5	−1·0154 −0·7975 ±j0·6168 −0·2544 ±j0·9507	−1·0000 −0·8090 ±j0·5878 −0·3090 ±j0·9511	−0·9848 −0·8195 ±j0·5587 −0·3641 ±j0·9485	−0·9699 −0·8289 ±j0·5297 −0·4205 ±j0·9428	−0·9552 −0·8373 ±j0·5008 −0·4767 ±j0·9342	−0·9408 −0·8449 ±j0·4718 −0·5338 ±j0·9221	−0·9265 −0·8516 ±j0·4427 −0·5906 ±j0·9072	−0·9125 −0·8574 ±j0·4138 −0·6478 ±j0·8888

For a given bandwidth the band-pass amplifier yields only half as much speed as does the corresponding low-pass filter. We therefore have:

$$\tau' . B' = \frac{\tau . B}{2} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (9)$$

hence using equation (2) for B and defining the rise factor δ as

$$\delta = \frac{g_m}{2\pi C} . \tau$$

We may now write

$$\delta = \frac{\tau' . 2\pi B'}{\beta\pi}$$

$$\text{or } \beta = \frac{\tau' . 2\pi B'}{\pi\delta} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (11)$$

From equations (1) and (11)

$$G = \left[\frac{\pi\delta}{\tau'}\right]^n$$

$$\text{or } G_{dB} = 20\, n \log_{10} \delta - 20\, n \log_{10} \frac{\tau'}{\pi} \quad .. \quad (12)$$

Equation (12) gives straight lines on a log-linear paper and is shown in Fig. 2 for the same values of m and n as in Fig. 1. Making use of Equ. (9), Equ. (8) is modified to give:

$$R_k = \frac{\tau}{2C\tau'} \cdot \frac{1}{(-\sigma_k)} \quad .. \quad .. \quad .. \quad .. \quad (13)$$

The design procedure is the same as explained above for the case of prescribed bandwidth.

Example: Design a band-pass amplifier having 80-dB gain at the centre frequency 80 Mc/s. The envelope rise time should not exceed $0 \cdot 120\ \mu$sec and the overshoot should be very small (less than $0 \cdot 5\%$).

Using 6AK5 pentodes with $g_m = 5$ mA/V and inter-stage capacitance $C = 12$ pF we find the figure of merit of the valve:

$$\frac{g_m}{2\pi C} = 66 \cdot 3 \text{ Mc/s}.$$

and as $\tau \leqslant 0 \cdot 12\ \mu$sec.

$$\delta = \frac{g_m}{2\pi C}\ \tau \leqslant 7 \cdot 96$$

In Fig. 2, two lines cross the 80-dB gain at values of δ a little less than $7 \cdot 96$. One line belongs to the group $n = 4$ with very high overshoot ($10 \cdot 9\%$). The other crossing the 80-dB line at $\delta = 7 \cdot 65$ belongs to the $n = 5$ group and has very small overshoot $\gamma = 0 \cdot 18\%$. For this line $m = 1.2$.

TABLE 3

k	f'_k (Mc/s)	b_k (Mc/s)	g_k
1	80	9·59	8·36
2	82·21	9·01	8·90
3	79·79	9·01	8·90
4	84·74	6·81	11·8
5	75·26	6·81	11·8

Note: If the bandwidth of the amplifier to be designed is given instead of the rise time, the procedure is the same except that Fig. 1 is used instead of Fig. 2.

Using Tables 1 and 2 we find:

$$2\pi B' = 0 \cdot 572\ ;\ \tau' = 3 \cdot 81$$
$$p_1 = -0 \cdot 9125$$
$$p_2\ ;\ p_3 = -0 \cdot 8574 \pm j\, 0 \cdot 4138$$
$$p_4\ ;\ p_5 = -0 \cdot 6478 \pm j\, 0 \cdot 8888$$

We now find the rise time and bandwidth:

$$\tau = \frac{\delta}{g_m/2\pi C} = \frac{7 \cdot 65}{66 \cdot 3 \text{ Mc/s}} = 0 \cdot 115\ \mu\text{sec}$$

$$B = \frac{2\tau' B'}{\tau} = 6 \cdot 01 \text{ Mc/s}$$

The resonant frequencies of the individual stage f'_k, and the 3-dB bandwidths of each stage b_k are found from Equs (5) and (6) and given in Table 3. The gain of each stage at its resonant frequency ($g_k = g_m R_k$) is also given.*

* Curves for steady state and transient response of the t.b.t. filters and band-pass amplifiers are given in reference 1.

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[2] G. E. Valley and H. Wallman, "Vacuum Tube Amplifiers" (M.I.T. Radiation Laboratory Series, Vol. 18), McGraw-Hill Book Co., Inc., p. 172.

[3] B. A. Wightman, "A Graphical Means for Determining the Number and Order (n) of n-uples in Stagger-Tuned Amplifier Design", National Research Council of Canada, Ottawa, December 1951.

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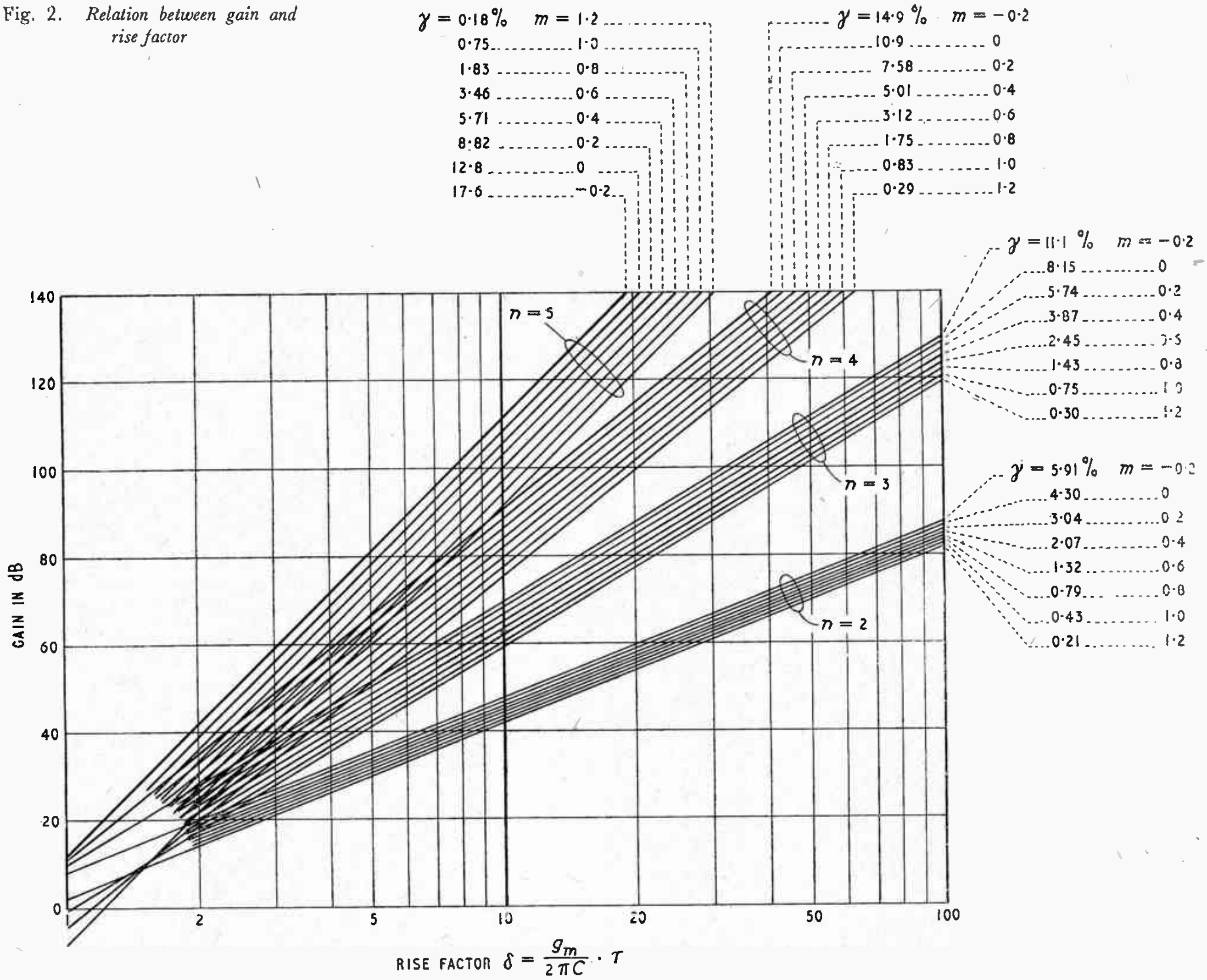
R. H. Cole (Overseas) Ltd., 2 *Caxton Street, London, S.W.*1.

Fig. 2. *Relation between gain and rise factor*



f_0 is the centre frequency of the amplifier.
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3	p_1 p_2, p_3	−1·0121 −0·4471 $\pm j$0·8877	−1·0000 −0·5000 $\pm j$0·8660	−0·9880 −0·5519 $\pm j$0·8411	−0·9764 −0·6026 $\pm j$0·8131	−0·9645 −0·6515 $\pm j$0·7823	−0·9530 −0·6997 $\pm j$0·7481	−0·9416 −0·7456 $\pm j$0·7114	−0·9304 −0·7899 $\pm j$0·6717
4	p_1, p_2 p_3, p_4	−0·3273 $\pm j$0·9328 −0·9264 $\pm j$0·4060	−0·3827 $\pm j$0·9239 −0·9239 $\pm j$0·3827	−0·4381 $\pm j$0·9117 −0·9209 $\pm j$0·3596	−0·4937 $\pm j$0·8961 −0·9175 $\pm j$0·3369	−0·5488 $\pm j$0·8775 −0·9136 $\pm j$0·3146	−0·6034 $\pm j$0·8553 −0·9094 $\pm j$0·2925	−0·6572 $\pm j$0·8301 −0·9047 $\pm j$0·2709	−0·7101 $\pm j$0·8017 −0·8998 $\pm j$0·2495
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hence using equation (2) for B and defining the rise factor δ as

$$\delta = \frac{g_m}{2\pi C} . \tau$$

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$$G = \left[\frac{\pi\delta}{\tau'}\right]^n$$

$$\text{or } G_{dB} = 20\, n \log_{10} \delta - 20\, n \log_{10} \frac{\tau'}{\pi} \quad .. \quad (12)$$

Equation (12) gives straight lines on a log-linear paper and is shown in Fig. 2 for the same values of m and n as in Fig. 1. Making use of Equ. (9), Equ. (8) is modified to give:

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The design procedure is the same as explained above for the case of prescribed bandwidth.

Example: Design a band-pass amplifier having 80-dB gain at the centre frequency 80 Mc/s. The envelope rise time should not exceed $0 \cdot 120\ \mu$sec and the overshoot should be very small (less than $0 \cdot 5\%$).

Using 6AK5 pentodes with $g_m = 5$ mA/V and inter-stage capacitance $C = 12$ pF we find the figure of merit of the valve:

$$\frac{g_m}{2\pi C} = 66 \cdot 3 \text{ Mc/s.}$$

and as $\tau \leqslant 0 \cdot 12\ \mu$sec.

$$\delta = \frac{g_m}{2\pi C}\ \tau \leqslant 7 \cdot 96$$

In Fig. 2, two lines cross the 80-dB gain at values of δ a little less than $7 \cdot 96$. One line belongs to the group $n = 4$ with very high overshoot ($10 \cdot 9\%$). The other crossing the 80-dB line at $\delta = 7 \cdot 65$ belongs to the $n = 5$ group and has very small overshoot $\gamma = 0 \cdot 18\%$. For this line $m = 1.2$.

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We now find the rise time and bandwidth:

$$\tau = \frac{\delta}{g_m/2\pi C} = \frac{7 \cdot 65}{66 \cdot 3 \text{ Mc/s}} = 0 \cdot 115\ \mu\text{sec}$$

$$B = \frac{2\tau' B'}{\tau} = 6 \cdot 01 \text{ Mc/s}$$

The resonant frequencies of the individual stage f'_k, and the 3-dB bandwidths of each stage b_k are found from Equs (5) and (6) and given in Table 3. The gain of each stage at its resonant frequency ($g_k = g_m R_k$) is also given.*

* Curves for steady state and transient response of the t.b.t. filters and band-pass amplifiers are given in reference 1.

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Metal-Flake Artificial Dielectric

PROPERTIES AT S-BAND FREQUENCIES

By Shanker Swarup*

SUMMARY. *The validity of the various expressions suggested for the dielectric constant of the obstacle-type artificial dielectric has been checked at a wavelength of* 14·712 *cm. A new expression, which is a modification of the Clausius-Mossotti relation, has been suggested for the dielectric constant of metal-flake artificial dielectric. This expression predicts a value of dielectric constant which compares very well with the experimental results even for high-volume fractions of the metal flakes. The permeability of the artificial medium used here shows a maximum of* 1·16 *at about* 10% *concentration of the metal flake in the medium. Such abnormal behaviour is due to the presence of small ferrous impurity in the aluminium powder used.*

In connection with microwave optics, the search for a medium which would refract electromagnetic waves in the same way as glass refracts light waves led to the development of two types of material known as artificial dielectrics. The principal effect of actual dielectrics on electromagnetic radiation is to alter its velocity of propagation. An artificial dielectric is a device which can simulate this effect. One type consists essentially of an array of waveguides within which the phase velocity is greater than in free space; the effective refractive index is thus smaller than unity. Such a medium was developed independently in Britain[1], America[2] and Germany[3]. Artificial dielectric of the second type has a phase velocity less than in free space, resulting in a refractive index greater than unity. Such a medium was first proposed by Kapzov[4] as early as 1922; however, it was Kock[5] who put the same idea on a more practical and sound basis in 1948. Such an artificial dielectric consists of a cubic lattice of conducting elements having a size and separation which are small compared with the wavelength. A lot of work on this type of dielectric has been done by Susskind[6], Cohn[7], Corkum[8], Jackson and Brown[9] and many others. With decreasing wavelength, the metal elements and the spacing between them become exceedingly small, with the result that for wavelengths less than about 5 cm the construction of such a dielectric is impractical. Confronted with these difficulties, Carruthers[10] in 1951 proposed a dielectric medium suitable for shorter wavelengths, consisting of fine flake-shaped metal particles dispersed randomly through a lightweight vehicle. Further research on this metal-powder dielectric was continued by Vogan[11], Neugebauer[12] and Peppiatt[13] in Canada; Kelly[14] and co-workers in America; E. Meyer[15] and others in Germany and Mikaelian[16] in Russia.

Similar work on metal-flake artificial dielectric in the 14·712-cm wavelength region was carried out by the author. Fine aluminium flakes were homogeneously dispersed in paraffin wax and the dielectric property of the material was studied by the short-circuited line technique. The purpose of this investigation was to test the validity of different expressions for the dielectric constant of such a medium containing fairly high percentages of the metal flakes. Incidentally, the polarizability of the particles could also be determined.

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Experimental Technique

The various dielectric parameters κ_e, κ_m, $\tan \delta_d$ and $\tan \delta_m$ of the artificial dielectric were determined by the standard shorted-line method in which the input impedance of a section of a line filled with a sample of the material is measured for two terminations; viz., (1) a short circuit and (2) an open circuit.

The input impedance of the dielectric-filled section of waveguide is expressed in the following form[11] in terms of the reciprocal standing-wave ratio E_{min}/E_{max} and the position of the first minimum X_0 in the standing-wave pattern in front of the dielectric.

$$\frac{Z}{Z_0} = \frac{\dfrac{E_{min}}{E_{max}} - j \tan \dfrac{2\pi X_0}{\lambda_g}}{1 - j \dfrac{E_{min}}{E_{max}} \cdot \tan \dfrac{2\pi X_0}{\lambda_g}} \quad \cdots \quad (1)$$

where Z_0 is the characteristic wave impedance in air-filled waveguide and Z is the input impedance. From the values of short-circuit and open-circuit input impedance the normalized characteristic impedance and propagation constant in the dielectric-filled section of the waveguide can be calculated. Finally, the various dielectric and magnetic parameters can be evaluated. The four parameters are given by the following expressions.

$$\kappa_e = \frac{A \cos (\phi + \theta)}{B\,[1 + (\lambda_g/\lambda_c)^2]} + \frac{(\lambda_g/\lambda_c)^2}{AB \cos (\phi - \theta)\,[1 + (\lambda_g/\lambda_c)^2]} \quad \cdots \quad (2)$$

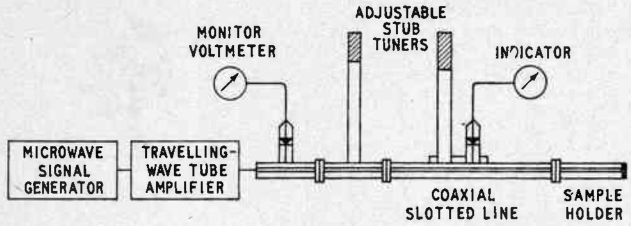


Fig. 1. *Schematic diagram of the arrangement for measurement of electric and magnetic properties of artificial dielectric in the 15-cm region*

$$\kappa_m = \frac{AB}{(1 + \tan^2 \delta_m)^{\frac{1}{2}}} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$$\tan \delta_m = -\tan (\phi - \theta) \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

$$\kappa_e \,.\, \tan \delta_d = \frac{A \sin (\phi + \theta)}{B\,[1 + (\lambda_g/\lambda_c)^2]} + \frac{\sin (\phi - \theta)}{A\,B\,[1 + (\lambda_g/\lambda_c)^2]} \quad \ldots \quad \ldots \quad (5)$$

where $A\,\underline{/-\theta} = \dfrac{\gamma_2 d}{j \cdot \dfrac{2\pi d}{\lambda_g}}$

and γ_2 = propagation constant in the dielectric-filled section of waveguide.

$$B\,\underline{/\phi} = \left[\frac{Z_{sc}}{Z_0} \cdot \frac{Z_{oc}}{Z_0}\right]^{\frac{1}{2}} = \text{normalized characteristic}$$

wave impedance of the dielectric-filled section of waveguide; Z_{sc} and Z_{oc} being the input impedance for a short-circuit or an open-circuit termination respectively.

Fig. 1 shows the general arrangement of the apparatus. The microwave power from a signal generator (Hewlett-Packard Model No. 614A) was first amplified by a travelling-wave tube amplifier (Hewlett-Packard Model No. 491A) and then fed into the line which consisted of a monitoring system, adjustable stub tuners, coaxial slotted line and a sample holder.

The coaxial-line sample holder is terminated in a short circuit in order to produce pronounced standing waves in the line. The position of a minimum is located with the help of a travelling probe in the slotted line. The sample is then inserted at the end of the line and terminated in a short circuit. The new position of the minimum and the reciprocal voltage standing-wave ratio are determined. Finally the sample is displaced from the short by a distance of $\lambda_g/4$ and the position of the minimum and reciprocal v.s.w.rs are again determined.

In these measurements, samples of length $\frac{5}{8}\lambda_{gd}$ were used; λ_{gd} being the guide wavelength inside the dielectric. The values of κ_e, κ_m, $\tan \delta_d$ and $\tan \delta_m$ can be calculated from the above measurements as indicated earlier.

Preparation of Sample

Aluminium powder was mixed and thoroughly stirred in molten paraffin wax. It was then allowed to solidify. The solid mass was scraped into fine flakes and put into a deep freeze for some time till it was quite crisp. It was then crushed to a very fine powder and desiccated for about twenty-four hours. A suitable jig and die were used to prepare the coaxial samples. This process ensures samples with homogeneous distribution of aluminium powder, as this is an important factor.

The exact percentage of aluminium in various samples was determined by the method used by Vogan[11]. A piece of the sample dissolved in liquid paraffin oil was acted upon by a solution of KOH. The volume of hydrogen generated, which is directly proportional to the amount of aluminium, was measured. The necessary calibration measurements were also made with known masses of aluminium powder.

Determination of Average Particle Size

In order to determine the average dimensions of an aluminium particle, some photomicrographs (magnification 43·34) of the aluminium powder were taken. One of such photographs is shown in Fig. 2. The linear dimensions of the aluminium particle were measured with the help of a travelling microscope which could be read accurately to one micron. In determining the average thickness of the particles again, the method employed by Vogan[11] was used. A small quantity of powder was allowed to form a monolayer film on the surface of water contained in a rectangular tank of known dimensions. The film was tightened by moving a board along the water surface, the board extending to the full length of the tank. The average thickness of the particle was given by the relation

Area of film × thickness × specific gravity = mass of powder.

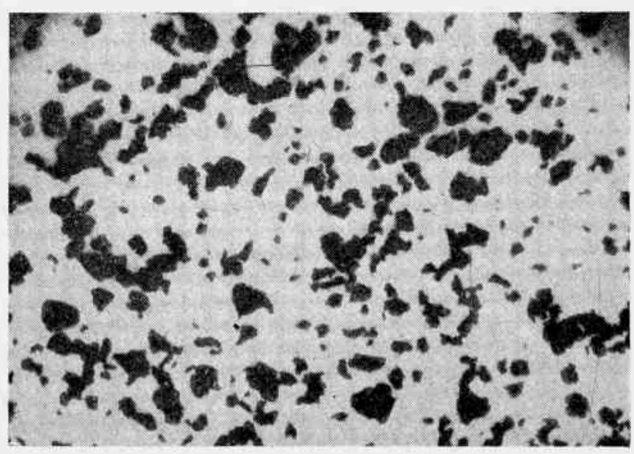
Results

Figs. 3, 4 and 5 illustrate the experimental values of κ_e, κ_m and $\tan \delta$ ($= \tan \delta_d + \tan \delta_m$) as a function of the volume concentration of aluminium flakes in the medium. Table 1 shows the experimental values of average particle dimensions; the particles were like elliptical discs.

TABLE I

Semi-major axis	..	..	..	24·34 micron
Semi-minor axis	..	..	..	18·10 ,,
Thickness	..	..	..	1·97 ,,

Fig. 2. *Photomicrograph of particles of aluminium powder (magnification 43·34)*



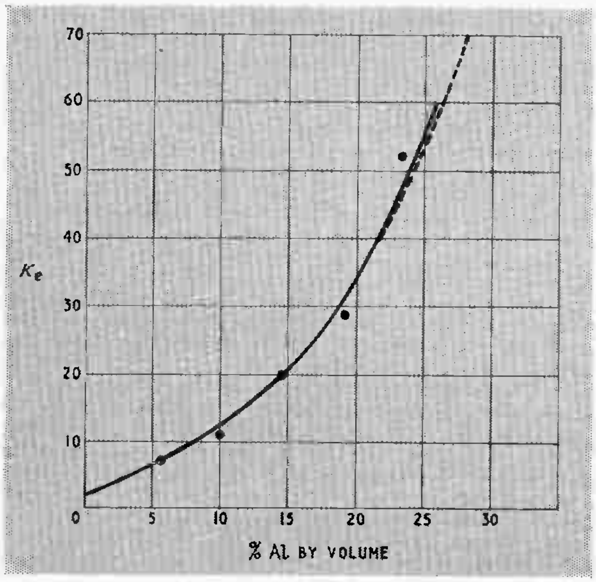


Fig. 3. *Dielectric constant κ_e, of aluminium flake–paraffin wax mixture as a function of the per-cent aluminium by volume*
[*Experimental* (————); *theoretical as obtained from Equ.* (11) (- - - - - -).]

Fig. 2 is a photomicrograph of aluminium flakes used and Fig. 6 shows the particle-size distribution.

Various Theoretical Expressions

Based upon the classical molecular theory, two fundamental expressions can be derived, depending upon whether or not interaction is assumed to be present between the obstacles of the artificial dielectric. The expression for the dielectric constant κ_e of the medium, after neglecting the interaction, is

$$\kappa_e = 1 + \frac{N\alpha_e}{\epsilon_0} \quad \ldots \quad (7)$$

where N is the number of particles per unit volume, α_e the electric polarizability and ϵ_0 is the free-space permittivity. This expression will hold exactly only if the spacing between the obstacles is large compared with their dimensions. Vogan[11] has tried to justify the expression

$$\kappa_e = \kappa + \frac{2}{3}\left(\frac{N\alpha_e}{\epsilon_0}\right) \quad \ldots \quad (8)$$

which has been obtained by taking the case of no interaction.

At high-volume fractions of aluminium, the interaction between the obstacles cannot be neglected. Taking into consideration this fact, one obtains the Clausius-Mossotti formula written in a modified form

$$\kappa_e = \kappa\left[\frac{1 + (2/3)\,(N\alpha_e/\epsilon_0)}{1 + (1/3)\,(N\alpha_e/\epsilon_0)}\right] \quad \ldots \quad (9)$$

where κ is the dielectric constant of the vehicle material.

Lewin[17], using the results of Mie[18] for the scattering of an incident plane-wave by a sphere, has calculated the bulk-dielectric constant and permeability of cubic arrays of spherical particles in terms of the particle-to-mixture

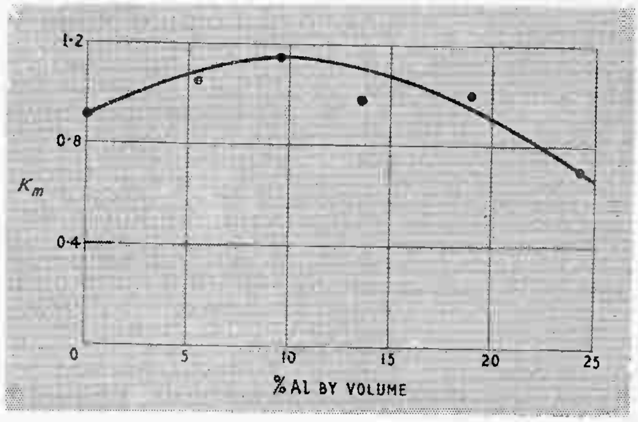


Fig. 4. *Permeability, κ_m, of aluminium flake–paraffin wax mixture as a function of per-cent aluminium by volume*

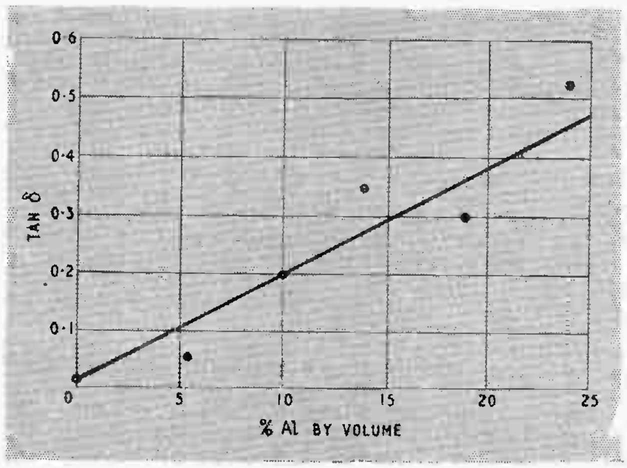
volume and the permeabilities and permittivities of the medium and the particle material. His results, when simplified, for the case of small spherical conducting particles give the same expression as (9) for the dielectric constant of the artificial medium.

Discussion of Results

Equ. (8), which does not take into consideration the mutual interaction of the particles, may predict the value of κ_e for very small values of volume fraction f, but in no case can it be applicable for higher volume fractions because then the particles are so close together that their interaction cannot be ignored.

The Clausius-Mossotti formula indicates that the polarizability of a particle is independent of the number of particles per unit volume. However, when the experimental results for aluminium–paraffin wax mixture are used to calculate α_e/ϵ_0 from the Clausius-Mossotti formula and the results plotted as a function of concentration, the resulting curve is not horizontal even for low values of f. Kelly[14] and co-workers have also found the same results with Zn and Al mixtures in paraffin wax. We may now conclude from this that even the Clausius-

Fig. 5. *Total loss tangent, tan δ, of aluminium flake–paraffin wax mixture as a function of per-cent aluminium by volume*



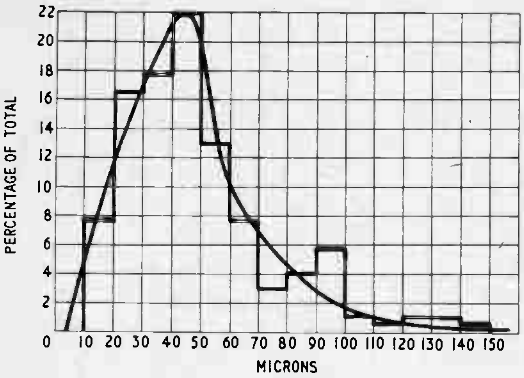


Fig. 6. *Particle size distribution of aluminium powder*

Mossotti formula is not able to predict the dielectric constant in the case of metal-flake artificial dielectric.

Now consider the Clausius-Mossotti formula (9) which can be written also as

$$\kappa_e = \kappa \cdot \left(1 + \frac{2}{3}\frac{\alpha_e}{\epsilon_0}N\right) \cdot \left(1 - \frac{1}{3}\frac{\alpha_e}{\epsilon_0}N\right)^{-1} \quad .. \quad (10)$$

Expanding the last factor by the binomial theorem and neglecting the cubic and higher terms, we obtain the following relation

$$\kappa_e = \kappa \cdot \left[1 + \left(\frac{\alpha_e}{\epsilon_0}\right)N + \frac{2}{9}\left(\frac{\alpha_e}{\epsilon_0}\right)^2 N^2\right] \quad .. \quad (11a)$$

or,

$$\kappa_e = \kappa \cdot \left[1 + \left(\frac{\alpha_e}{\epsilon_0}\right) \cdot \frac{f}{v_1} + \frac{2}{9}\left(\frac{\alpha_e}{\epsilon_0}\right)^2 \cdot \frac{f^2}{{v_1}^2}\right] \quad .. \quad (11b)$$

where v_1 is the average volume of the individual particle and f is the ratio of the volume of the particles in the mixture to the volume of the mixture.

The above equations (11) are found to give a value of dielectric constant which compares well with the experimental results. This can be seen from Fig. 3.

As another means of checking, the average polarizability of a particle was calculated from the particle geometry with the help of the formulae given by Susskind[6]. The particles were considered as thin elliptical discs. The value thus obtained is

$$\frac{\alpha_e}{\epsilon_0} = 0{\cdot}0861 \times 10^{-6} \quad .. \quad .. \quad .. \quad .. \quad (12)$$

It is the geometric mean of the two values obtained by assuming the electric vector to be parallel either to the major axis or to the minor axis of the elliptical discs.

The experimental results were then substituted in Equ. (11) and the value of α_e/ϵ_0 was calculated by taking the average of the values obtained for different values of f. The experimental value of α_e/ϵ_0 for the aluminium particles used was thus found to be

$$\frac{\alpha_e}{\epsilon_0} = (0{\cdot}0865 \pm 0{\cdot}0060) \,.\, 10^{-6} \quad .. \quad .. \quad (13)$$

This value is very close to that calculated [*vide* Equ. (12)] from the geometry of the particle.

The excellent correlation between the experimental and the theoretical values of κ_e or α_e/ϵ_0 has been obtained by using a modified Clausius-Mossotti relation where terms containing cubic and higher powers of N are neglected. This indicates that in such an artificial dielectric medium it is not possible either to neglect completely mutual interaction between the particles or to assume as high an interaction as considered by the Clausius-Mossotti relation.

In a purely dielectric medium the permeability is nearly unity. The permeability of an artificial dielectric medium containing conducting particles will decrease because the induced eddy current in the particles will produce opposing magnetic fields. The decrease in permeability occurs only when the conducting particles are aligned perpendicular to the magnetic vector. The decrease in the permeability is directly proportional to the concentration of the conducting particles because, at higher concentration, there are more particles which distort the field.

In the case examined here, it is found that the value of κ_m first increases with concentration, showing a maximum of 1·16 at about 10%, and then decreases with concentration. This abnormal behaviour can be explained by attributing it to the presence of a small ferrous impurity in the aluminium powder used. This impurity was detected by a spectroscopic analysis of the powder.

The loss-tangent tan δ, as shown in Fig. 5, is reasonably low and increases approximately linearly with the concentration of the particles. A detailed analysis of these losses has shown that the dielectric loss constitutes about 35% of the total loss.

The studies reported here, apart from their theoretical interest, indicate the possibility of having artificial media, for use at v.h.f. and microwaves, which can have controlled values of permittivity as well as permeability. A few such samples are being developed in this laboratory.

Acknowledgments

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Atmospheric Radio Noise*

EQUIPMENT FOR THE MEASUREMENT OF AMPLITUDE DISTRIBUTIONS

By J. Harwood, M.A., Ph.D. and C. Nicolson, B.Sc.

SUMMARY. *A description is given of equipment used to measure the characteristics of atmospheric noise. The measurements relate to the envelope of the noise after passage through a narrow-bandwidth receiver, and the following parameters were recorded:*

(*i*) *the average voltage*
(*ii*) *the average of the parts exceeding a series of voltages*
(*iii*) *the number of excursions per second above these voltages*
(*iv*) *the proportion of time for which these voltages were exceeded.*

A technique used at very low frequencies (10–40 kc/s) to measure the first three parameters has already been described[1], *together with the type of result obtained. More recently, the equipment was redesigned to cover a wider range of frequencies and amplitudes, and to introduce a direct measurement of the fourth parameter; this measurement was based on a technique of counting the r.f. cycles in the noise waveform at the receiver output. A method of automatically recording the parameters of the noise envelope is described.*

Measurements of the characteristics of atmospheric radio noise have been made for several years at the Radio Research Station, Slough. Descriptions have been published[1] of a basic technique of measurement and of the results obtained at low frequencies, but the equipment has not previously been described in detail. The measurements relate to the envelope of the noise after it has been received on an omni-directional aerial and passed through a narrow-bandwidth receiver. At the output of the receiver, the noise has been studied by recording its intensity and by measuring a number of statistical parameters related to its distribution of amplitude.

From 1953 to the present time, the equipment passed through various stages of development as techniques were improved and as interest was concentrated on different parameters of the noise. This development, outlined in the next section, may be viewed in two stages; first, the production of equipment used during the years 1953 to 1955 to measure a set of parameters at frequencies between 10 and 40 kc/s, and second, the more recent development of equipment for operation over a greater range of frequencies and amplitudes, in which different techniques were used to measure the amplitude distributions.

1. Survey of Equipment and Measured Parameters

The equipment to be described evolved from apparatus designed to measure average voltage; this apparatus consisted of a vertical aerial, a 'straight' low-frequency receiver, and an averaging unit. The frequency was restricted to the range 10 to 40 kc/s where atmospheric-noise intensities were greatest and station interference was not a serious problem. Recordings of the average voltage of the noise envelope, using 8-second charge and discharge time-constants, provided a measure of the noise intensity and its variations. Later, to examine the structure of the noise, a simple modification was made to the average voltage unit; a bias voltage was applied to the detector in this unit so that the average voltage could be measured of the parts of the envelope which exceeded each of a series of threshold voltages (average above a threshold). At the same time, shaping circuits and a ratemeter were added to count the number of times per second that the envelope exceeded each of these thresholds (pulse-rate).

With this equipment, incorporating automatic switching of thresholds, a large number of results was obtained at low frequencies.

More recently, as a result of experience gained in the operation of the equipment and analysis of the measurements, important modifications were made. The measurement of average above a threshold, which had been used mainly to derive the amplitude probability distribution by a graphical differentiation process[1], was replaced by a direct measurement of this distribution; the proportion of time for which each of a series of thresholds was exceeded (occupation-time) was measured by counting with a ratemeter the number of r.f. cycles per second which exceeded each threshold. The range of amplitude over which the distributions could be measured was increased by a change in voltage discrimination technique; direct variation of threshold voltage was replaced by variable amplification of the noise waveform before selection above a fixed threshold. Finally, the original straight low-frequency receiver was replaced by a superheterodyne receiver; in this

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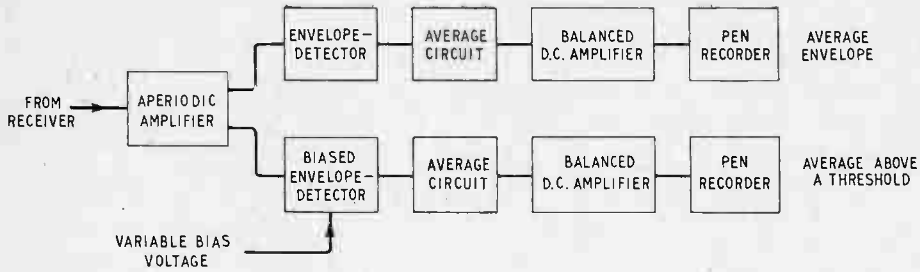


Fig. 1. *Measurement of average voltage*

way, the frequency-range of the noise measurements was extended while the waveform was made available for analysis at a fixed frequency of 10 kc/s for convenience in the r.f. cycle-counting technique. The modified receiving system consisted of a commercial superheterodyne followed by a frequency-changer and 10-kc/s tuned amplifier. It is interesting to note that the recent development of noise analysis equipment in Japan appears to have followed similar lines in using an r.f. cycle-counting technique at high frequencies[2].

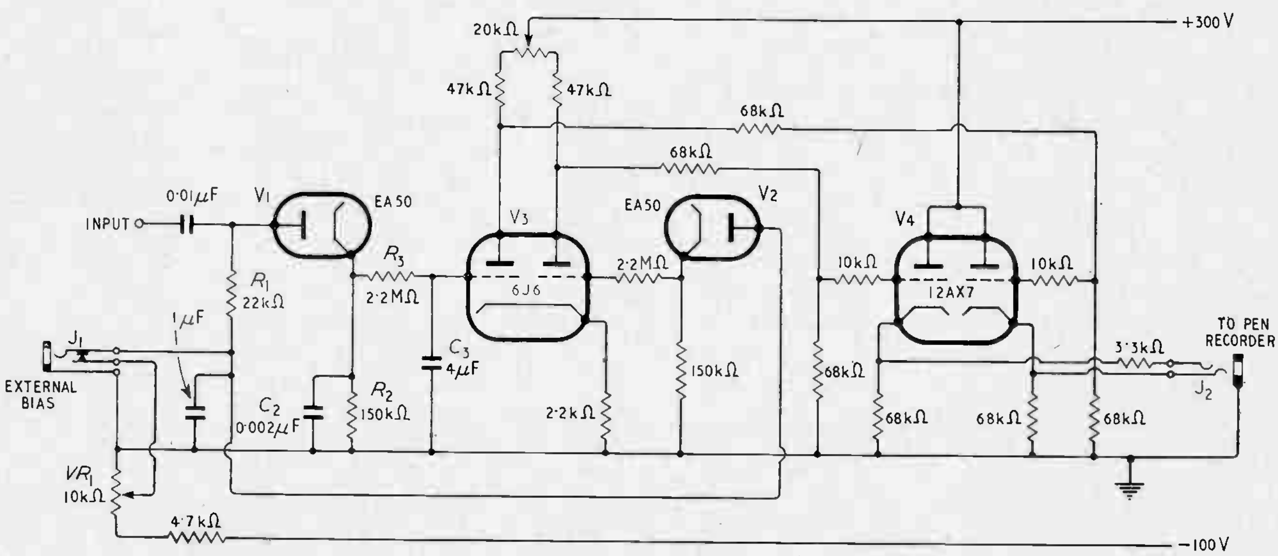
The description of the equipment is classified into the measurement of the following four parameters of the noise envelope defined above:

(a) the average voltage
(b) the average above a threshold
(c) the occupation-time
(d) the pulse-rate.

The noise is assumed to be available at a final carrier frequency of 10 kc/s at the output of the receiving system, this frequency being particularly convenient in the occupation-time measurements. The first two parameters were measured in similar units which are described together in the next section, although the first was a measure of noise intensity and the second a measure of noise-amplitude structure. The measured values of average above a threshold were, in fact, plotted against threshold, and the resultant curve differentiated to give a graph of the occupation-time against threshold; this derived graph is the cumulative amplitude probability distribution, and was used as the final presentation of the measurements. The direct measurement of occupation-time, described in Section 3, has now replaced the measurement of average above a threshold at Slough, but the latter can be recommended as a satisfactory technique where simplicity of equipment is important. A method of providing automatic operation of the equipment is described in Section 5.

Most experience with the equipment has been obtained in noise measurements at low frequencies, and the extension to higher frequencies introduces the problem of interference from stations. Although some measures can be taken in the receiving system to reduce the effect of unwanted signals, such as the use of additional filters, it is impracticable to remove them completely, and their presence for substantial periods of time can influence the measuring technique which is adopted. The following description assumes the use of ratemeters for counting r.f. cycles and impulses in the noise envelope, and a method of automatic operation which gives the required results on pen-records is described. As an alternative, scalers and digital counters may be operated over known time-intervals which are free from interference; although these counters are inherently more accurate, they are not as easily adaptable to automatic recording. The choice of technique in this respect might depend on the nature and degree of interference, and would be governed by various factors whose influence cannot yet be fully indicated; for example, while some forms of interference may readily be detected by aural or visual

Fig. 2. *Average-voltage recorder*



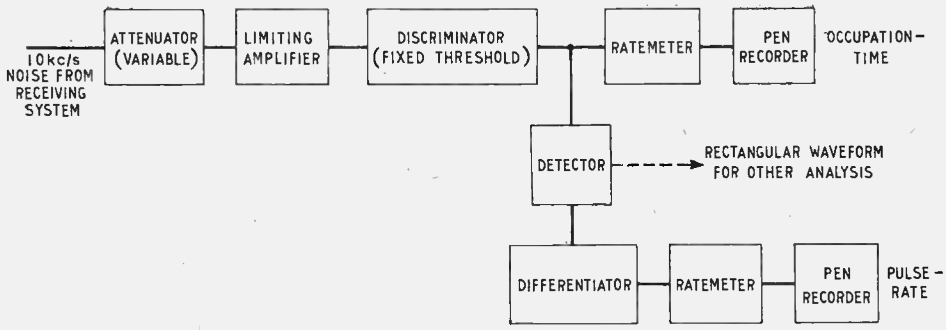


Fig. 3. *Measurement of occupation-time and pulse-rate*

monitoring, others may only be discernible as changes on a long-term pen record.

2. Average Envelope Voltage and Average above a Threshold

The average voltage of the envelope was measured in a unit comprising a detector circuit to obtain the envelope voltage, an averaging circuit, and a balanced d.c. amplifier connected to a pen-recorder. The unit was preceded by an aperiodic amplifier capable of giving sufficiently high output amplitudes for the full linear range of the detector circuit to be used. The average above a threshold was measured in a similar unit, to the detector of which a variable bias voltage was added. The method of measurement is illustrated by the block diagram in Fig. 1.

Aperiodic Amplifiers

Two conventional forms of amplifier have been used. The first, used in the earlier equipment and for photographic work, comprised a self-balancing paraphase inverter followed by two power amplifiers in push-pull. Peak voltages of 100V were available at the balanced output across 15-kΩ resistive loads. The second, used in the later equipment, was a single-ended circuit comprising a voltage amplifier and cathode-follower giving peak outputs of 200V at low impedance.

Average Voltage Unit

The circuit of the average voltage unit is shown in Fig. 2. The output of the aperiodic amplifier was connected to the anode of the detector V_1 through an *RC* coupling, and bias was applied to this anode to determine a threshold voltage. In manual operation, the bias was obtained from the potentiometer VR_1, and in automatic operation from an externally switched supply via the jack J_1. The envelope of the noise was obtained across C_2R_2, and was integrated by the series

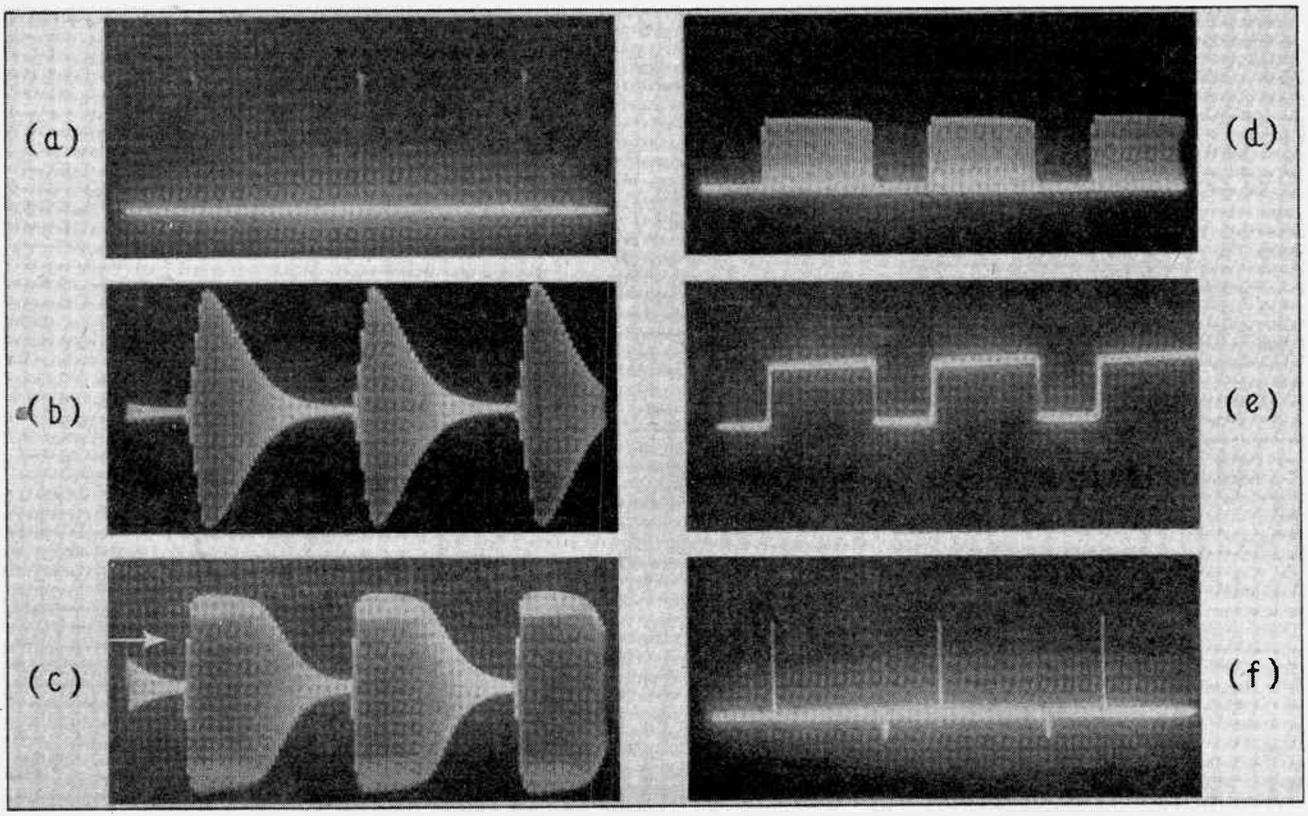


Fig. 4. *Waveforms corresponding to short impulses at input to receiver: (a) input to receiver, (b) 10-kc/s output of receiver, (c) output of peak-limiting amplifier, (d) output of discriminator selecting above arrow in (c) (pulse counted for occupation time), (e) rectangular waveform from detector, (f) differential of (e) with negative impulses clipped (positive pulses counted for pulse-rate)*

circuit C_3R_3. With the components shown, the charge and discharge time-constants of the integrating circuit were approximately equal, each being about 8 seconds, so that the average voltage of the envelope was produced across C_3 as a running mean over this time. The remainder of the unit was a balanced d.c. amplifier V_3 with a cathode-follower output stage V_4 to which a pen-recording milliammeter was connected (full-scale 1 mA). For long-term recording, stability of zero was achieved by the balanced circuit, stabilized supply voltages, and the use of a dummy diode V_2.

The detector was operated at as high a voltage level as was practicable, but the degree of pre-amplification of the noise was limited by saturation at the aperiodic amplifier output. When the pre-amplification of low-frequency atmospheric noise was set so that only a few pulses reached a saturation level of 100 volts, the average level was only one or two volts, and a relatively high degree of d.c. amplification was subsequently required. For waveforms similar to that of fluctuation noise, however, in which there is less divergence between the peak excursions and the average voltage, greater pre-amplification would be possible, and correspondingly less d.c. amplification could be used.

3. Occupation-Time

Technique of Measurement

Although relatively simple equipment was used in the technique by which the occupation-time was deduced from measurements of the average above a threshold, a fairly laborious analysis process was involved. The technique was replaced by the following method in which the proportion of time for which the noise envelope exceeded a series of thresholds was measured directly.

Referring to the block diagram in Fig. 3, the 10-kc/s noise waveform from the receiving system was applied via an attenuator and peak-limiting amplifier to an amplitude-discriminator. The pulses at the output of the discriminator were applied to a ratemeter which then indicated the number of r.f. cycles per second exceeding the discriminator threshold. The ratio of this number to 10,000 was the occupation-time of the envelope. In obtaining this parameter of the envelope, no detection process was involved, and thus the various inaccuracies and limitations associated with detector circuits were avoided. Effective thresholds were obtained by varying the amplification of the noise waveform before discrimination at a fixed voltage, as distinct from varying the bias voltage itself as in the measurements of average above a threshold.

Fig. 4 shows the different waveforms which could be seen at various stages in the equipment when the input to the receiving system was a series of short pulses from a pulse-generator [Fig. 4(a)].

Attenuator and Peak-Limiting Amplifier

In manual operation the effective threshold was varied by means of a ladder-type attenuator, providing coarse control in 10-dB steps, followed by a potentiometer for finer control. For automatic operation a different attenuator, described in Section 5, was used.

Since the minimum undistorted output amplitude from the receiving system was about 50 volts and, since the discriminator was operated at a threshold of 10 volts, it was necessary in order to obtain the desired range of thresholds (1000:1) to follow the attenuator by an amplifier having a gain of about 200. It was not necessary, however, for this amplifier to have a large dynamic range as, provided a satisfactory pulse response

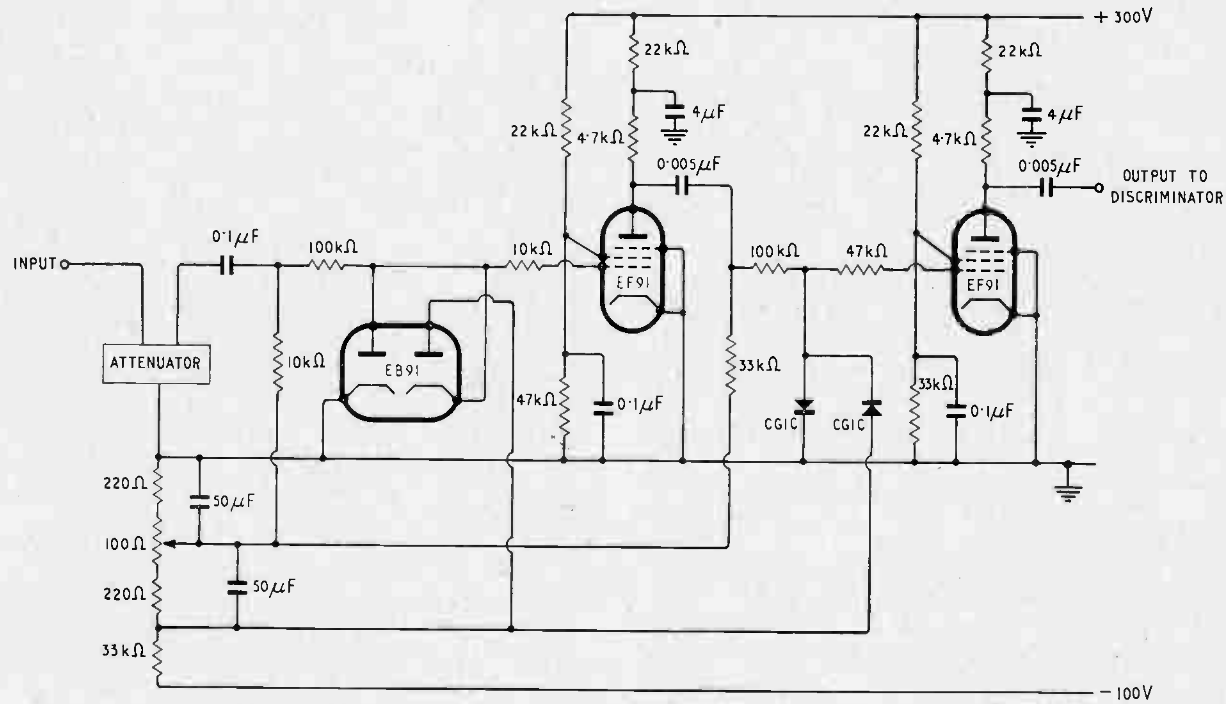


Fig. 5. *Attenuator and limiting amplifier*

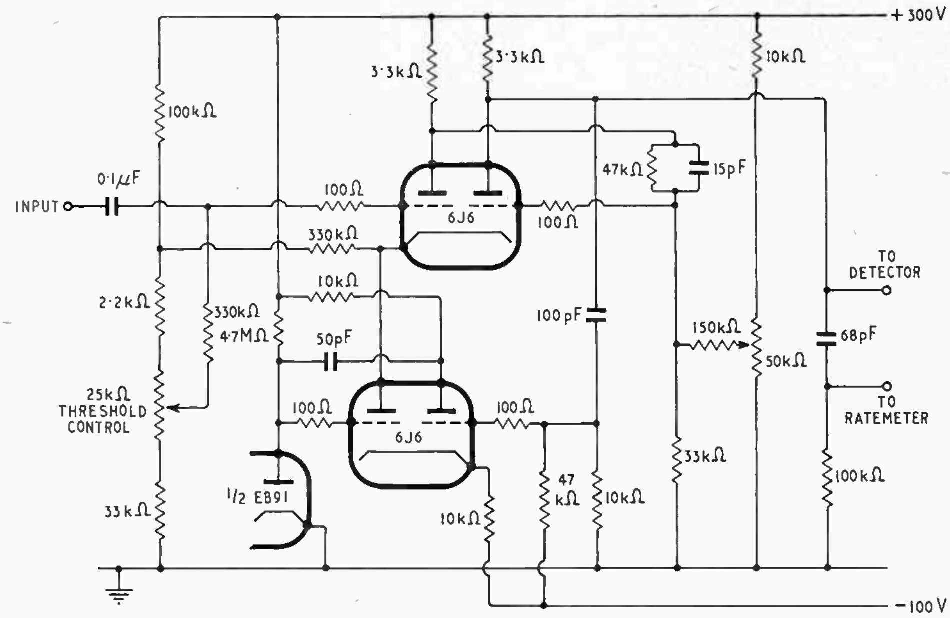


Fig. 6. *Discriminator*

was maintained up to the discriminator threshold, 10 volts, any distortion introduced by the amplifier at greater output levels was unimportant.

The amplifier (Fig. 5) consisted of two *RC*-coupled stages. To obtain a satisfactory pulse response all *RC* time-constants were kept to a minimum, and the voltage swing at the grid of each of the pentode amplifiers was limited to ± 1 volt by means of biased diodes. By these means, a symmetrical output waveform was maintained throughout the dynamic range of the input signal [Fig. 4(c)].

Discriminator

The discriminator, shown in Fig. 6, was a form of Schmitt trigger[3] which produced a rectangular pulse of constant amplitude for each excursion of the input waveform above the triggering threshold. The threshold was adjustable between 5 and 50 volts, but was normally operated at 10 volts. The voltage selection was carried out with the upper of the two double triodes, while the lower one introduced a paralysis time of about 80 microseconds following each trigger. In this way, for each r.f. cycle which triggered the discriminator, a rectangular pulse of width 80 microseconds was produced at the output. In measurements of occupation-time, these pulses were counted, and no use was made of their extended width. In measurements of pulse-rate, however, the widening of the r.f. pulses facilitated a subsequent detection process described in Section 4.

Ratemeter

The ratemeters used in occupation-time and pulse-rate measurements were built from conventional circuits, and commercially-available units could have been used for manual operation of the equipment. For automatic operation, a similar unit with range-switching circuits was built. Five decade ranges were used, with full-scale deflections from 10,000 down to 1 pulse per second, corresponding to occupation-times of 100 to 0·01 per cent respectively. The degree of statistical fluctuation about the mean rate indicated by the meter could be controlled by means of an integrating time-constant, and there was provision for operating a pen-recorder.

4. Pulse-Rate

Further information about the amplitude structure of the atmospheric noise was obtained by counting the number of excursions of the noise envelope above a series of thresholds. This parameter, the pulse-rate, has greatest significance at the higher thresholds where each excursion above the threshold then corresponds to a discrete pulse; at lower voltage levels the larger number of pulses, together with the narrow bandwidth used in the receiving system, resulted in an increasing amount of mutual interference between pulses.

In measuring the pulse-rate, further use was made of the discrimination process already carried out in the measurement of occupation time. Instead of counting each of the individual output pulses from the discriminator, however, the number of groups of pulses, each group corresponding to one excursion of the r.f. waveform envelope above the threshold, was counted. For this purpose the discriminator output [Fig. 4(d)] was rectified, the resultant waveform being of a rectangular type [Fig. 4(e)]. This waveform was differentiated and the pulse-rate obtained by counting the positive spikes [Fig. 4(f)] with a second ratemeter.

The circuit of the detector is shown in Fig. 7: the left-hand section of the double triode acts as an infinite impedance detector and the right-hand as a limiting amplifier. In order to maintain fast rise and decay times in the final rectangular waveform, the detector time-constant C_1R_1 was made as short as possible. While this resulted in incomplete rectification at the cathode of the valve, it was possible to remove the residual 10-kc/s component completely from the amplifier output by adjustment of its limiting bias control VR_1. Widening the discriminator output pulses, as

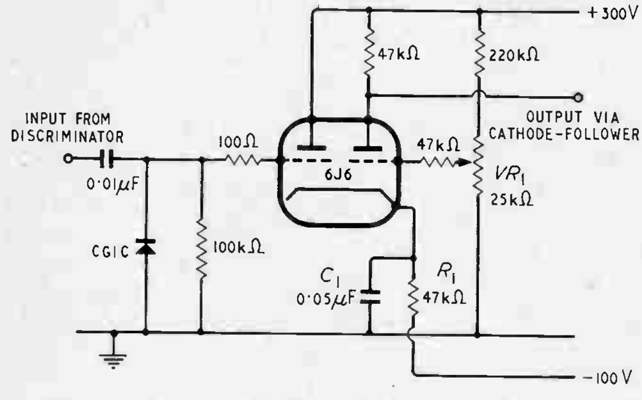


Fig. 7. *Detector*

described in Section 3, and consequently reducing the space between successive pulses in a group, also facilitated the use of a short detector time-constant.

For the purpose of triggering the ratemeter, rapid rise and decay times were not essential, and a simpler form of detector might have been acceptable. The rectangular type of waveform, however, was provided to simplify possible future measurements of other parameters such as the pulse widths and spacings.

5. Automatic Operation

For automatic measurement of the noise distributions, the main requirement was a means of automatically varying the effective threshold at regular intervals. Simultaneous recording at different thresholds, although very desirable, was rejected in favour of a time-sequential method because of the considerable equipment duplication which would have been involved. To obtain a representative measure of the distribution, ten different thresholds, covering a voltage range of about two hundred to one, were considered desirable. Also, to enable a satisfactory mean value to be read from the fluctuating pen-records, a period of several minutes was required at each threshold. On the other hand, it was necessary to complete the measurements in a time during which the noise distribution remained substantially the same. These considerations governed the timing sequence adopted, in which a complete cycle occupied one hour. The form of the pen-records is shown in Fig. 8. The top recording shows the variation of average voltage (time-constant eight seconds) over a period of about three hours, with breaks in reception of ten minutes each hour for calibration purposes. The middle record shows the average above a series of decreasing thresholds, the last of which is zero ; the vertical lines indicate the changes of threshold every five minutes. The bottom record is a simple example of a recording at the output of a ratemeter, which introduces another feature of automatic operation ; namely, the necessity for switching from one decade range of a ratemeter to another. In this particular example, the pulse-rate was recorded above a series of decreasing thresholds, and the conditions were such that only two of the decade ranges were involved (Scales A and B).

Timing and Threshold Unit

A mains clock motor driving a cam switch was arranged to operate a uniselector switch at five-minute intervals. A series of ten bias voltages was obtained from a potentiometer chain wired to one bank of the

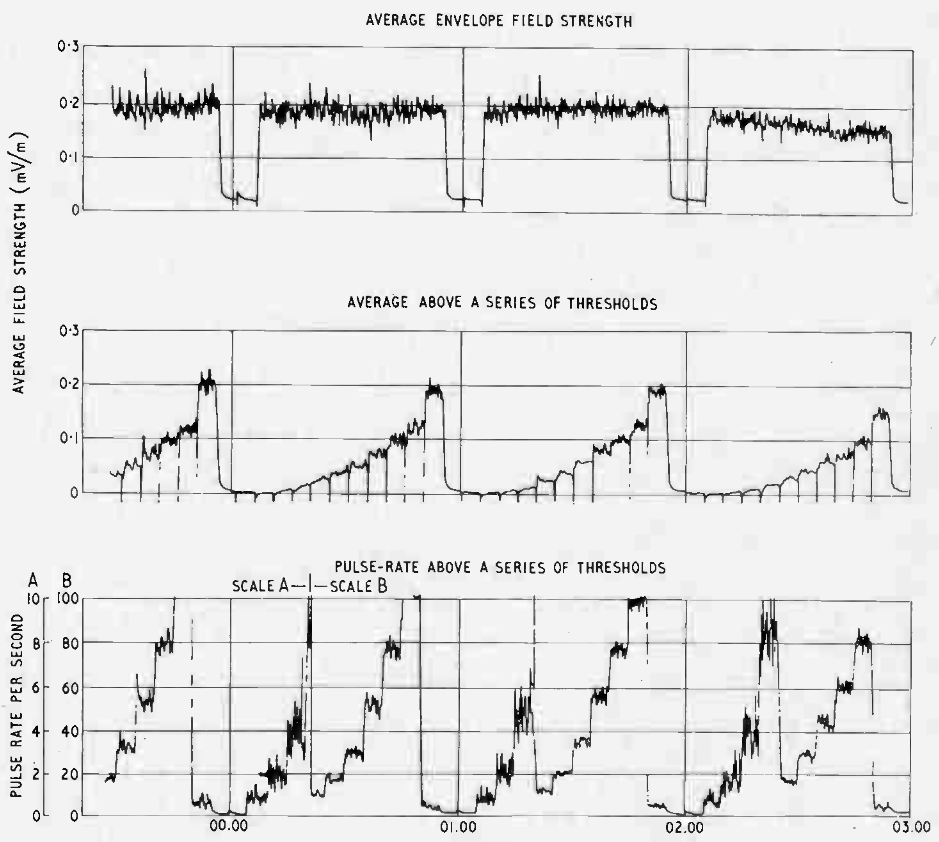
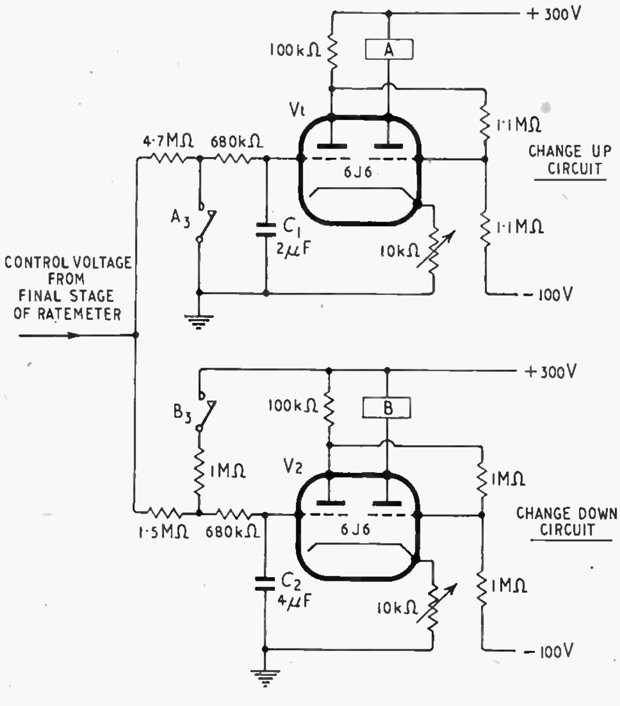
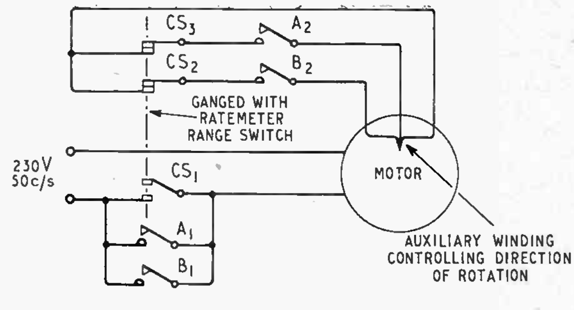


Fig. 8. Typical pen-records at 10 *kc/s, 22nd August* 1955



SCHMITT TRIGGER CONTROL CIRCUITS



MOTOR SWITCHING ARRANGEMENT

Fig. 9. *Automatic range-switching of ratemeter*

uniselector, and supplied from a stabilized d.c. source. These were switched in sequence to the averaging unit via a jack which also disconnected the manually-operated threshold bias control. Similarly, for the automatic measurement of occupation-time and pulse-rate an r.f. potentiometer was wired to another bank, providing ten 6-dB steps of attenuation. Relays in an aerial cathode-follower unit were operated during two further positions of the uniselector switching cycle and, first by short-circuiting the aerial terminals and secondly, by changing over from the aerial to a signal generator, provided zero and c.w. calibrations respectively on the pen records of the average level.

Automatic Switching of Ratemeter Ranges

For automatic recording of the occupation-time and pulse-rate, the wide range of count rates encountered during the threshold cycle necessitated some form of automatic switching through the five ranges of the rate-meter. Fig. 9 shows the arrangement adopted.

A reversible motor, coupled to the ratemeter range switch, was controlled by two Schmitt trigger circuits operating from a voltage, at the ratemeter output, proportional to the meter indication. These trigger circuits, one operating at full-scale deflection of the ratemeter and the other at approximately one-tenth of this deflection, controlled upward and downward changes in range respectively. In each case the Schmitt trigger was preceded by an integrating circuit, having a time-constant of about ten seconds, to prevent triggering on transient excursions beyond the triggering levels. A relay in each of the trigger circuits had three sets of contacts performing the following operations : (a) switching the a.c. supply to the motor (A_1 or B_1), (b) switching auxiliary windings on the motor which governed its direction of rotation (A_2 or B_2), and (c) discharging the integrating capacitor, and thus resetting the trigger circuit a few seconds after it had operated (A_3 or B_3). A five-way cam switch, CS_1, ganged with the ratemeter range switch, was also incorporated, the cam being so shaped that the contacts were open at each of the rate-meter range positions and closed between ranges.

On the operation of one or other of the trigger circuits, the mains voltage was applied to the motor by the closing of either contact A_1 or B_1, and the motor started to turn. Almost immediately the cam switch CS_1 closed, maintaining the mains supply to the motor after the relay contact A_1 or B_1 opened a few seconds later. Rotation continued until the cam switch CS_1 broke the mains supply to the motor at the next range position. The direction of rotation was determined by the contacts A_2 or B_2 in the auxiliary winding circuit, which closed at the same time as A_1 or B_1. Although the motor would not start without an auxiliary winding circuit being closed, it would continue to turn if the auxiliary winding circuit was later opened. Two further cams, ganged with the five-way cam, opened contacts CS_2 and CS_3 in the auxiliary winding circuits on the top and bottom range positions of the ratemeter to prevent further rotation beyond these limits despite the operation of the trigger-circuit relay. The combination of 'backlash' in the trigger circuit and the integration characteristics of its input circuit allowed adjustment of the time-intervals involved in the operation of the circuit, and provided the necessary facility for consecutive changes of range in one direction.

6. Calibration and Test of Equipment

As stated earlier, the measurements related to the envelope of the noise at the output of the receiving system, and the voltage scale therefore depended on the gain of the receiving system. The final results were expressed in units of effective field-strength at the aerial by dividing the voltage scale by the c.w. gain of the receiving system. Routine calibrations were carried out by injecting c.w. signals from a standard generator at the input to the receiving system, and measuring at the output

(a) the peak voltage corresponding to a given input
(b) the reading of the average voltage recorder
(c) the input required to exceed each effective threshold voltage.

The gain of the system was determined each day from (a) and (b). The threshold voltage scale for the measurements of average above a threshold was determined by the d.c. detector bias, which was measured less frequently. The threshold scale for measurements of occupation-time and pulse-rate was determined by an occasional calibration of the attenuator steps, and by frequent observation of the signal required to exceed the threshold corresponding to one attenuator position.

In addition to routine calibration, the operation of the equipment was checked on known input waveforms. For example, the functioning of a number of units was verified by observation of the waveforms in Fig. 4 when short regular pulses were injected at the input to the equipment. Quantitative tests were made with c.w. signals and with short pulses (e.g., ratemeter scale calibrations). Another important test waveform was fluctuation noise from a diode source, and it was shown that the occupation-time and pulse-rate distributions agreed with those expected theoretically.

Acknowledgements

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Detection of Pulsed Signals in Noise

OPTIMUM BUTTERWORTH THIRD-ORDER FILTERS

By H. S. Heaps, B.Sc., M.A.* and A. T. Isaacs, B.E.*

SUMMARY. *An analysis is presented to determine the optimum design of a Butterworth low-pass third-order filter to detect a rectangular pulsed signal upon a background of white noise. The filter is regarded as optimum if, for a given input signal energy U, input-signal duration T, and output sampling time T_0, it produces a maximum ratio of output-signal energy to output-noise energy. It is found that for values of T_0/T between $0 \cdot 4$ and 2 a maximum signal-to-noise energy is obtained if the filter parameter is chosen to equal $2T/(3 \cdot 5 - T_0/T)$. The resulting signal-to-noise ratio is shown graphically.*

The design of electrical filter circuits arises in many problems that involve the detection of signals in noise backgrounds. The purpose of the filter is to increase the signal-to-noise ratio over a sufficient time to facilitate detection of the signal.

While in certain instances it is easy to obtain an expression for the desired frequency response of a filter to fulfil a particular purpose[1,2], it is, in general, not easy to synthesize a circuit with that frequency response. Furthermore, the practical requirement that only a finite number of electrical components of resistance, inductance, and capacitance may be used in the circuit usually implies that the desired response must be synthesized to within an allowable approximation.

In view of the difficulties involved in synthesis, the design of an optimum filter is often replaced by the problem of choosing the values of components so as to make a particular circuit configuration as effective as possible. Such, for example, has been the approach of Atiya[3], Belevitch[4], and Griffiths[5]. The filter so obtained is then optimum only for the prescribed configuration of circuit components. However, the use of such a circuit, if it contains relatively few components, may have considerable advantage over the use of a more efficient circuit that requires more components.

In order to facilitate the design of filters by choice

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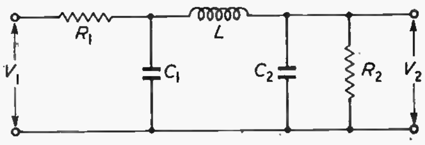

Fig. 1. *Third-order low-pass filter*

of components in simple circuit configurations, it is desirable to know in detail the behaviour of a few relatively simple circuits that permit numerical analysis. One such circuit is the third-order low-pass network shown in Fig. 1. The effect of this circuit upon a continuous wave has been discussed by many authors, especially when the components are all chosen in terms of a single parameter as in the case of the Butterworth or Tchebycheff filter[6,7].

The present paper presents the optimum design of a Butterworth low-pass third-order filter for the detection of a rectangular pulsed signal upon a background of white noise. The filter is regarded as optimum if, for a given input-signal energy U, input-signal duration T, and output sampling time T_0, it produces a maximum ratio of output signal energy to output noise energy.

The mathematical basis is described below, and the results of the calculations are presented graphically.

Output Voltage for a Pulse Input

For the filter shown in Fig. 1, if the input is a continuous wave $e^{j\omega t} = e^{pt}$ of unit amplitude and frequency $\omega/2\pi$ the output is a continuous wave of the form

$$\frac{R_2}{R_1 + R_2} \frac{1}{N(p)} e^{pt} \quad \ldots \quad (1)$$

where $N(p)$ denotes the expression given in reference 6, p. 370.

$$N(p) = 1 + \frac{R_1R_2(C_1+C_2)+L}{R_1+R_2}p + \frac{(R_1C_1+R_2C_2)L}{R_1+R_2}p^2 + \frac{R_1R_2LC_1C_2}{R_1+R_2}p^3 = 1+\alpha p+\beta p^2+\gamma p^3. \quad (2)$$

The amplitude of the output wave is

$$\frac{R_2}{R_1+R_2}\frac{1}{|N(j\omega)|} = \frac{R_2}{R_1+R_2}\frac{1}{[1+(\alpha^2-2\beta)\omega^2+(\beta^2-2\alpha\gamma)\omega^4+\gamma^2\omega^6]^{1/2}} \quad \ldots \quad (3)$$

which may be termed the amplitude transfer-function of the network.

At sufficiently low frequencies, for a fixed value of α the amplitude transfer-function with the least frequency dependence is obtained by choosing the circuit elements such that $\beta = \alpha^2/2$ and $\gamma = \beta^2/2\alpha = \alpha^3/8$. Thus $|N(j\omega)| = [1 + (\alpha\omega/2)^6]^{1/2}$. The circuit is then known as a Butterworth filter and $N(p)$ has the form

$$N(p) = \tfrac{1}{8}(\alpha p + 2)(\alpha^2p^2 + 2\alpha p + 4) \, . \quad \ldots \quad (4)$$

If the input to the filter is a voltage of general form $V_1(t)$ then it is related to the output voltage $V_2(t)$ through the formula

$$\mathcal{L}_2(p) = \frac{R_2}{R_1 + R_2}\frac{1}{N(p)}\mathcal{L}_1(p) \quad \ldots \quad \ldots \quad (5)$$

in which $\mathcal{L}_1(p)$ and $\mathcal{L}_2(p)$ are respectively the Laplace transforms of V_1 and V_2. Specifically

$$\mathcal{L}_1(p) = \int_0^\infty V_1(t)\, e^{-pt}dt \, . \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Thus for a Butterworth filter

$$\mathcal{L}_2(p) = \frac{R_2}{R_1+R_2}\frac{8}{(\alpha p+2)(\alpha^2p^2+2\alpha p+4)}\mathcal{L}_1(p) \, . \quad (7)$$

When the input consists of a rectangular pulse of amplitude A and duration T commencing at time $t = 0$ the integration in Equ. (6) may be performed to give

$$\mathcal{L}_1(p) = A\left[\frac{1-e^{-pT}}{p}\right]$$

and Equ. (7) may be written in the form

$$\mathcal{L}_2(p) = \frac{AR_2}{R_1+R_2}\left[\frac{1}{p} - \frac{\alpha}{\alpha p+2} - \frac{2\alpha}{\alpha^2p^2+2\alpha p+4}\right](1-e^{-pT}) \, . \quad \ldots \quad (8)$$

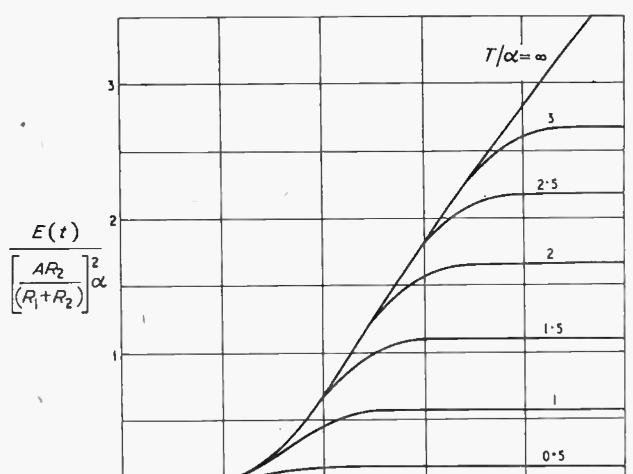

Fig. 2. *Signal energy E(t) contained in an output sample commencing at time $t = 0$ and ending at time t. The input signal has duration T*

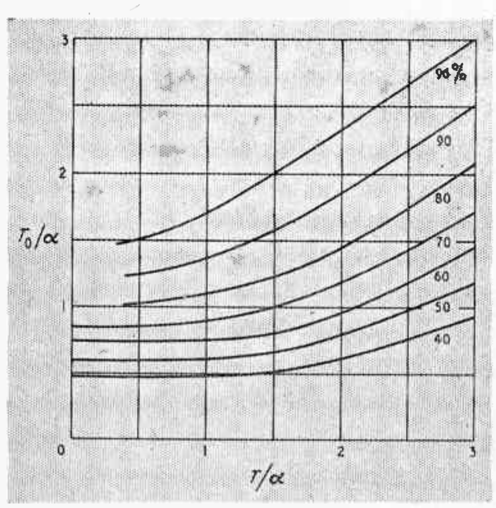

Fig. 3. *Least sampling times T_0 required to obtain a given percentage of the total available output signal energy*

The inverse transform of Equ. (8) is the equation

$$V_2(t) = V_{21} = \frac{AR_2}{R_1+R_2}\left[1 - e^{-2t/\alpha} - \frac{2}{\sqrt{3}} e^{-t/\alpha} \sin(\sqrt{3}t/\alpha)\right] \quad .. \quad (9)$$

if $t < T$, and

$$V_2(t) = V_{22} = \frac{AR_2}{R_1+R_2}\left[-e^{-2t/\alpha} - \frac{2}{\sqrt{3}} e^{-t/\alpha} \sin(\sqrt{3}t/\alpha) + e^{-2(t-T)/\alpha} + \frac{2}{\sqrt{3}} e^{-(t-T)/\alpha} \sin\sqrt{3}(t-T)/\alpha\right] \quad (10)$$

if $t > T$. The equations (9) and (10) represent the signal voltage at the output of the filter.

Signal and Noise Energies at Output

The output signal power through the resistance R_2 is V_2^2/R_2. Thus the output power per unit of load resistance is V_2^2. If the output is sampled over a time interval commencing at time $t=0$ and ending at time t the total signal energy (per unit of load resistance) contained in the sample is

$$E(t) = \int_0^t V_2^2 \, dt, \quad .. \quad .. \quad .. \quad .. \quad (11)$$

the explicit form of which is listed in the Appendix.

The signal energy $E(t)$ is plotted as a function of t/α in Fig. 2 for values of T/α equal to 0·5, 1, 1·5, 2, 2·5, 3, and infinity.

If the noise input to the filter consists of white noise of root-mean-square power B per unit bandwidth then by Equ. (3) the output noise power is

$$\left[\frac{R_2 B}{R_1+R_2}\right]^2 \int_0^\infty \frac{1}{|N(j\omega)|^2} \frac{d\omega}{2\pi} . \quad .. \quad .. \quad (12)$$

For a Butterworth filter, the noise energy output contained in a time interval of duration t is thus

$$E_n(t) = \left[\frac{R_2 B}{R_1+R_2}\right]^2 t \int_0^\infty \frac{1}{1+(\alpha\omega/2)^6} \frac{d\omega}{2\pi}$$

$$= \left[\frac{R_2 B}{R_1+R_2}\right]^2 \frac{1}{3} t/\alpha , \quad .. \quad .. \quad .. \quad (13)$$

the value of the integral being given in reference 8, p. 197.

Signal-to-Noise Ratio in Sample of Output

Suppose the input consists of a rectangular signal pulse of total energy $U = A^2T$ together with white noise of root mean square power B per unit bandwidth. For purposes of detection, it is desirable that the ratio of signal-to-noise energy contained within the sampling interval should be as large as possible. However, it is also desirable that the sample should contain a considerable proportion of the available output signal energy.

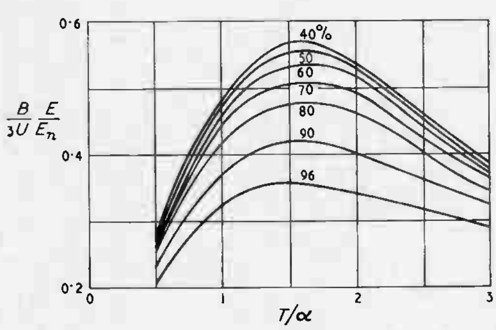

Fig. 4. *Output signal-to-noise ratios E/E_n for the sampling times plotted in Fig. 3*

According to Equ, (13) the energy contained in a sample of the output is proportional to the sampling time t and inversely proportional to the filter parameter α.

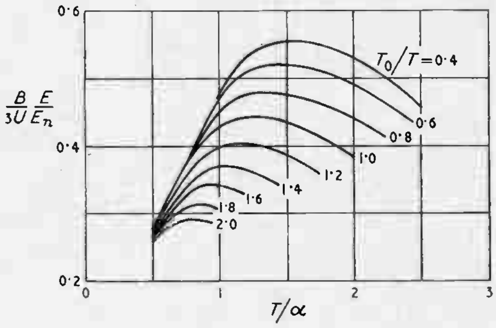

Fig. 5. *Output signal-to-noise ratio E/E_n for given values of input signal duration T and sampling time T_0*

From Fig. 2 it is apparent that most of the output signal energy is confined within a finite time interval. For example, if $T/\alpha = 2$ the maximum value of $E(t)\,[AR_2/(R_1+R_2)]^{-2}\alpha^{-1}$ is 1·66. Only 10% of the output signal energy appears before a time $t = 1{\cdot}35\alpha$ and only 10% appears after a time $2{\cdot}80\alpha$. The least sampling time T_0 over which 80% of the total output signal energy may be received is thus equal to $1{\cdot}45\alpha$, and the signal energy contained in the sample is $E = [AR_2/(R_1+R_2)]^2\alpha(1{\cdot}33) = [R_2/(R_1+R_2)]^2U(1.33)(\alpha/T) = [R_2/(R_1+R_2)]^2U(0{\cdot}665)$. The noise energy in the sample is $E_n = [BR_2/(R_1+R_2)]^2(1/3)(1{\cdot}45)$.

The least sampling times T_0 required to obtain 40%, 50%, 60%, 70%, 80%, 90%, and 96% of the total available signal output energy are plotted as functions of T/α in Fig. 3. For such sampling times the values of E/E_n are shown in Fig. 4. For each required percentage of total available output energy there is a value of T/α, and a corresponding value of T_0/α, that leads to a maximum signal-to-noise ratio.

For various pairs of values of T/α and T_0/α the corresponding percentage of total output energy may be found from Fig. 3 and used to determine the signal-to-noise ratio from Fig. 4. For values of $T_0/T = (T_0/\alpha)/(T/\alpha)$ between 0·4 and 2, the resulting signal-to-noise ratios are plotted as functions of T/α in Fig. 5.

It may be observed from Fig. 5 that when T_0/T lies between 0·4 and 2 the maximum signal-to-noise ratio occurs when T/α is chosen to fit the empirical equation

$$T/\alpha = \tfrac{1}{2}(3{\cdot}5 - T_0/T) \quad .. \quad .. \quad .. \quad (14)$$

Thus, for given values of T and T_0, the maximum signal-to-noise ratio is obtained by choosing the filter parameter α such that

$$\alpha = \frac{R_1R_2(C_1+C_2)+L}{R_1+R_2} = \frac{2T}{3{\cdot}5 - T_0/T} . \quad (15)$$

APPENDIX

Integration of Equ. (11), after substitution of V_2 from Equs. (9) or (10), leads to the following formulae where s denotes t/α and a denotes T/α.

$$\int_0^t V_{21}{}^2 dt = \left[\frac{AR_2}{R_1+R_2}\right]^2 \alpha \Big[s - \frac{7}{6} - \frac{1}{4}e^{-4s} + \frac{2}{3}e^{-2s} + \frac{1}{12}e^{-2s}\cos(2\sqrt{3}s) - \frac{\sqrt{3}}{12}e^{-2s}\sin(2\sqrt{3}s) + e^{-s}\cos(\sqrt{3}s) + \frac{1}{\sqrt{3}}e^{-s}\sin(\sqrt{3}s) - \frac{1}{3}e^{-3s}\cos(\sqrt{3}s) - \frac{1}{\sqrt{3}}e^{-3s}\sin(\sqrt{3}s)\Big] \quad \ldots \quad (16)$$

$$\int_0^t V_{22}{}^2 dt = \left[\frac{AR_2}{R_1+R_2}\right]^2 \alpha \Big\{ -\frac{1}{4}e^{-4s} - \frac{1}{3}e^{-2s} + \frac{2}{3}e^{a-2s}\cos(\sqrt{3}a) - \frac{1}{4}e^{4a-4s} - \frac{1}{3}e^{2a-2s} + \frac{1}{2}e^{2a-4s}$$
$$+ \left[e^{2a} - 1 - e^{3a}\cos(\sqrt{3}a) + e^{a}\cos(\sqrt{3}a)\right] \left[\frac{1}{3}e^{-3s}\cos(\sqrt{3}s) + \frac{1}{\sqrt{3}}e^{-3s}\sin(\sqrt{3}s)\right]$$
$$+ \left[e^{3a}\sin(\sqrt{3}a) - e^{a}\sin(\sqrt{3}a)\right] \left[\frac{1}{\sqrt{3}}e^{-3s}\cos(\sqrt{3}s) - \frac{1}{3}e^{-3s}\sin(\sqrt{3}s)\right]$$
$$+ \left[1 + e^{2a}\cos(2\sqrt{3}a) - 2e^{a}\cos(\sqrt{3}a)\right] \left[\frac{1}{12}e^{-2s}\cos(2\sqrt{3}s) - \frac{\sqrt{3}}{12}e^{-2s}\sin(2\sqrt{3}s)\right]$$
$$+ \left[e^{2a}\sin(2\sqrt{3}a) - 2e^{a}\sin(\sqrt{3}a)\right] \left[\frac{\sqrt{3}}{12}e^{-2s}\cos(2\sqrt{3}s) + \frac{1}{12}e^{-2s}\sin(2\sqrt{3}s)\right]\Big\} \quad (17)$$

After the expressions (16) and (17) have been calculated, $E(t)$ may be found from the identities

$$E(t) = \int_0^t V_{21}{}^2 dt \quad \ldots \quad (18)$$

if $t < T$, and

$$E(t) = \int_0^T V_{21}{}^2 dt + \int_0^t V_{22}{}^2 dt - \int_0^T V_{22}{}^2 dt \quad \ldots \quad (19)$$

if $t > T$.

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Television Tape Recorder

NEW MAGNETIC SYSTEM FOR SOUND AND VISION

VERA, the B.B.C's Vision Electronic Recording Apparatus, has been designed to record the vision and sound signals of television programmes for subsequent reproduction at any time after the recording has been effected. A photograph of one machine is shown in Fig. 1. Two such machines, which can be controlled from a central control desk, have been put into service. They employ half-inch magnetic tape and a reel of 20½-in. diameter, such as those shown in Fig. 1, will accommodate 15 minutes of programme. Continuous recording is possible by the use of two machines and the control desk. The tape speed employed in the present model is 200 in./sec. and the magnetic tape used may be a normal thin-base sound-recording tape of good quality.

The machine employs a three-track system of recording, two of the tracks being devoted to the storing of the video signal and one to the storing of the sound signal. Separate recording and reproducing head-stacks are employed, each stack containing three identical heads separated from each other by copper screens and aligned to the required accuracy in the manufacturing process. Continuous monitoring of the recorded signal during the process of recording may be carried out.

The principal sources of difficulty in television tape recording are the recording heads and the tape transport system. In the B.B.C. machine, the recording heads employ ferrite as the main material, with a thin protective layer of mumetal. Wear due to abrasion from the tape limits the life to 50–100 hours. The high-frequency response of the heads is level to 2 Mc/s, and no pre-emphasis is used. The low-frequency response also falls off because of the usual long-wavelength losses, but this difficulty is removed by the modulation system described below. An important cause of amplitude variation is displacement of the tape from the head. At a displacement of one wavelength, the loss in signal strength is 55 dB. Attention had to be given to air flow along the tape to minimize such losses.

The degree of constancy of tape speed required is very high (a tape-positional error of 0·001 in. represents a lateral displacement of about 5% of the picture width). In the tape transport system embodied in the machine, most of the power required to drive the tape is supplied by the spooling motors which are arranged to move the tape past the heads at a speed just below the chosen recording speed of 200 in./sec. and close to the constant tension required, even when the drive motor is not engaged. This result is obtained by varying the power fed to the spooling motors in accordance with (a) their torque/speed characteristic and (b) the amount of tape on the reels at any particular moment, the latter determining the speed of rotation required of the reels. When the drive is engaged the drive motor is, therefore, required to supply only a limited amount of power to bring the tape speed up to 200 in./sec. The drive is engaged by lowering two rubber idlers on to a common capstan so that a loop of tape, largely isolated from transient effects in the reels by these idlers and other mechanical filtering elements, is formed. Inside this

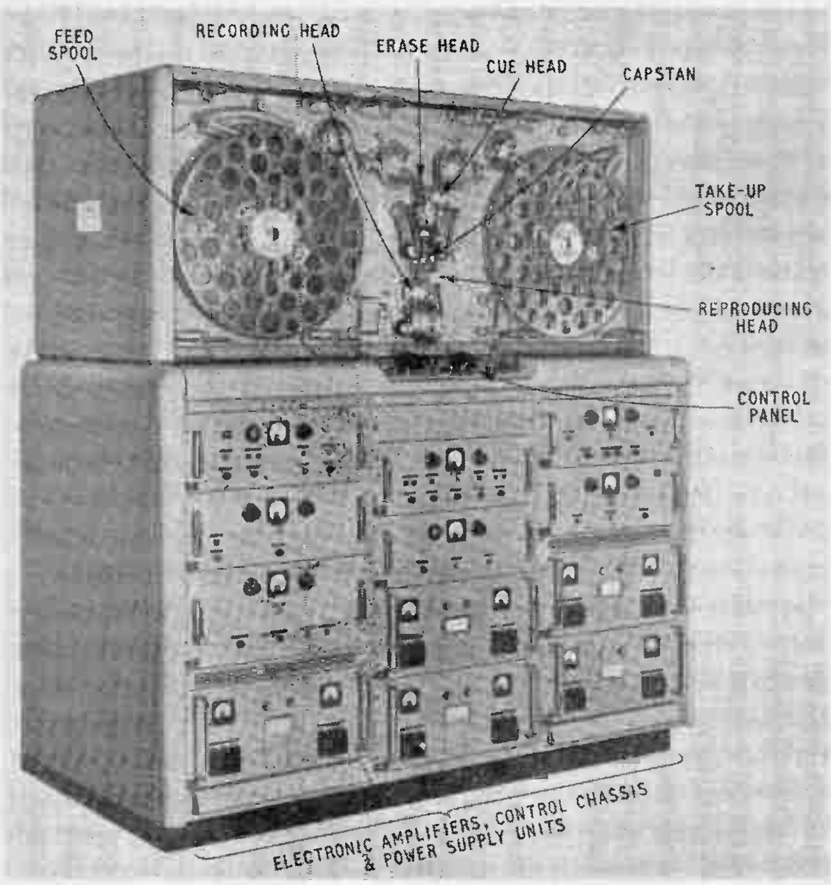
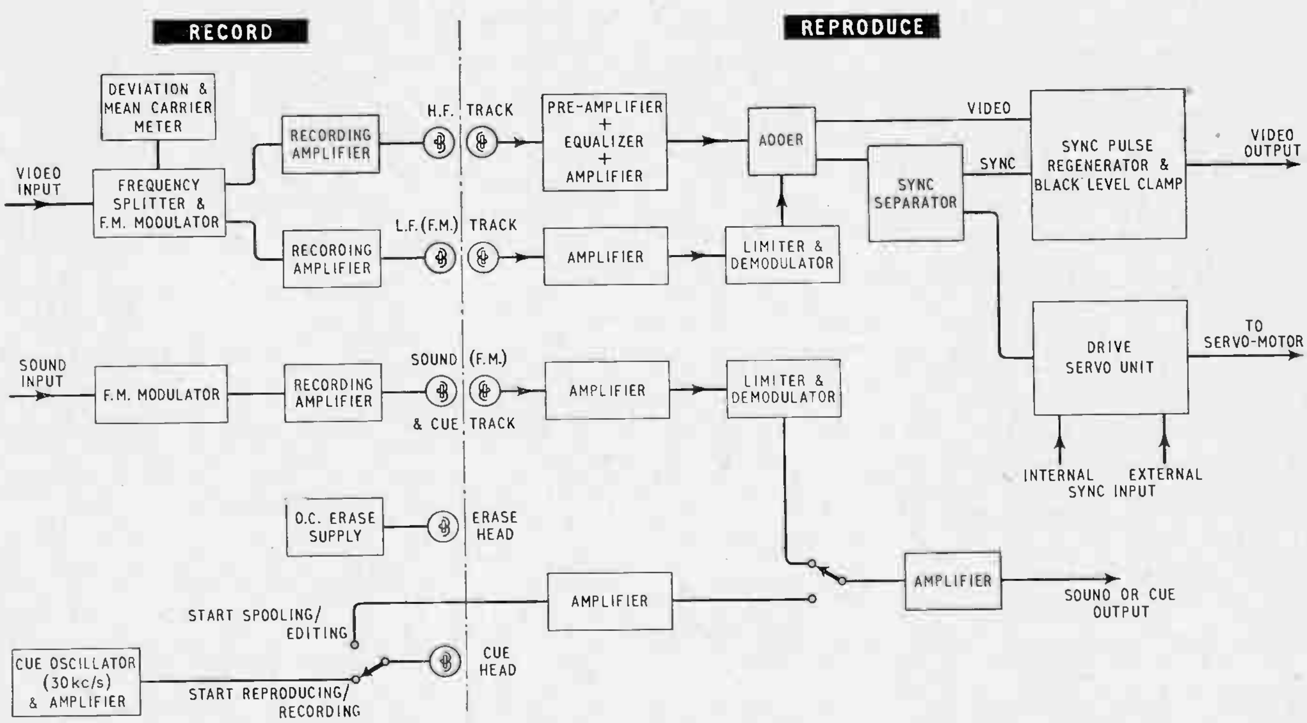


Fig. 1. Front view of vision electronic recording apparatus.

loop lie the recording and reproducing head-stacks. The erasing head is placed at a convenient point which lies outside the loop and precedes the recording head. A "Velodyne" system of speed control and correction of the driving capstan is employed. During recording periods the servo driving motor is made synchronous with the mains frequency while, on reproduction, the output of the machine is frame-synchronized to station synchronization signals. The machine is fitted with the usual facilities for braking and for spooling the tape backwards or forwards at a variable speed when the drive system is not engaged.

A block schematic diagram showing the connections of the principal electronic units embodied in the machine is shown in Fig. 2. For storing the video signal the two video tracks are associated, on the recording side, with a band-splitting system in which the video signal is divided into two frequency bands of approximately 0–100 kc/s and 100 kc/s–3 Mc/s. The 0–100-kc/s video band is made to frequency-modulate a carrier and this frequency-modulated carrier is recorded on one track. The low-frequency content of the video signal is thereby transferred to a frequency band corresponding to shorter wavelengths so that both the low-frequency and the long-wavelength difficulties inherent in the conventional magnetic-recording

Fig. 2. Block schematic of principal electronic units.



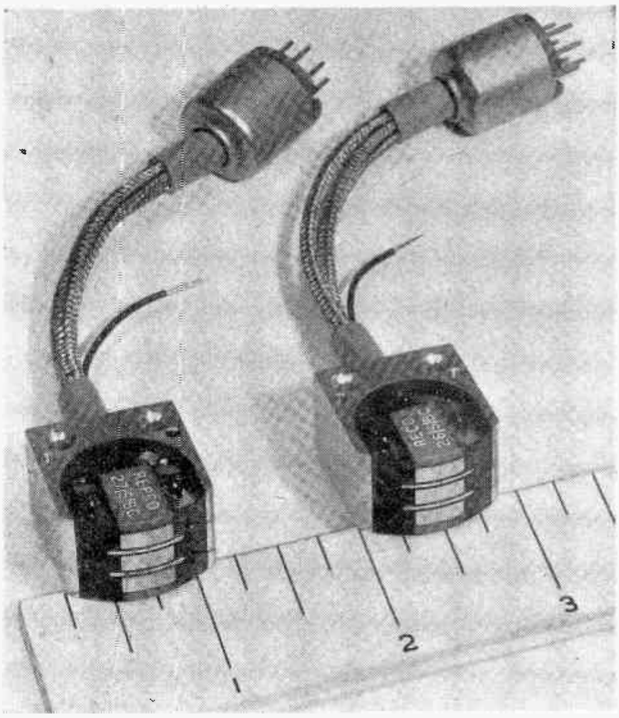


Fig. 3. *Completed 3-track recording and reproducing heads*

system are avoided. In addition, the amplitude-limiting facilities normally associated with the reception of frequency-modulated signals may be incorporated in the reproducing chain to eliminate undesired amplitude fluctuations even when employing thin-base sound-recording tape not specifically manufactured for video or instrumentation purposes. The higher vision band, from 100 kc/s upwards, is recorded simultaneously on the second video track in a conventional manner.

On reproduction, the output from the frequency-modulated video track is limited, demodulated, and added to the output from the higher-frequency track to produce the composite television waveform. Before transmission to line, the synchronization information, including line and frame synchronizing signals and suppression periods, is extracted, reconstituted and added back into the video signal.

The higher-frequency video band, which employs a conventional recording/reproducing system, will be subject to the same unwanted amplitude-modulation which is being eliminated by the frequency-modulation system of the lower frequency video band. It is, however, an important finding that in practice this does not seem to be of major importance, for as long as the synchronizing signals and the main brightness structure of the picture, represented by the 0–100 kc/s band of the video signal, are maintained intact, reasonable variations in the higher-frequency band do not noticeably degrade the resulting picture.

All the low-frequency and long-wavelength difficulties which, in the case of the lower video frequency, are overcome by the use of the carrier system, will also be manifest in the sound channel if a conventional recording of the sound signal is attempted under the higher tape-speed conditions dictated by the video-signal requirements. Accordingly, the sound signal is, before recording, made to frequency-modulate another carrier which is recorded on the third track. On reproduction, the carrier is limited and demodulated to provide a sound signal of high fidelity in exact synchronism with the video information reproduced from the other two tracks.

As in other forms of picture or sound recording, a requirement will arise in the use of magnetic vision recorders for the editing of programmes previously recorded. Simple editing, in the form of replaying extracts from a previously recorded programme, may be achieved by starting the machine at any predetermined point in the recording. This facility is available because the machine is equipped with the usual facilities for spooling the tape backwards and forwards to find a desired point in the recording. The method may be extended, as in magnetic sound-recording practice, by cutting and joining extracts from various recordings or different parts of the same recording. Individual frames cannot, however, be examined in a 'gate', as in optical film editing, for the tape must be running at the correct speed before a picture can be reproduced on a monitor. A cueing arrangement for the 'marking' of editing points has, therefore, been provided. The method adopted is to provide an extra cueing head, lying outside the isolated tape loop, which is fed through a separate recording amplifier from a 30-kc/s oscillator. When the tape is being normally played-back and the observer wishes to mark some particular point for subsequent cutting or starting he presses a 'Cue' key on the control panel of the machine which causes a burst of 30-kc/s signal to be recorded on the sound track of the tape. At this frequency it will not appear in subsequent normal reproduction, since it lies well below the frequency-modulated carrier signals which carry the sound programme and any interference effects it might otherwise have will be removed by the limiting process which precedes detection of the television sound signal. However, when the tape is being slowly transported past the reproducing head, using the spooling speed control, at a fraction of the normal speed, the cue signal will produce an audible note in the loudspeaker or headphone system so that the point previously marked is found. The cutting and joining of tapes is accurately and quickly carried out by the use of a splicing device provided and the resultant join provides no visible disturbance in the picture.

MECHANICAL HANDLING

The Mechanical Handling Exhibition and Materials Handling Convention will be held at Earls Court, London, from 7th–17th May.

CORRECTION

In the list of exhibitors at the I.E.A. Exhibition (p. 147, April) Livingston Laboratories Ltd. were included as agents for Ballantyne Laboratories and Kintel. We understand that Livingston Laboratories do not represent either of these firms.

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.

Time Signals

SIR,—In your March 1958 issue Mr. Norman Lea questions the need for the retention of the rhythmic time signals. I should like to take this opportunity of informing him, and your other readers who may be interested, that the continuation of these signals has already been under review, and it was decided recently to discontinue them after 30th June 1958.

The rhythmic or 'vernier' form of time signal was adopted when the service of international radio time signals from the Royal Observatory was inaugurated on 19th December 1927, since these were best suited to provide an adequate standard of accuracy when no elaborate measuring equipment was available to the user. Their retention has been primarily in the interests of surveyors and prospectors, who still require to keep their essential equipment to a minimum. When it was realized that a new group of users had arisen, who demanded a very high standard of accuracy and were prepared to equip themselves with complicated and elaborate equipment in order to secure it, the mean-time signals, referred to by Mr. Lea, were introduced. The advantages of this type of signal, now universally known as the English system, were soon recognized, and at the General Assembly at Dublin in 1955 the International Astronomical Union recommended for permanent retention only the English system, remarking that "the use of the three systems—American, O.N.O.G.O., and rhythmic—may be continued for a provisional period."

Following enquiries among the departments interested, the Admiralty recently approved the proposal to discontinue the rhythmic signals controlled from the Royal Greenwich Observatory, and to retain only the mean-time series.

I trust that Mr. Lea will continue to find the radio time signals of value to him in the field of frequency standardization.

Royal Greenwich Observatory, HUMPHRY M. SMITH
Herstmonceux Castle, Sussex.
26th March 1958.

Subjective Sharpness of Television Pictures

SIR,—Mr. Sproson's paper in the April issue is especially valuable because of the rarity of such work in the television field. It is therefore important that the results be examined carefully to ensure that all useful information is extracted. With this in view, it would be most interesting to know the author's opinion on the following two questions.

(1) Would it be preferable to calculate the difference limen by a somewhat more sophisticated method; e.g., by assuming (a) a logistic-function relationship between sharpness and opinion score, and (b) a binomial distribution of observers among the seven opinion categories for each test condition ?

Thus the data of Fig. 9 may be re-plotted in terms of $\log\{p/(1-p)\}$ against $\log S$, where p is the normalized opinion score (obtained by linear transform of the '-45 to $+45$' scale into a '0 to 1' scale) and S is the sharpness factor. The result appears to be a set of parallel lines expressible by:

$$p = 1/\{1 + (S/S_0)^{-n}\}$$

where S_0 is the sharpness factor of the comparison picture and n is a constant (about 4).

This treatment disposes of the anomalous curve of Fig. 9, provides the desirable asymptotic relationship (the curve of p against $\log S$ is asymptotic to 0 and 1) and, most significantly, yields a difference limen which is a constant sharpness-factor *ratio* over the whole range of the experiment. The value of the limen appears to be about 7/8 (or 8/7); e.g., the ratio of 3-Mc/s and 2·63-Mc/s equivalent rectangular bandwidths when phase distortion is absent.

(2) Would it be preferable to extend the definition of sharpness factor to include the effect of phase distortion on sharpness of the kind considered in the paper ?

This could be done by making the sharpness factor proportional to the maximum step-response slope whether or not this occurs at the half-amplitude point. The equivalent rectangular bandwidth, as defined in the paper, would then be meaningful only in the absence of phase distortion. Expressed differently, the proposal is to make the sharpness factor proportional to the peak amplitude of the response to a (sin $\omega_c t/\omega_c t$ pulse, where $\omega_c/2\pi$ is the nominal cut-off frequency (3 Mc/s). This form of expression emphasizes the fact that distortion of the type considered causes a reduction of detail-contrast in pictures, an impairment which is commonly reported by non-technical observers as a "loss of sparkle".

In practice, the required peak amplitude is best found by calculation from a measurement of the response to a sine-squared pulse. This is, in fact, one of the features of the rating method mentioned in Dr. Rendall's paper, "Waveform Testing Methods for Television Links", in the issue of December 1957.

Post Office Research Station, N. W. LEWIS
Dollis Hill, London, N.W.2.
11th April 1958.

New Books

Semiconductor Thermoelements and Thermoelectric Cooling. By A. F. IOFFE. Pp. 184. Infosearch Ltd., 16 Ladbroke Gardens, London, W.11. Price 42s.

Prof. A. F. Ioffe is Director of the Institute for Semiconductors of the U.S.S.R. Academy of Sciences, and this book is a translation of two separate monographs originally published in 1956. The translator has done his work well, and the book is singularly fortunate in its English editor, H. J. Goldsmid, whose successful application (with R. W. Douglas) of bismuth telluride in 1954 first drew attention in this country to the practical possibilities of thermoelectric refrigeration.

The first part of the book deals with semiconductor thermoelectric materials, the general theory of the thermocouple, the calculation of the e.m.f., and its efficiency as a generator. While pure-metal couples have efficiencies of about one-tenth of one per cent, it appears possible nowadays to tailor semiconductor materials which may yield efficiencies of the order of ten or fifteen per cent! Among the general conditions making for high efficiency are: first, the use of purely n-type material for one arm of the couple and purely p-type for the other; and, second, the arrangement of an impurity concentration-gradient down each arm. Data for various materials are given. The list of applications includes the thermoelectric refrigerator, the thermoelectric heat pump, and of course thermoelectric batteries —which seem to have been developed to a size suitable for use on tractors instead of a dynamo.

The second part is concerned with the theory and practice of thermoelectric refrigeration. Details, and performance figures on test, for a 40-litre domestic refrigerator which is produced on a semi-commercial scale are given; its d.c. power consumption is only 55 watts. Nothing is said about first cost, but from the point of view of running cost the thermoelectric unit is better than either the absorption or the compression type for small refrigerators, though for larger ones the compression type is still superior at present. Microcoolers and thermostats for use in electronic equipment, instruments, and medical apparatus, are described; there is even a dew-point hygrometer.

The book is mainly intended for physicists, and for electrical and refrigerating engineers, who will probably be most interested in the problems of design which are so fully discussed in the second part.

G.R.N.

High Fidelity Sound Reproduction. Edited by E. MOLLOY. Pp. 200. George Newnes Ltd., Southampton Street, London, W.C.2. Price 20s.

There are ten chapters in this book, each by a different author. Starting with chapters on subjective and objective judgment of performance, the acoustics of sound reproduction and multiple channel systems, the book goes on to treat apparatus. There are chapters on amplifiers and pre-amplifiers, dynamic loudspeakers, loudspeaker enclosures and the electrostatic loudspeaker. The final parts of the book cover record, tape and radio reproduction.

The discussion is essentially non-mathematical and provides a very good picture of the requirements for sound reproduction. A great deal of useful information is included. W.T.C.

Wireless & Electrical Trader Year Book 1958
Pp. 372. Trader Publishing Co. Ltd., Dorset House, Stamford Street, London, S.E.1. Price 12s. 6d. (postage 1s.).

Sections include: Valve Base Connections and Diagrams, Specifications (of receivers and appliances), Radio and Electrical Wholesalers, Proprietary Names, Buyers' Guide, Trade Addresses.

Elementary Nuclear Physics
By W. K. Mansfield. Pp. 60. Price 10s. 6d.

Nuclear Reactor Theory
By J. J. Syrett. Pp. 80. Price 12s. 6d.

Reactor Heat Transfer
By W. B. Hall. Pp. 68. Price 10s. 6d.

These three books are Nos. 1, 2 and 3 respectively of a series of monographs intended for university and technical college students and others, who "require a broad understanding of those topics of nuclear engineering outside their own field of study". The monographs are published by Temple Press Ltd., Bowling Green Lane, London, E.C.1, in association with their monthly journal, *Nuclear Engineering*.

Electron Tube Circuits (2nd Edition)
By S. Seely, Ph.D. Pp. 695. McGraw-Hill Publishing Co. Ltd., 95 Farringdon Street, London, E.C.4. Price 81s. 6d.

Chapters on: Characteristics of Electron Devices; Vacuum Triodes and Transistors as Circuit Elements; Basic Amplifier Principles; Untuned Potential Amplifiers; Feedback in Amplifiers; Rectifiers; Power Supplies; Electronic Computing Circuits; Special Electronic Circuits; Untuned Power Amplifiers; Tuned Potential Amplifiers; Tuned Power Amplifiers; Oscillators; Heavily Biased Relaxation Circuits; Saw-Tooth Sweep Generators; Special Sweep Generators; Amplitude Modulation; Demodulation; Frequency Modulation and Detection; Electronic Instruments.

Programming for an Automatic Digital Calculator
By K. H. V. Booth. Pp. 238. Butterworths Publications Ltd., 88 Kingsway, London, W.C.2. Price 42s. (By post 43s. 9d.).

An account of programming digital computers, based on the machine APEXC at Birkbeck College, London.

Mechanical Resolution of Linguistic Problems
By A. D. Booth, L. Brandwood and J. P. Cleave. Pp. 306. Butterworths Publications Ltd., 88 Kingsway, London, W.C.2. Price 50s.

An account of some results obtained at Birkbeck College on the application of digital calculators to linguistic problems such as translation. Some details of a proposed translating machine are also included.

Magnetic Recording Handbook (2nd Edition)
By R. E. B. Hickman. Pp. 176. George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Price 21s.

Television in Britain
Pp. 67. Published by P.E.P., 16 Queen Annes Gate, London, S.W.1. Price 3s. 6d.

This report, which forms Vol. XXLV, No. 420, of "Planning", contains a wealth of information of a non-technical nature. The following subjects are covered: organization and finance, development of television, the television public, contents of television programmes, the viewing audience, television advertising expenditure and financial aspects.

Tubi Elettronici
By Andrea Pinciroli. Pp. 275. Scienza Nuova, 39 Via Andrea Doria, Milan, Italy. Price L. 3800. (In Italian.)

Electronic Measuring Instruments (2nd Edition, revised)
By E. H. W. Banner, T.D., M.Sc., M.I.E.E., M.I.Mech.E., F.Inst.P., M.Cons.E. Pp. 496. Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price 56s.

Electrical Research Association Technical Reports:
Radio Interference from High Voltage Distribution Systems. By S. F. Pearce. Pp. 14. Price 10s. 6d.
A Stable Decade Amplifier for the Frequency Range 10c/s to 1 Mc/s. By D. C. G. Smith. Pp. 16. Price 10s. 6d.

Copies of these reports are available from The Electrical Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey.

Cours Élémentaire de Mathématiques Supérieures: Vol. 2.
By J. Quinet. Pp. 252. Price 960 F. Published by Dunod, 92 rue Bonaparte, Paris (6e).

Covers series, complex numbers and differential calculus.

Electrical Engineering
By D. O. Bishop, B.Sc., Ph.D., M.I.E.E. Pp. 107. Robert Hale Ltd., 63 Old Brompton Road, London, S.W.7. Price 8s. 6d.

Deals with electrical engineering (including electronics) as a career.

British Plastics Year Book 1958: A Classified Guide to the Plastics Industry (28th Edition)
Pp. 816. Published by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 42s. (Postage 1s. 9d.).

This edition has been thoroughly revised and it has now been divided into eight sections. Three are devoted to classified lists of manufacturers and suppliers of materials, finished products and equipment, while a fourth section contains the world's largest list of trade and proprietary names connected with the industry, covering materials as well as finished goods. Each trade name is followed by a definition of the product and the manufacturer concerned. A glossary of plastics technical terms is also included.

Metal Industry Handbook and Directory 1958
47th year of publication. Pp. 544. Published for *Metal Industry* by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 15s. (By post 16s. 6d.).

A standard work of reference offering a comprehensive source of information about the non-ferrous metal industries. Information on the properties of the newer as well as more familiar metals has been brought up to date, and the extensive section devoted to summaries of British Standard Aircraft Material, D.T.D., and Admiralty specifications has again been included.

Long-Wave and Medium Wave Propagation
By H. E. Farrow, Grad. I.E.E. Pp. 39. Published by arrangement with the B.B.C. for *Wireless World* by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 4s. 6d.

This booklet is based on lectures given by the author at the B.B.C. Engineering Training Department. It brings together a large amount of useful information not otherwise readily available. There are sections on aerials, ground-wave propagation, the effect of geological formations on propagation, propagation curves over terrain of given conductivity, recovery and loss effects, mixed-path propagation, synchronized group working, low-power installations, ionospheric reflection, fading and the effects of the sky wave. A table of data on B.B.C. medium and long-wave transmitting stations is given.

How Television Works
By W. A. Holm. Pp. 318. Philips Technical Library, distributed in Britain by Cleaver-Hume Press Ltd., 31 Wright's Lane, Kensington, London, W.8. Price 32s. 6d.

A description of television for the intelligent layman. Detailed but non-mathematical.

Telecommunication Economics
By T. J. Morgan, A.M.I.E.E. Pp. 452. Macdonald & Co. (Publishers) Ltd., 16 Maddox Street, London, W.1. Price 50s.

The author, who is on the staff of the British Post Office, has written this book with the needs of the telephone systems engineer in mind. However, the first seven of his twenty-four chapters are of a sufficiently general nature to be of use to any engineer interested in the economics of large systems. These chapters deal with the need for engineering economic studies, interest formulae and allied subjects, depreciation accounting, statistics and probability, service life of plant, methods of carrying out an engineering economic study and studies based on annual costs. The last chapter, on the use of capitalized costs, is also of general interest, as are some of the tables in the appendixes.

Foundations of Wireless (7th Edition)
By M. G. Scroggie, B.Sc., M.I.E.E. Pp. 388. Published for *Wireless World* by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 15s. (By post 16s. 4d.)

An enlarged, completely revised, and almost entirely re-written edition of a book which, since it was first published in 1936, has helped those making acquaintance with the principles of radio and electronics for the first time. Television is included.

No previous technical knowledge whatever on the part of the reader is assumed; mathematics are eschewed except where absolutely essential.

Though the background of the book is still sound broadcasting, there is now more emphasis throughout on f.m., v.h.f., and television (including colour).

Stereophonic Sound
By Norman H. Crowhurst. Pp. 128. John F. Rider, Publisher,Inc., 116 West 14th Street, New York 11, N.Y., U.S.A. Price $2.25.

The B.B.C. Riverside Television Studios: Some Aspects of Technical Planning and Equipment
By H. C. Nickels and D. M. B. Grubb. B.B.C. Engineering Division Monograph No. 14. Pp. 31. B.B.C. Publications, 35 Marylebone High Street, London, W.1. Price 5s.

Worked Radio Calculations (2nd Edition)
By Alfred T. Witts, A.M.I.E.E. Pp. 155. Sir Isaac Pitman & Sons Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 12s. 6d.

This edition has been revised using the m.k.s. system of units, and a chapter has been added on "Calculations with Decibels". The book is for technical college students.

Aircraft Communications Systems
By J. H. H. Grover, A.R.Ae.s., M.I.N. Heywood & Co. Ltd., Tower House, Southampton Street, London, W.C.2. Price 22s. 6d.

A reference book for radio operators. Deals with specific S.T.C. and Marconi equipments.

Selected British Technical Journals
Pp. 15. Intended especially for the use of former F.B.I. overseas scholars and other overseas engineers trained in Britain. Lists and describes technical journals and lists principal professional engineering institutions. The Federation of British Industries, 21 Tothill Street, London, S.W.1. Price 2s.

Ceramic Insulators for Telecommunication Purposes
Pp. 15. Specification prepared by the R.E.C.M.F. and recently revised. Published from 21 Tothill Street, London, S.W.1. Price 1s.

Tabellen und Kurven zur Berechnung von Spulen und Ubertragern (3rd Edition)
By Richard Feldtkeller. Pp. 69. S. Hirzel Verlag, Stuttgart N., Birkenwaldstrasse 185, Germany. Price D.M. 10.

Data and charts relating to the design of iron-cored chokes and transformers for use at low frequencies. Some charts are of a general nature showing, for example, mass of core material required against magnetizing force, while others relate to specific German cores. Details of the latter are included, as are details of the composition of the various magnetic materials used in making the general charts.

U.H.F. CONGRESS PAPERS

All the papers presented at the Congress on Ultra High Frequency Circuits and Antennas in October 1957 will be published in July 1958 by the Société des Radioélectriciens. They will be published in English or in French according to the language used by the author. Entitled "Congrès Circuits et Antennes Hyperfréquences", they will be available from Société des Radioélectriciens, 10 Avenue Pierre Larousse, Malakoff (Seine), France: Subscription price (until 15th June) 5,000 F (French); after Subscription offer, 9,000 F (French). Pamphlet containing abstracts of the papers (published both in English and French), 1,000 F (French).

MEETINGS

I.E.E.

6*th May*. "Some Case Histories of Business Computers in U.S.A.", by A. T. Starr, M.A., Ph.D., B.Sc., at 5.30.

9*th May*. "The Teaching of Applied Acoustics", discussion to be opened at 6 o'clock by G. Mather, B.Sc.Tech.

14*th May*. "A New Cathode-Ray Tube for Monochrome and Colour Television", by D. Gabor, Dr. Ing., F.R.S., P. R. Stuart and P. G. Kalman, to commence at 5.30.

15*th May*. Annual General Meeting, followed at 6.30 by "Recent Developments in Electronics in the United States" by D. G. Fink.

These meetings will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.

Brit. I.R.E.

21*st May*. "Cold-Cathode Voltage Transfer Circuits", by J. H. Beesley, B.Sc., to be held at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

The Society of Instrument Technology

8*th May*. "Control of the Radio Telescope", by J. G. Davies, Ph.D., M.A., to be held at 7 o'clock at Manson House, Portland Place, London, W.1.

The Physical Society

16*th May*. "Ultrasonic Transducers", by R. J. Copley.

Institute of Physics

16*th May*. "The Characteristics and Design of Ultrasonic Flaw-Detector Transducers", by D. G. Christie, to be held at the Institute of Physics, 47 Belgrave Square, London, S.W.1, at 6 o'clock.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Deviations from nominal frequency for March* 1958

Date 1958 March	MSF 60 kc/s 2030 G.M.T. Parts in 10^9	Droitwich 200 kc/s 1030 G.M.T. Parts in 10^8
1	− 2	N.M.
2	− 2	N.M.
3	− 2	− 2
4	− 2	− 2
5	− 2	− 2
6	− 2	− 2
7	− 1	− 2
8	N.M.	N.M.
9	− 1	N.M.
10	− 1	− 2
11	− 1	− 1
12	− 1	− 1
13	− 1	− 1
14	− 1	− 1
15	− 1	N.M.
16	− 1	N.M.
17	− 1	− 1
18	− 1	0
19	− 1	0
20	− 1	0
21	− 1	0
22	− 1	0
23	− 1	0
24	− 1	0
25	− 1	0
26	− 1	0
27	− 1	+ 1
28	− 1	0
29	− 1	N.M.
30	− 1	N.M.
31	− 1	+ 1

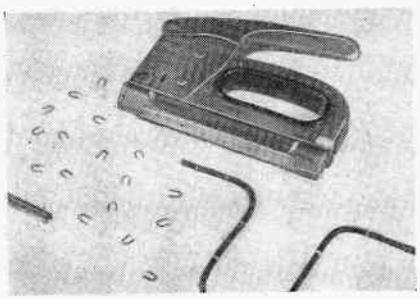
* *Nominal frequency is defined to be that frequency corresponding to a value of* 9 192 631 830 *c/s for the N.P.L. caesium resonator. N.M. = Not Measured.*

New Products

Cable-Fastening Gun

The illustration shows a tacking 'gun' firing curved roof-staples after the fashion of an office stapling machine.

A special feature is the 'twin impact'



selector which enables a hard or a soft strike to be selected, depending upon the material into which the staples have to be driven.

Industrial Staplers Ltd.,
Truman House, 7-9 Rathbone Street,
London, W.1.

Silicon Zener Diodes

The Z2 series of SenTerCel silicon zener reference diodes has been extended by the addition of twenty-six new types. Three useful ranges with small voltage overlaps have been introduced and voltage tolerances of ±5% and ±10% are included, as well as the earlier ±20% range. Each range covers 3·3 to 15 V, the nominal voltage being defined at 20 mA reverse current.

Standard Telephones & Cables Ltd.,
Edinburgh Way, Harlow, Essex.

Sub-Miniature Germanium Diodes

Gold-bonded germanium diodes only 2 mm in diameter are now obtainable. These have a rated dissipation of 33 mW at 25°C, and it is claimed that prolonged overloads of ten times this amount are permissible. The diodes are useful up to 100 Mc/s.

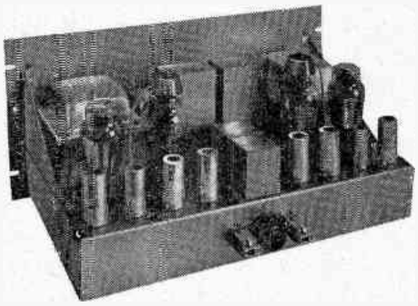
Indium-bonded rectifiers (diameter 6 mm) have a continuous dissipation rating of 300 mW at 25°C, can pass a continuous forward current of 400 mA, and operate from a.c. supplies up to 70 V r.m.s.

Kynmore Engineering Co. Ltd.,
19 Buckingham Street, London, W.C.2.

Dual Stabilized Power Unit

The photograph shows a general-purpose highly-stabilized power unit comprising two separate power supplies built into one chassis. Each power supply has a centre voltage of 250 V d.c. at a maximum current of 200 mA, and has an unstabilized supply of 6·3 volts a.c. at 4 amps. The output voltage is adjustable by pre-set potentiometer over the range 200 to 300 V, with a limitation of the current drawn.

The unit has been designed for the operation of a number of d.c. amplifiers when the positive line of one supply and the negative line of the other supply are connected to the chassis. Each power supply is arranged so that either the positive or negative line may be connected to the chassis



by a single link, permitting the two supplies to be used in a number of ways. Connected in series, the stabilized output may be increased to 500 V at 200 mA or balanced out so that unbalancing the supplies will enable a stabilized voltage of 0–100 V at 200 mA to be obtained. It is not recommended that the supplies be connected in parallel.

Measurements taken on an average unit are given below:

Mains Fluctuation. The output voltage variation of an average supply when the mains fluctuate ±10% is less than ±0·02 V at 250 V, full load.

Regulation of an Average Unit. Change of output voltage for 200 mA current change, 0·08 V.

Output Impedance. At 250 V, 200 mA, approximately 0·1 Ω.

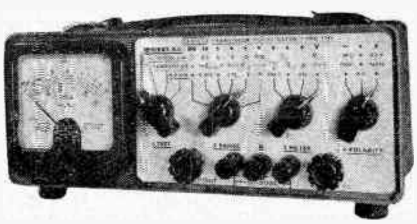
Ripple. Less than 3 mV r.m.s. at full load.

Cape Electrophonics Ltd.,
43-45 Shirley High Street, Southampton.

Transistor Multitester

This instrument is intended both for testing transistors and for general circuit testing.

Transistors are used to generate 1-kc/s



sinusoidal oscillations and to amplify audio-frequency signals prior to connection to a sensitive a.f. rectifier–moving-coil meter. The oscillator output is said to be sufficient to provide an audible note in a loudspeaker and the sensitivity of the voltmeter to be sufficient to measure the signal level at the second detector of most radio and television receivers.

With the 'test' selector in one position, the internal battery supply is disconnected and the 500-μA 3¼ in. meter is used to measure external d.c. voltages. The 'range' selector is then used to give three d.c. voltage ranges.

There are four 'ohms' ranges covering 500 Ω to 1 MΩ. The internal battery can also be used to pass currents of 0·1–100 mA through an external circuit, and the actual current indicated. This facility is useful for testing rectifiers.

The common-emitter current amplification factor is measured by passing a small 1-kc/s current into the base of the transistor in addition to a direct base current. Current amplifications of up to 500 are measurable in three ranges. The minimum collector voltage during this test is 1 V.

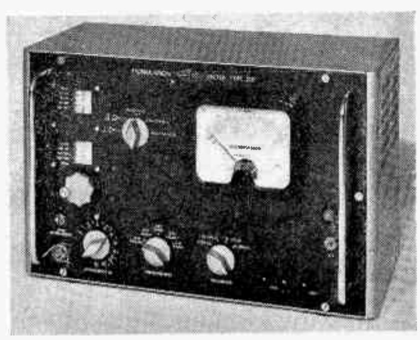
For audio-frequency tests, the output of the 1-kc/s oscillator is connected to two terminals via a 50-ohm variable potentiometer. External audio-frequency signals may be measured by a transistor a.f. voltmeter of 150-mV full-scale deflection. The a.f. voltmeter monitors either the output from the oscillator or an external a.f. signal. A.F. currents up to 15 mA are measured with a low d.c. resistance path across the input terminals. These current ranges may be used in conjunction with the calibrated output signal to measure the stage gains of transistor and valve circuits.

Levell Electronics,
High Street, Edgware, Middx.

A.M./F.M. Modulation Meter

Modulation meter type 210 may be used to measure the percentage modulation of amplitude-modulated signals and the peak deviation of frequency-modulated signals in the carrier-frequency range 2·25 Mc/s to 300 Mc/s. Operation with reduced sensitivity is possible up to a frequency of 600 Mc/s. Modulation depths up to 100% and frequency deviations up to ±100 kc/s may be measured in the modulation frequency range 30 c/s to 15 kc/s.

Outputs at the intermediate frequency of 750 kc/s and at low frequency are available



from terminals on the front panel. These outputs enable the modulated envelope of the input signal and the demodulated signals to be observed on an oscilloscope.

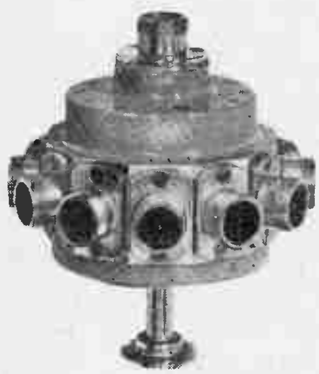
The limiting action of the instrument is claimed to be so effective that it can be used to measure spurious frequency modulation occurring on amplitude-modulated signals. Changes of mean carrier level when amplitude-modulation is applied can be measured to an accuracy of better than ±1%.

A feature of the instrument is simplicity of operation. The tuning control is adjusted until a meter reading is obtained, and the input attenuator adjusted for full-scale deflection. It is then only necessary to switch to the a.m. or one of the f.m. positions to obtain a direct reading of modulation.

Airmec Ltd.,
High Wycombe, Bucks.

12-Way Coaxial Switch

There are many instances where a v.h.f. transmitter or receiver is required to operate



with a number of aerials at different frequencies. To simplify this process of aerial selection, Racal have developed a 12-way coaxial switch type MA.42. Selection is obtained manually or remotely by the operation of a single control, the connections to the various aerials being taken direct to the switch through inter-service connectors style SR.4G.

The switch has a solid aluminium casing, and is claimed to operate satisfactorily under severe conditions. Attention has been given to keeping a truly coaxial construction. Contact is made to any of the twelve output connections by a rotary movement combining wiping and self-locating actions, and very little torque is required for its operation.

The MA.42 will handle up to 1 kW of r.f. power continuously, providing the standing-wave ratio does not exceed 2 : 1, with a maximum frequency of 250 Mc/s. It is normally manufactured with an impedance of 52 Ω. Cross-talk is low (−80 dB on the selected input).

Racal Engineering Ltd.,
Bracknell, Berks.

L-Band Magnetron

The M554 is a high-power pulse magnetron which operates at a fixed frequency in the range 1,300–1,365 Mc/s and functions at pulse widths up to 5 μsec, with a maximum peak input rating of 6 MW. The valve is designed for use with a separate magnet.

The output circuit is arranged to fit into a transition which couples directly to No. 6 waveguide. The transition is supplied by the makers and the dimensions have been chosen so that all valves will be mechanically and electrically interchangeable. The anode is water-cooled.

The makers state that the weight has been kept sufficiently low to permit the valve and its output transitron to be readily handled by one man.

English Electric Valve Co. Ltd.,
Chelmsford, Essex.

Humidity Test Cabinets

New types are available in the following sizes:

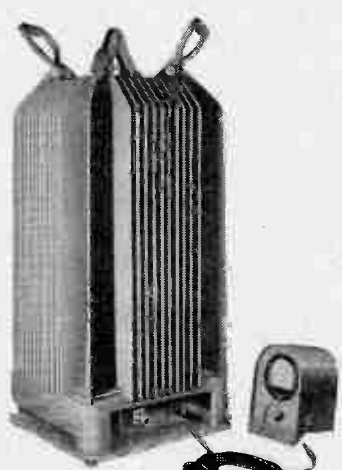
HTC 5. 36 in. wide by 36 in. high by 36 in. deep.
HTC 6. 54 in. wide by 36 in. high by 36 in. deep.
HTC 7. 72 in. wide by 36 in. high by 36 in. deep.

These can be used for tests to specifications such as K114 (issue 2) and RCS11 (issue 5), as well as for general laboratory service. They are self-contained, requiring only connection to electricity and water supplies and provision for drainage. The interiors are made of heavy tinned copper. Dry-heat temperatures up to 100°C are catered for, and temperatures up to 70°C at relative humidites of 40–90%.

Barlow-Whitney Ltd.,
2 Dorset Square, London, N.W.1.

500-Watt R.F. Power Meter

The TF1205 is an absorption-type instrument for direct measurement of power in the range d.c. to 500 Mc/s. The load resistor is oil-immersed and cooling of the finned outer casing is by free-air convection. A heavy-duty high-stability resistor of tubular form is employed, so mounted that it forms the central conductor of a parallel-plate line. The input power is fed to the 'live' end of the resistor by an outward-tapering section which preserves a constant impedance between the connector and the relatively large-dimensioned resistor. From 'live' to 'earthy' end of the resistor, the broad metal plates which form the outer conductor have an inward taper so that continuous matching is maintained along the whole length of the resistor. The complete slab-line assembly is immersed in a tank of transformer oil. Cooling fins provide a total surface area of over twenty square feet. By this means, the overall temperature rise of the oil is restricted to approximately 30°C.



The measuring circuit comprises a vacuum thermocouple, fed from a tap on the load resistor, and a moving-coil meter mounted in a separate indicator unit.

The directly-calibrated meter has a substantially linear scale and indicates true mean power, irrespective of waveform. Intended for direct connection to a coaxial cable, the power meter has an input impedance of 50 ohms.

Marconi Instruments Ltd.,
St. Albans, Herts.

Loudspeaker for Portable Receivers

The latest addition to the range of loudspeakers produced by the Plessey Company is a 3-in. shallow unit which has been specially developed for use in the smaller types of portable receivers.

Overall depth of the standard model is 1 in. and the flux density is 8,500 gauss; it employs a magnet with a $\frac{3}{4}$-in. diameter pole.

The standard voice coil is 3 or 5 ohms

impedance, but high impedance coils up to 80 ohms may be fitted if required.

The Plessey Co. Ltd.,
Ilford, Essex.

High-Frequency Induction Generator

The C50/SR 6-kW induction equipment is specially designed for silicon refining and similar processes where a very high work coil kVA is essential.

It operates at a nominal frequency of 5 Mc/s and will develop a peak voltage in excess of 4,500 V across a work coil of 0·5 μH.

The equipment is designed for use with work coils of between 0·3 and 1 μH. As the work coil forms the actual tank coil of the oscillator, the operating frequency varies over a range of 3·5 to 6·5 Mc/s.

A manual power output control is provided in the form of a separate self-contained voltage regulator. This feeds the primary of the high-voltage transformer and provides the facility of reducing the anode voltage fed to the oscillator valve to 25% of the normal value of 5·5 kV d.c. This regulator can also maintain a constant output at any pre-determined voltage setting over its control range.

Radio Heaters Ltd.,
Eastheath Avenue, Wokingham, Berks.

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 journal titles conform generally with the style of the World List of Scientific Periodicals. An Author and Subject Index to the abstracts is published annually; it includes a selected list of journals abstracted, the abbreviations of their titles and their publishers' addresses. Copies of articles or journals referred to are not available from Electronic & Radio Engineer. *Application must be made to the individual publishers concerned.*

ACOUSTICS AND AUDIO FREQUENCIES

534.121.2 1290

Variational Treatment of Arbitrarily Mass-Loaded Membranes.—E. T. Kornhauser & D. B. Van Hulsteyn. (*J. acoust. Soc. Amer.*, Nov. 1957, Vol. 29, No. 11, pp. 1204–1205.) See 921 of 1954 (Kornhauser & Mintzer).

534.133 1291

Vibrations of a Monoclinic Crystal Plate.—E. G. Newman & R. D. Mindlin. (*J. acoust. Soc. Amer.*, Nov. 1957, Vol. 29, No. 11, pp. 1206–1218.)

534.21 1292

Acoustical Radiation from a Point Source in the Presence of Two Media.—D. I. Paul. (*J. acoust. Soc. Amer.*, Oct. 1957, Vol. 29, No. 10, pp. 1102–1109.) Two semi-infinite isotropic media (porous or non-porous) are separated by a plane interface. Expressions for the resultant wave function are obtained by a method of steepest descents in a form applicable also to the analogous electromagnetic case. See also 3387 of 1947 (Rudnick).

534.21-8-14 1293

Ultrasonic Absorption by Steady Thermal Method.—S. Parthasarathy & S. S. Mathur. (*Ann. Phys., Lpz.*, 20th Dec. 1956, Vol. 19, Nos. 3–5, pp. 242–246. In English.) A new method of determining ultrasonic absorption coefficients in liquids is described.

534.21-8-14 1294

Ultrasonic Pulse Technique for Measuring Acoustic Losses and Velocities of Propagation in Liquids as a Function of Temperature and Hydrostatic Pressure.—H. J. Meskimin. (*J. acoust. Soc. Amer.*, Nov. 1957, Vol. 29, No. 11, pp. 1185–1192.)

534.212 : 534.121.2 1295

On the Transmission of a Spherical Sound Wave through a Stretched Membrane.—G. L. Lamb, Jr. (*J. acoust. Soc. Amer.*, Oct. 1957, Vol. 29, No. 10, pp. 1091–1095.)

534.22-14 : 546.212 1296

Speed of Sound in Water by a Direct Method.—M. Greenspan & C. E. Tschiegg. (*J. Res. nat. Bur. Stand.*, Oct. 1957, Vol. 59, No. 4, RP 2795, pp. 249–254.) The speed of sound in distilled water was measured over the temperature range 0°–100°C to within 1 part in 30 000. Details of the method and equipment are given and results are tabulated.

534.23 1297

Representation of the Field of an Acoustic Source as a Series of Multipole Fields.—H. L. Oestreicher. (*J. acoust. Soc. Amer.*, Nov. 1957, Vol. 29, No. 11, pp. 1219–1222.)

534.23 1298

Field of a Spatially Extended Moving Sound Source.—H. L. Oestreicher. (*J. acoust. Soc. Amer.*, Nov. 1957, Vol. 29, No. 11, pp. 1223–1232.)

534.231 1299

Oppositely Directed Plane Finite Waves.—R. D. Fay. (*J. acoust. Soc. Amer.*, Nov. 1957, Vol. 29, No. 11, pp. 1200–1203.) An adaptation of the analytical method described earlier (1300 of 1957) to determine the sound field of waves progressing in opposite directions.

534.232-14-8 : 534.133 1300

Relation between Efficiency of Quartz Transducers and Ultrasonic Absorption Coefficient of Liquids: Parts 1 & 2.—S. Parthasarathy & P. P. Mahendroo. (*Z. Phys.*, 6th Feb. 1957, Vol. 147, No. 5, pp. 573–581. In English.) Report on experimental investigations of absorption in organic liquids and discussion of the resulting transducer efficiency curves. See also 324 of 1957 (Parthasarathy & Narasimhan).

534.24 1301

Reflection on a Rough Surface from an Acoustic Point Source.—M. A. Biot. (*J. acoust. Soc. Amer.*, Nov. 1957, Vol. 29, No. 11, pp. 1193–1200.)

534.613 1302

Acoustic Torques and Forces on Disks.—J. B. Keller. (*J. acoust. Soc. Amer.*, Oct. 1957, Vol. 29, No. 10, pp. 1085–1090.)

534.78 1303

Acoustics and Physiology of Phonation.—R. Husson. (*J. Phys. Radium*, March 1957, Vol. 18, Supplement to No. 3, *Phys. appl.*, pp. 23A–35A.)

621.395.61 + 621.395.62 1304

Real-Power Damping of Electroacoustic Transducers.—T. Hayasaka.

(*Rep. elect. Commun. Lab., Japan*, Sept. 1957, Vol. 5, No. 9, pp. 1–3.) Real-power damping is defined. Design methods using this are similar to those minimizing vector power damping.

621.395.623.7.012 1305
Panoramic Representation of the Sound Field.—G. G. Sacerdote & C. Bordone-Sacerdote. (*J. acoust. Soc. Amer.*, Nov. 1957, Vol. 29, No. 11, pp. 1165–1168.) Note of records obtained using a sonagraph method of recording the sound field of a rotating loudspeaker fed by white noise. See 2950 of 1956.

621.395.625.3 : 621.397.5 1306
The Ampex Video Tape-Recording System.—Snyder. (See 1568.)

AERIALS AND TRANSMISSION LINES

621.314.22 : 621.317.343.2 1307
Measurement of the Characteristic Impedance of a Coaxial Cable.—D'Alton. (See 1496.)

621.372.2 1308
The Helical Line with a Coaxial Cylindrical Attenuating Layer.—G. Landauer. (*Arch. elekt. Übertragung*, July 1957, Vol. 11, No. 7, pp. 267–277.) The attenuated helical line is analysed by considering a coaxial system formed by an obliquely conducting cylinder with infinitely thin walls and a cylindrical semiconducting outer shell. Attenuation and phase rotation are plotted as a function of the surface resistance of the attenuating cylinder. Two different surface resistances can produce the same attenuation but different phase velocities.

621.372.2 : 621.318.134 1309
Microwave Magnetic Field in Dielectric-Loaded Coaxial Line.—B. J. Duncan, L. Swern & K. Tomiyasu. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 500–502.) Additional experimental work and theoretical considerations show that the probable mode configuration for a coaxial line half filled with a low-loss high-dielectric-constant material suggested in an earlier paper [2023 of 1957 (Duncan et al.)] should be rotated by 180° relative to the dielectric.

621.372.8 1310
Ghost Modes in Imperfect Waveguides.—E. T. Jaynes. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 416–418.) Microwave resonances exist which are nonradiating and thus have high Q, although the fields are not enclosed completely by metallic walls. Complicated resonance effects observed in waveguides operating close to the cut-off frequency of a propagation mode are explained. These spurious resonances are analogous to certain phenomena observed in imperfect crystals of solid-state materials.

621.372.8 : 537.226 1311
Shielded Dielectric Waveguide.—H. Uchida, S. Nishida & H. Shioya. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, June 1956, Vol. 8, No. 1, pp. 7–22.) A theoretical analysis of a shielded dielectric waveguide shows the existence of both symmetrical E and H waves. The dominant mode of the latter is easily propagated and has a low transmission loss. They both have similar cut-off frequencies but the E wave may be suppressed.

621.372.8 : 621.018.75 1312
Influence of Wall Losses on Pulse Propagation in Waveguides.—R. Gajewski. (*J. appl. Phys.*, Jan. 1958, Vol. 29, No. 1, pp. 22–24.) "Assuming that the resistivity of waveguide walls is not too large, the influence which energy losses have upon the shape of a pulse propagating along the waveguide is discussed. It is found that pulses are damped with a damping factor equal in the first approximation to that in a steady state."

621.372.829 1313
Propagation of Waves in Helical Waveguides.—Chiao-Min Chu. (*J. appl. Phys.*, Jan. 1958, Vol. 29, No. 1, pp. 88–89.) An analysis is developed for determining the effects of wire size and shape on the attenuation and harmonic fields of monofilar and multifilar helices. Calculated attenuation characteristics agree well with experimental data.

621.372.831 1314
Junction of Smooth Flared Waveguides.—D. J. Leonard & J. L. Yen. (*J. appl. Phys.*, Dec. 1957, Vol. 28, No. 12, pp. 1441–1448.) "Stevenson's general theory of e.m. horns or flared waveguides [1841 of 1952], which is valid only for geometrical configurations whose cross-sections are continuous along the direction of propagation together with their first and second derivatives, is generalized to include sudden jumps in the first derivatives of the cross-sections."

621.372.85.011.21 1315
A Physical Interpretation of Impedance for Rectangular Waveguides.—J. A. Lane. (*Proc. phys. Soc.*, 1st Dec. 1957, Vol. 70, No. 456B, pp. 1173–1174.) Impedance measurements on narrow transverse films in the centre of a rectangular waveguide indicate that the most appropriate definition of impedance for such obstacles is one based on total transmitted power and maximum transverse voltage.

621.372.852.3 1316
An Improved Microwave Attenuator for Military Use.—F. L. Rose. (*Bell Lab. Rec.*, Oct. 1957, Vol. 35, No. 10, p. 418.)

621.372.852.323 : 621.318.134 1317
A Nonreciprocal Attenuator (Isolator) for 4 Gc/s.—J. Deutsch & W. Haken. (*Frequenz*, July 1957, Vol. 11, No. 7, pp. 217–220.) Description of a 3·8–4·2-kMc/s ferrite-type isolator; the reflection coefficient is about 1% over the whole frequency range, reverse attenuation is greater than 13 dB and forward attenuation about 0·5 dB.

621.396.67 : 621.396.11 1318
Interaction between Two Aerials.—J. Robieux. (*C. R. Acad. Sci., Paris*, 12th Aug. 1957, Vol. 245, No. 7, pp. 793–796.) A general expression for the transmission of energy from one aerial to another is derived on the assumptions that (*a*) both aerials have directivity and (*b*) they are so far apart that the radiation of one is unaffected by the other. Applications of the expression are suggested for cases of tropospheric propagation, or radiation involving diffraction.

621.396.67.012.12 1319
Graphical Solution of the Radiation from Aerial Systems Composed of Two Active Elements.—V. Caha. (*Slab. Obz., Praha*, March 1957, Vol. 18, No. 3, pp. 144–149.) A theoretical analysis of the radiation diagrams of aerial systems with two active elements. Details of a direct geometric procedure for drawing these diagrams are given.

621.396.67.029.6 + 621.372.8] (091) 1320
Microwave Antenna and Waveguide Techniques before 1900.—J. F. Ramsay. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 405–415.) In the years between 1888 when Hertz initially demonstrated radio waves and 1900 when Marconi established radio communication, experimenters developed microwave devices and techniques anticipating much of present-day practice. A historical review is given of aerials and waveguides of the period with some reference to associated microwave techniques.

621.396.674.3-415 1321
Rolled Triangular-Sheet Antennas.—J. R. McDougal, S. Adachi & Y. Mushiake. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, Dec. 1956, Vol. 8, No. 3, pp. 125–132.) A dipole made up of two spirally rolled right-angled triangular metal sheets has a power pattern and input impedance suitable for wide-band application in the full-wavelength region. In the half-wavelength region the dipole approximates to an ordinary cylindrical dipole.

621.396.676 1322
Capacity Feed for the Mobile Whip.—J. M. Osborne. (*Short Wave Mag.*, Oct. 1957, Vol. 15, No. 8, pp. 408–410.) Details of a capacitive feed system for a whip aerial for mobile use.

621.396.677 1323
Simple Two-Band Cubical Quad.—C. Teale. (*Short Wave Mag.*, Oct. 1957, Vol. 15, No. 8, pp. 406–407.) Design and constructional details of an inexpensive directional aerial array of small dimensions for 10 and 15 m λ with a gain of 8–10 dB.

621.396.677.3 1324
More about the Minibeam.—G. A. Bird. (*R.S.G.B. Bull.*, Oct. 1957, Vol. 33, No. 4, pp. 168–172.) Additional constructional and operational details of an aerial array for 10, 15 and 20 m λ of a design described earlier (*ibid.*, Feb. 1956, Vol. 31, No. 8, pp. 355–358).

621.396.677.7/.8 1325
The Design of Horn-Parabola Aerials.—H. Laub. (*Frequenz*, July 1957, Vol. 11,

No. 7, pp. 201–207.) The dependence of the aerial dimensions on the angle of illumination is investigated. See also 2628 of 1956 (Laub & Stöhr).

621.396.677.71 **1326**

Pattern of a Flush-Mounted Microwave Antenna.—J. R. Wait. (*J. Res. nat. Bur. Stand.*, Oct. 1957, Vol. 59, No. 4, RP 2796, pp. 255–259.) "The numerical results for the far-zone radiation from an axial slot on a circular cylinder of perfect conductivity and infinite length are discussed. It is shown that the results for large-diameter cylinders can be expressed in a universal form that is suitable for pattern calculations for arrays of slots on a gently curved surface." See also 355 of 1957 (Wait & Kates).

621.396.677.71 **1327**

Radiation from Slots on Dielectric-Clad and Corrugated Cylinders.—J. R. Wait & A. M. Conda. (*J. Res. nat. Bur. Stand.*, Nov. 1957, Vol. 59, No. 5, RP 2802, pp. 307–316.) "An approximate formula is derived for the radiation pattern of an axially slotted cylinder with a thin dielectric coating. The accuracy of the formula is shown to be sufficient for practical purposes. Using a similar method, the pattern function for a slot on a corrugated cylinder is derived. Extensive numerical results are presented for both dielectric-clad and corrugated cylinders."

621.396.677.8 **1328**

On Focusing Electromagnetic Radiators.—R. W. Bickmore. (*Canad. J. Phys.*, Nov. 1957, Vol. 35, No. 11, pp. 1292–1298.) "The transmission of electromagnetic energy between two apertures is examined as a function of their sizes, separation, excitation functions, and surface shapes with Fresnel approximations made throughout. Relations are derived which show when it is advantageous to focus the apertures by curving about a spherical surface."

621.396.677.8 **1329**

Fraunhofer Pattern Measurement in the Fresnel Region.—R. W. Bickmore. (*Canad. J. Phys.*, Nov. 1957, Vol. 35, No. 11, pp. 1299–1308.) The Fraunhofer pattern of an aperture may be obtained by probing the field at a radius of $0\cdot1(l^2/\lambda)$ instead of $2l^2/\lambda$, provided the aperture can be moulded to a radius of curvature less than $2l^2/\lambda$. There is less inherent phase error in the main-lobe region than in measurements on a plane aperture at $2l^2/\lambda$.

621.396.677.81 **1330**

Reflection of a Plane Wave at a Wire Mesh in the Case of Normal Polarization.—V. G. Yampol'skiĭ. (*Radiotekhnika, Mosk.*, Nov. 1956, Vol. 11, No. 11, pp. 33–37.) The reflection of a plane e.m. wave at a wire mesh consisting of equidistant circular conductors is considered for the case in which the field intensity vector of the incident wave is perpendicular to the axes of the conductors.

621.396.677.81 : 621.396.932.1 **1331**

Current Distribution on Vertical Cylindrical Reflectors.—G. Ziehm. (*Frequenz*, Aug. 1957, Vol. 11, No. 8, pp. 233–243.) Problems arising in ship d.f. equipment due to the effects of parasitic currents are discussed. The magnitude and distribution of vertical currents are determined for various types of aerial and are shown graphically. Suggestions for minimizing errors are based on these investigations.

621.396.677.833.2 : 621.396.65 **1332**

Aerials for 4 000-Mc/s Radio Links.—R. L. Corke & J. Hooper. (*P.O. elect. Engrs' J.*, Oct. 1957, Vol. 50, Part 3, pp. 178–185.) "After a brief discussion of normal radio propagation losses a simple explanation is given of the way microwave aerials function. A particular form of the paraboloidal reflector aerial is then described in some detail."

AUTOMATIC COMPUTERS

681.142 **1333**

A Unique Approach to Computer Versatility.—L. S. Michels. (*Electronic Ind. Tele-Tech*, Oct. 1957, Vol. 16, No. 10, pp. 72–75 . . 142.) The need for a computer which can perform specialized computations as well as general data processing is met by the integration of a general-purpose computer with a digital differential analyzer. The design involves a shared storage system and special input/output facilities.

681.142 **1334**

Description of a Large Electronic Computer.—A. P. Speiser. (*Bull. schweiz. elektrotech. Ver.*, 9th Nov. 1957, Vol. 48, No. 23, pp. 1013–1016.) Description of the IBM Type-704 computer which comprises storage units of magnetic tape, core, and drum type.

681.142 **1335**

Cycle and Delay Time Considerations in a Real-Time Digital Computer.—H. Freeman. (*Commun. & Electronics*, Nov. 1957, No. 33, pp. 588–593.) Considerable improvement in a computer program can be obtained by careful selection of cycle and delay times. The criterion of information-handling efficiency provides a basis for comparing the quality of various programs.

681.142 **1336**

Recording and Read-Out Circuits for Binary Numbers in a Magnetic-Drum Storage System.—L. Dadda. (*Ricerca sci.*, Aug. 1957, Vol. 27, No. 8, pp. 2403–2425.) Details of the storage system used in the computer Type CRC 102A at the Milan Polytechnic. See also 3758 of 1957.

681.142 **1337**

A Swiss Analogue Computer.—E. Jucker. (*Bull. schweiz. elektrotech. Ver.*, 9th Nov. 1957, Vol. 48, No. 23, pp. 1017–1020.) An electromechanical system is described in which quantities are represented by a.c. voltage amplitudes and by the angle of rotation of shafts in a servo system.

681.142 : 537.312.62 **1338**

Trapped-Flux Superconducting Memory.—J. W. Crowe. (*IBM J. Res. Developm.*, Oct. 1957, Vol. 1, No. 4, pp. 294–303.) "A memory cell based on trapped flux in superconductors has been built and tested. The cell is constructed entirely by vacuum evaporation of thin films and can be selected by coincident current or by other techniques, with drive-current requirements less than 150 mA. The short transition time of the trapped-flux cell indicates its possible use in high-speed memories. The superconductive film memory does not exhibit the problems of 'delta noise' in core memories resulting from the difference in half-select pulse outputs."

681.142 : 537.312.62 **1339**

An Analysis of a Persistent-Supercurrent Memory Cell.—R. L. Garwin. (*IBM J. Res. Developm.*, Oct. 1957, Vol. 1, No. 4, pp. 304–308.) A theoretical model of a storage cell based on thin films of superconductors is discussed. An experimental device built to resemble the model was found to have the predicted behaviour.

681.142 : 621.385.832 **1340**

A Binary-Weighted Current Decoder.—E. J. Smura. (*IBM J. Res. Developm.*, Oct. 1957, Vol. 1, No. 4, pp. 356–362.) A method for driving c.r. tubes from digital equipment is described, in which the deflection yoke is fed directly from binary-weighted constant-current sources. Design considerations are outlined and a comparison is made with other methods.

681.142 : 621.396.828 **1341**

Radio-Interference Control as Applied to Business Machines.—Sarley & Hendery. (See 1542.)

CIRCUITS AND CIRCUIT ELEMENTS

621.3.011.21 : 621.314.7 : 621.372.52 **1342**

Negative Impedances, Transistors and Feedback Circuits and their Interrelations.—T. Scheler & H. W. Becke. (*Frequenz*, July & Aug. 1957, Vol. 11, Nos. 7 & 8, pp. 207–217 & 250–259.) The use of transistors in negative-impedance feedback circuits is investigated and the influence of transistor characteristics on the network parameters is determined theoretically and by measurement. Some practical difficulties are discussed.

621.3.049.7 **1343**

Mechanics of Electronics.—W. D. Cussins. (*Wireless World*, March 1958, Vol. 64, No. 3, pp. 133–137.) Some suggestions for layout and mechanical design of equipment.

621.3.09 **1344**

The Influence of the Coefficients of the Transfer Function of a Transmission System on the Output Characteristics as a Function of Time.—R. Hofmann & W. Walcher. (*Arch. elekt.*

Übertragung, Aug. 1957, Vol. 11, No. 8, pp. 321–324.) The input considered is in the form of a step function.

621.314.22.029.55 : 621.318.134 **1345**

On the Use of Ferrites in Wide-Band H.F. Transformers.—(*Point to Point Telecommun.*, June 1957, Vol. 1, No. 3, pp. 22–25.) Design problems encountered using ferrite cores in h.f. power transformers are discussed including methods of heat dissipation. Characteristics of two commercially available designs are given.

621.318.57 : 621.375.132.3 **1346**

Electronic Switch doubles as Cathode Follower.—R. Benjamin. (*Electronics*, 17th Jan. 1958, Vol. 31, No. 3, pp. 81–83.) "Basic two-way electronic switch may be expanded to multiway unit by adding input selector circuits, or may be used as a precision cathode follower by eliminating the selector. Circuit has near-infinite input impedance and near-zero output impedance. Comparator compensation permits accuracy of 0·1% over ±100 V."

621.318.57 : 621.396.669 **1347**

An Electronic Transmitter-Receiver Antenna Switch.—E. Arvonio. (*QST*, Oct. 1957, Vol. 41, No. 10, pp. 32–33.) Description of a twin-triode circuit for instantaneous break-in operation.

621.319.45 **1348**

Miniaturized Tantalum Solid Electrolytic Capacitors.—F. S. Power. (*Bell Lab. Rec.*, Oct. 1957, Vol. 35, No. 10, pp. 419–422.) The replacement of an aqueous electrolyte by an oxide film results in an improvement in the low-temperature characteristics and an extension of the frequency range. These capacitors also have the advantage of storing more charge per unit volume than previous types.

621.372.001.1 **1349**

Theory of Electrical Networks with Nonlinear Elements.—J. J. Schäffer. (*Arch. Elektrotech.*, 20th May 1957, Vol. 43, No. 3, pp. 151–168.) Mathematical treatment making use of almost periodic functions.

621.372.41 : 621.318.424 **1350**

The Occurrence of Abnormal States in Certain Ferroresonant Circuits.—M. Panet. (*C. R. Acad. Sci., Paris*, 19th Aug. 1957, Vol. 245, No. 8, pp. 834–837.) Two identical parallel resonance circuits incorporating coils with iron cores are connected in series. Conditions are examined under which an applied alternating voltage is not equally distributed between the circuits. See also 2986 of 1956 (Skalnik).

621.372.412 **1351**

The Problem of Increasing the Frequency Stability of Crystal Oscillators by means of Compensation.—G. Becker. (*Arch. elekt. Übertragung*, July 1957, Vol. 11, No. 7, pp. 289–294.) Herzog's method (2734 of 1952) of improving the Pierce oscillator by including a compensating resistance is investigated. The dependence of the oscillator frequency on the circuit parameters, with or without compensation, is calculated. The advantages of compensation are offset by serious drawbacks especially in crystal-clock applications.

621.372.5 : 512.831 **1352**

The Calculation of Linear Circuits.—W. Klein. (*Arch. elekt. Übertragung*, Aug. 1957, Vol. 11, No. 8, pp. 341–347.) Circuit components, which may include valves, transistors and transformers, are set up in the form of a multipole admittance matrix; from this five determinants are obtained.

621.372.5 : 621.316.82 **1353**

Theory of Networks of Linearly Variable Resistances.—H. Levenstein. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 486–493.) A network of fixed resistances and linear rheostats driven by a common shaft can replace nonlinear elements. Such networks are amenable to good design techniques and can be described in a mathematical form analogous to that of fixed *RL* networks.

621.372.5.018.783 : 621.375.4.029.4 **1354**

Theoretical and Experimental Investigation of Distortion in Low-Frequency Junction-Transistor Quadripoles.—G. A. Spescha & M. J. O. Strutt. (*Arch. elekt. Übertragung*, Aug. 1957, Vol. 11, No. 8, pp. 307–320.) Expressions are derived for calculating distortion by differentiating the quasilinear hybrid parameters of the quadripole. Methods are described of measuring distortion in junction-transistor quadripoles in earthed-base, earthed-emitter, and earthed-collector circuits. Calculated and measured results are compared for the earthed-base and for the earthed-emitter circuits; close agreement is found. The application of the results of the investigation to the design of transistor amplifiers is discussed. See also 2392 of 1957 (Meyer).

621.372.54 : 621.372.412 **1355**

High-Frequency Crystal Filter Design Techniques and Applications.—D. I. Kosowsky. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 419–429.) Commercially available h.f. crystal filters exhibit performance characteristics previously attainable only at lower frequencies. Filters normally consist of from two to eight quartz resonators in a lattice or bridge network and are characterized by high *Q* and stability under extreme environmental conditions. Normal values of *Q* for filter components in the 1–40-Mc/s range are from 50 000 to 200 000; in certain filters, element *Q*'s exceed 1 000 000. By eliminating the need for multiple frequency conversions, the small rugged filters are useful in many a.m., s.s.b. and f.m. receivers as well as single-sideband generators.

621.372.54 : 621.396.828 **1356**

Low-Pass Filters for Mobile Use.—W. Rudolph. (*QST*, Oct. 1957, Vol. 41, No. 10, pp. 24–25.) Constructional details are given of simple compact filters for the suppression of radiation at television frequencies from mobile transmitters operating at frequencies below 30 Mc/s and in the 50–54-Mc/s range.

621.372.54.029.62/.63 : 621.372.2 **1357**

Transmission-Line Low-Pass Filters.—F. Charman. (*Electronic Radio Engr*, March 1958, Vol. 35, No. 3, pp. 103–111.) The networks consist of sections of line with suitably constructed lumped shunt capacitance. Design curves are given, and practical models are illustrated.

621.372.543.2 **1358**

Design of Three-Resonator Dissipative Band-Pass Filters having Minimum Insertion Loss.—M. Dishal & B. Sellers: J. J. Taub & B. F. Bogner. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 498–499.) Comment on 2370 of 1957 and authors' reply.

621.372.543.2(083.57) **1359**

Band-Pass Filter Design Technique.—D. R. J. White, (*Electronics*, 3rd Jan. 1958, Vol. 31, No. 1, pp. 79–81.) "Universal curves provide design information for Butterworth and Tchebycheff stagger-tuned filter networks for band-pass amplifiers. Required number of stages, centre frequency, cut-off frequencies, and stage gain requirements can be determined."

621.373.1 : 538.632 **1360**

Galvanomagnetic Oscillators.—V. N. Bogomolov. (*Zh. tekh. Fiz.*, April 1957, Vol. 27, No. 4, pp. 663–674.) The type of Hall-effect oscillator described has an efficiency of 37·5%.

621.373.42 **1361**

An Ultrastable Keyed V.F.O.—J. M. Shulman. (*QST*, Oct. 1957, Vol. 41, No. 10, pp. 34–39.) High stability is achieved by constructing the variable tuned circuit, which has a high *Q* and is of rigid construction, as a single unit separate from the remainder of the oscillator. Clickless keying is obtained by a relatively small change in screen grid potential.

621.373.421.11 **1362**

Self-Oscillatory Systems with Two Degrees of Freedom at Multiple Frequencies.—G. M. Utkin. (*Radiotekhnika, Mosk.*, Oct. 1956, Vol. 11, No. 10, pp. 66–76.) Mathematical analysis of the operation of an oscillator using two coupled tuned circuits resonating at frequencies one of which is an approximate multiple of the other. Expressions are derived for the oscillator frequencies and their instability as a function of the instability of the tuned circuits and the supply voltages.

621.373.43 **1363**

Idealized Treatment of Relaxation Oscillator Circuits.—M. Draganescu. (*Bul. Inst. polit. Bucuresti.*, Jan./June 1956, Vol. 18, Nos. 1/2, pp. 231–244.) Topological analysis of idealized circuits with the introduction of critical-point notation. A correct solution can only be obtained if the system oscillates.

621.373.52 **1364**

Transistor Oscillator supplies Stable Signal.—L. H. Dulberger. (*Electronics*, 31st Jan. 1958, Vol. 31, No. 5, p. 43.) "Colpitts circuit, employing one germanium transistor and one Zener diode, operates from a laboratory regulated power supply to maintain a sine-wave voltage of precise amplitude."

621.373.52 : 621.373.431.1 **1365**

Determination of the Frequency of a Transistor Multivibrator between 4 and 4 000 c/s.—M. Bichara. (*C. R. Acad. Sci., Paris*, 26th Aug. 1957, Vol. 245, No. 9, pp. 896–898.) Experimental and theoretical results supplement those of McDuffie (682 of 1953) for the pulse duration and repetition rate of an astable transistor multivibrator circuit.

621.374.3 **1366**

Pulse Height Selector with Constant Analysis Time.—M. Spighel & L. Pénege. (*J. Phys. Radium*, March 1957, Vol. 18, Supplement to No. 3, *Phys. appl.*, pp. 19A–22A.) A single-channel pulse height selector with an analysis time constant to within 2×10^{-8} s independent of the pulse height is described.

621.374.3 : 621.314.7 **1367**

Unusual Transistor Circuits.—P. L. Burton & J. Willis. (*Wireless World*, March 1958, Vol. 64, No. 3, pp. 107–110.) The main features of design and a physical explanation of the action are given for voltage catching, transistor pump, emitter-squared follower and transistor gating circuits.

621.374.3.029.65 **1368**

Millimicrosecond Pulses in the Millimetre-Wave Region.—C. A. Burrus. (*Rev. sci. Instrum.*, Dec. 1957, Vol. 28, No. 12, pp. 1062–1065.) A technique is described for the generation, amplification and detection of pulses in the 5–6-mm region. The pulses are 3 mμs wide at the base, with a peak power of a few milliwatts.

621.374.32 **1369**

Forty-Megacycle Scaler.—M. Nakamura. (*Rev. sci. Instrum.*, Dec. 1957, Vol. 28, No. 12, pp. 1015–1020.) The scaler has a scale of eight and uses a fast flip-flop as a basic element. The latter can be triggered at a rate higher than 50 Mc/s and has a double-pulse resolution of 20 mμs.

621.374.32 **1370**

Decade Decimal Counter speeds Printed Read-Out.—R. W. Wolfe. (*Electronics*, 17th Jan. 1958, Vol. 31, No. 3, pp. 88–90.) "High-speed circuit uses magnetron beam-switching tubes to sample, store and provide multi-output functions without stopping the original count or losing input information during read-out."

621.375.1.012.6 **1371**

Amplifier Low-Frequency Compensation.—J. E. Flood & J. E. Halder. (*Electronic Radio Engr*, March 1958, Vol. 35, No. 3, pp. 92–100.) General expressions are deduced for the indicial response (i.e. response to unit step input) and gain/frequency and phase/frequency response, leading to conditions for maximal flatness. Compensation is then considered, together with the effects of negative feedback. Multistage amplifiers are also discussed.

621.375.1.029.4 : 621.376.54 **1372**

Pulse Method for the Amplification of A.F. Oscillations.—V. V. Malanov. (*Radiotekhnika, Mosk.*, Oct. 1956, Vol. 11, No. 10, pp. 38–46.) The advantages and efficiency of a p.w.m. method are discussed.

621.375.132.018.756 **1373**

Dynamic Range of Negative-Feedback Pulse Amplifiers.—V. Pauker. (*Bul. Inst. polit. Bucuresti*, Jan./June 1956, Vol. 18, Nos. 1/2, pp. 245–252.) Analysis of the limiting conditions for grid current in two- or three-stage amplifiers.

621.375.2.029.3 **1374**

More Transformerless Amplifiers.—(*Wireless World*, March 1958, Vol. 64, No. 3, pp. 145–146.) A review of recent work published since an earlier article (1030 of 1957). Single-input series-connected and Petersen-Sinclair output stages (1250 of 1952) are discussed.

621.375.4.029.33 **1375**

Practical Circuits of Video Amplifiers using Junction Transistors.—T. M. Agakhanyan & Yu. A. Volkov. (*Radiotekhnika, Mosk.*, Nov. 1956, Vol. 11, No. 11, pp. 38–44.) Practical circuits with two types of Russian transistor are described. Complex feedback is used in order to reduce the distortion of the leading edges of the pulses.

621.375.9 : 538.569.4.029.63 : 621.396.822 **1376**

Noise Temperature Measurement on a Solid-State Maser.—A. L. McWhorter, J. W. Meyer & P. D. Strum. *Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1642–1644.) Noise measurements have been made on a three-level, 2 800-Mc/s maser operating at 1·25°K, with sufficient accuracy to establish that its noise temperature does not exceed 20°K.

621.375.9 : 621.385.029.64 : 537.533 **1377**

A Parametric Electron-Beam Amplifier.—Bridges. (See 1606.)

621.376.32 **1378**

The Optimum Design of a Tunable Multiplier for Frequency-Modulated Oscillations.—H. Schönfelder. (*Frequenz*. Aug. 1957, Vol. 11, No. 8, pp. 244–249.) The design of tunable frequency multipliers, containing simple one- or two-stage filters in the individual multiplier stages, is investigated. 70-dB adjacent-channel attenuation and 3% distortion can be achieved if the multiplication per stage does not exceed 5:1. The fundamental frequency should not be less than about 1 Mc/s.

621.376.332 **1379**

Combined Limiter and Discriminator.—J. W. Head & C. G. Mayo. (*Electronic Radio Engr*, March 1958, Vol. 35, No. 3, pp. 85–88.) The limiter incorporates a 3rd-harmonic rejector in series with the diode. Distortion less than 0·1% of any harmonic is easily obtained, and stray capacitances are small, leading to high sensitivity and output.

621.376.5 **1380**

Pulse Detector with an Inductance-Capacitance Filter.—E. L. Gerenrot. (*Radiotekhnika, Mosk.*, Oct. 1956, Vol. 11, No. 10, pp. 30–37.) An ideal detector with an *LCR* filter is considered taking into account the internal impedance of the current source. A method is proposed for calculating the voltage at the load, when detecting pulses of arbitrary shape, and the necessary formulae are derived.

GENERAL PHYSICS

530.112 : 530.12 : 531.18 **1381**

The Ether and the Special Theory of Relativity.—A. Datzeff. (*C. R. Acad. Sci., Paris*, 19th & 26th Aug. 1957, Vol. 245, Nos. 8 & 9, pp. 827–829 & 891–894.) An ether which is immobile in its immediate surroundings but capable of a movement of translation is suggested. It is hoped that this hypothesis will provide a physical explanation of electrodynamic and other phenomena and will not be inconsistent with the results of the special theory of relativity.

535.56-15 **1382**

Polarimetry in the Infrared.—R. Duverney & A. M. Vergnoux. (*J. Phys. Radium*, Aug./Sept. 1957, Vol. 18, Nos. 8/9, pp. 526–536.)

537.12 **1383**

Connection between Electron Temperature Determination by means of the Langmuir Probe Method and the Two-Probe Method.—V. I. Tverdokhlebov. (*Zh. tekh. Fiz.*, April 1957, Vol. 27, No. 4, pp. 753–755.)

537.122 : 539.152 **1384**

The Lamb Shift.—(*Electronic Radio Engr*, Feb. & March 1958, Vol. 35, Nos. 2 & 3, pp. 52–55 & 89–91.)An elementary account of present-day knowledge concerning the electron, and a discussion of Lamb & Retherford's experiment (see e.g. *Rep. Progr. Phys.*, 1951, Vol. 14, pp. 19–63) in relation to the anomalous magnetic moment of the electron.

537.226 : 537.311.3 : 530.17 **1385**

Use of Complex Conductivity in the Representation of Dielectric Phenomena.—F. A. Grant. (*J. appl. Phys.*, Jan. 1958, Vol. 29, No. 1, pp. 76–80.) A representation for complex conductivity is proposed in which a simple Debye mechanism results in a semicircular locus. A non-zero value of d.c. conductivity does not cause this plot to lose its unique shape in the low-frequency range.

537.312.62 **1386**

Theory of Superconductivity.—J. Bardeen, L. N. Cooper & J. R. Schrieffer. (*Phys. Rev.*, 1st Dec. 1957, Vol. 108, No. 5, 1175–1204.)

537.321 : [621.314.63+537.311.4 **1387**

Temperature Rise of Solid Junctions under Pulse Load.—E. J. Diebold. (*Commun. & Electronics*, Nov. 1957, No. 33, pp. 593–598.) The magnitude and duration of current pulses are correlated with temperature rise in the junction. Use of successive approximations assuming that various parts of a body (*a*) are not yet subjected to a temperature increase or (*b*) have already reached a temperature differential corresponding to the steady state, reduces the problem to a simple case of heat diffusion.

537.533 : 621.385.029.6 **1388**

Charged Particles in a Nonuniform Radio-Frequency Field.—H. A. H. Boot & R. B. R. S. Harvie. (*Nature, Lond.*, 30th Nov. 1957, Vol. 180, No. 4596, p. 1187.) Under certain conditions particles of either sign will experience an acceleration towards the position of least field strength. Such an acceleration is demonstrated in a 10-cm slotted magnetron having no magnetic field and a cold cathode.

538.221 **1389**

Theory of Ferromagnetic Anisotropy.—W. J. Carr, Jr. (*Phys. Rev.*, 1st Dec. 1957, Vol. 108, No. 5, pp. 1158–1163.) By means of a virial theorem and perturbation theory, the anisotropy energy of a ferromagnetic crystal is expressed in terms of the Coulomb energy alone. This is approximated by a multipole expansion and the anisotropy constants are given in terms of electric multipole moments and crystalline-potential constants. The multipole moments which arise from the orbital angular momentum induced by spin-orbit coupling have been estimated from the known values of angular momentum.

538.221 : 548.0 **1390**

Effect of Crystalline Electric Fields on Ferromagnetic Anisotropy.—W. P. Wolf. (*Phys. Rev.*, 1st Dec., 1957, Vol. 108, No. 5, pp. 1152–1157.) The effect of the electrostatic crystalline field has been considered for a magnetic crystal in which the ions are strongly coupled by ferromagnetic exchange. On the basis of the one-ion approximation that the exchange can be represented by a Weiss molecular field, expressions for the anisotropy constants have been derived. The treatment assumes that the magnetic electrons can be considered as localized on the individual ions, and thus applies primarily to nonmetallic substances such as ferrites.

538.244 : 538.221 **1391**

The Time Sequence and Amplitude Distribution of Barkhausen Jumps.—K. Jost. (*Z. Phys.*, 6th Feb. 1957, Vol. 147, No. 5, pp. 520–530.) Report and discussion of results obtained in investigations of the magnetization of Fe-Ni alloy wire specimens to determine the dependence of Barkhausen-jump characteristics on field strength and specimen shape.

538.566 **1392**

Some New Aspects of the Reflection of Electromagnetic Waves on a Rough Surface.—M. A. Biot. (*J. appl. Phys.*, Dec. 1957, Vol. 28, No. 12, pp. 1455–1463.) The roughness is represented by electromagnetically interacting hemispherical bosses whose radii and mutual distances are small relative to the wavelength. The effects of such a surface on both vertically and horizontally polarized radiations are considered as functions of the angle of incidence.

538.566 : 535.42 **1393**

Apparatus for the Experimental Study of the Diffraction of Centimetre Waves.—J. Mével. (*J. Phys. Radium*, March 1957, Vol. 18, Supplement to No. 3, *Phys. appl.*, pp. 45A–53A.) Apparatus operating at $1 \cdot 25$ cm λ is described for determining the phase and intensity at any point of the e.m. field. Two versions are presented: one for the investigation of diffraction near the axis and the other for the distant diffraction field. The effect of diffracting bodies less than $\lambda/100$ in size can be detected.

538.566 : 535.42 **1394**

Diffraction of 3·2-cm Electromagnetic Waves by Dielectric Rods: Part 3—Lucite 1½-in.-Diameter Semicylinder, Fields Very Close to Surface.—C. E. Jordan & A. B. McLay. (*Canad. J. Phys.*, Nov. 1957, Vol. 35, No. 11, pp. 1253–1264.) The diffraction field is examined very close to the surface of a lucite semicylindrical rod with its plane surface at various orientations relative to the axis of propagation of the incident wave. Parts 1 & 2 : 93 of 1957 (Subbarao & McLay).

538.569.4 **1395**

The Microwave Spectrum of TlI and $BiCl_3$ in the 3-cm and 1·5-cm Bands.—H. Happ. (*Z. Phys.*, 6th Feb. 1957, Vol. 147, No. 5, pp. 567–572.)

538.569.4 : 537.525 **1396**

The Characteristic Frequencies of Negative Molecular Ions of Oxygen between 3 and 13 Mc/s, Observed in Ionized-Air Discharge Tubes.—T. V. Ionescu & O. C. Gheorghiu. (*C. R. Acad. Sci., Paris*, 26th Aug. 1957, Vol. 245, No. 9, pp. 898–901.) Absorption frequencies are determined from the current variations in a coil round a discharge tube containing pure air, supplemented in some cases by O_2, at pressures of 10^{-2}–10^{-5} mm Hg. Absorption frequencies above 5 Mc/s give rise to strong absorption at pressures below 10^{-3} mm Hg.

538.569.4.029.63 : 621.375.9 : 621.396.822 **1397**

Noise Temperature Measurement on a Solid-State Maser.—McWhorter, Meyer & Strum. (See 1376.)

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.164.32 **1398**

Radio Pictures of the Sun.—W. N. Christiansen, D. S. Matthewson & J. L. Pawsey. (*Nature, Lond.*, 9th Nov. 1957, Vol. 180, No. 4593, pp. 944–946.) A radioheliograph erected at Sydney, Australia, combines the principles of the multi-element or grating interferometer and the Mills cross. It consists of two rows of parabolic aerials of 19-ft diameter arranged in the form of a cross, each row being 1 240 ft long. Diagrams of the lower corona have been prepared from observations of 21-cm-λ radiation.

523.164.32 **1399**

Investigation of Scintillation of the Sun Observed at a Wavelength of 3·2 cm.—I. Kazès. (*C. R. Acad. Sci., Paris*, 5th Aug. 1957, Vol. 245, No. 6, pp. 636–639.) Results of observations including simultaneous measurements at 3·2 and 34 cm λ indicate that scintillations are of atmospheric origin and are related to zenithal height, solar activity and wavelength. The apparent diameter of the sun also fluctuates.

523.164.32 **1400**

Investigation of the Scintillation of the Sun Observed using Several Aerials on a Wavelength of 3·2 cm.—I. Kazès & J. L. Steinberg. (*C. R. Acad. Sci., Paris*, 12th Aug. 1957, Vol. 245, No. 7, pp. 782–785.) Results of measurements of scintillation made with three receivers at variable distances show that the average dimension of the ground shadows is 170 m; their velocities are compared with those of winds at the altitude of the tropopause.

523.164.32 : 523.75 **1401**

Polarization of Solar Radio Outbursts.—K. Akabane & T. Hatanaka. (*Nature, Lond.*, Nov. 1957, Vol. 180, No. 4594, pp. 1062–1063.) Changes in the polarization of r.f. emission at 9 kMc/s were recorded at Tokyo on 3rd July 1957 during a solar flare.

523.3 : 621.396.9 **1402**

The Scattering of Radio Waves by the Moon.—J. V. Evans. (*Proc. phys. Soc.*, 1st Dec. 1957, Vol. 70, No. 456B, pp. 1105–1112.) Measurements of the rapid fading of echoes at a frequency of 120 Mc/s show that the effective scattering region has a radius of about one third of the lunar radius and is located at the centre of the visible disk. Range measurements indicate that the echo is returned from the front edge, with a power reflection coefficient of 0·1. See also 753 of 1957 (Browne et al.).

523.74 : 538.12 **1403**

Sweet's Mechanism for Merging Magnetic Fields in Conducting Fluids.—E. N. Parker. (*J. geophys. Res.*, Dec. 1957, Vol. 62, No. 4, pp. 509–520.) The mechanism is investigated in a semi-quantitative manner. If two oppositely directed sunspot fields, having scales of about 10^4 km, were brought together, Sweet's mechanism would allow them to merge in about two weeks. The mechanism gives a means of altering quickly the configuration of magnetic fields in ionized gases and converting magnetic energy into kinetic energy of the fluid.

523.75 : 551.594.6 **1404**

The Solar Flare of 23rd February 1956: its Cosmic and Geophysical Effects.—R. Bureau & A. Dauvillier. (*J. Phys. Radium*, Aug./Sept. 1957, Vol. 18, Nos. 8/9, pp. 512–517.) Records of the intensity of cosmic rays and of atmospherics show that a sudden large increase in the former at 0345 U.T. was accompanied by a sudden decrease in v.l.f. atmospherics, particularly as observed at Bagneux at 11 km λ.

550.38 : 525.24 1405

The Earth and its Magnetic Field.—G. H. A. Cole. (*Sci. Progr.*, Oct. 1957, Vol. 45, No. 180, pp. 628–645.) Review of modern theory which attempts to explain the presence and properties of the observed magnetic field in terms fully compatible with the structure of the earth determined independently. 50 references.

550.385 : 523.75 1406

The Effect of Solar Flares on the Geomagnetic Field.—R. Pratap. (*J. geophys. Res.*, Dec. 1957, Vol. 62, No. 4, pp. 581–588.) "The dynamo equation is solved for a conductivity produced by solar-flare ultraviolet radiations from the sun. The crochet amplitudes in horizontal field components are then computed and compared with observed results. It is found that fair agreement exists between the theoretical and experimental values only if the seat of the crochet current system is within a few kilometers of the current system producing the quiet-day solar variation."

550.385.4 : 551.511 1407

Sudden Commencements of Magnetic Storms and Atmospheric Dynamo Action.—T. Obayashi & J. A. Jacobs. (*J. geophys. Res.*, Dec. 1957, Vol. 62, No. 4, pp. 589–616.) Statistical analysis of world-wide magnetic data discloses an appreciable diurnal change in the amplitude of SC's. The average electric current system for the disturbance diurnal variation shows marked concentrations in polar regions and suggests that the system exists within the earth's atmosphere while the current system of the storm-time variation would appear more likely to be of extra-terrestrial origin. A dynamo theory is applied to explain the atmospheric part of magnetic disturbances and a consistent wind system is obtained to produce current systems for magnetically quiet and disturbed days. This system contains diurnal and semi-diurnal terms and its order of magnitude agrees with recent ionospheric wind observations.

550.389.2 : 551.510.535 1408

The Geophysical Year and the Ionosphere.—R. P. Lejay. (*J. Phys. Radium.*, Aug./Sept. 1957, Vol. 18, Nos. 8/9, pp. 481–489.) Discussion of the organization and program of the I.G.Y. with particular reference to ionospheric measurements and techniques.

550.389.2 : 629.19 1409

Radio Observations of the Russian Earth Satellite.—(*Nature, Lond.*, 2nd Nov. 1957, Vol. 180, No. 4592, pp. 879–883.) Observations were made at 20, 40 and 80 Mc/s at the Mullard Radio Observatory, Cambridge, using interferometer and Doppler techniques. Details of the calculation of the orbit are given and possible new methods of finding the distribution of electron density with height are suggested.

550.389.2 : 629.19 1410

Observations on the Orbit of the First Russian Earth Satellite.—(*Nature, Lond.*, 9th Nov. 1957, Vol. 180, No. 4593, pp. 937–941.) Report of calculations carried out at the Royal Aircraft Establishment, Farnborough, Hants, to determine orbit constants from interferometer and Doppler measurements. Observations of signal amplitude and fading indicate that the ray path of long-distance transmission from the satellite to a receiving station is complicated.

550.389.2 : 629.19 1411

Radar Observations of the First Russian Earth Satellite and Carrier Rocket.—(*Nature, Lond.*, 9th Nov. 1957, Vol. 180, No. 4593, pp. 941–942.) A note of instruments used and observations made at Jodrell Bank at frequencies of 120 and 36 Mc/s with pulse durations of 2 ms and 150 μs respectively.

550.389.2 : 629.19 1412

Further Radio Observations of the First Satellite.—I. R. King, G. C. McVittie, G. W. Swenson, Jr, & S. P. Wyatt, Jr: N. Lea. (*Nature, Lond.*, 9th Nov. 1957, Vol. 180, No. 4593, p. 943.) Reports of interferometer measurements at 40 Mc/s made at Urbana, Illinois, and Doppler measurements at 40 Mc/s made at Chelmsford.

551.51 1413

Charge Transfer Reactions.—S. N. Ghosh & W. F. Sheridan. (*Indian J. Phys.*, July 1957, Vol. 31, No. 7, pp. 337–352.) An improved method for determining charge transfer cross-sections is applied to symmetric and unsymmetric reactions for a large number of gases and gives higher values than originally reported. A comparison of the rates of collisional processes in the D, E and F regions shows that the charge transfer rate is much larger than that for any other collisional process in the upper atmosphere. See 3365 of 1956 (Ghosh).

551.510.53 : 539.12.08 1414

An Appraisal of Photon Counter Measurements of Upper-Atmosphere Parameters.—G. J. Simmons. (*J. geophys. Res.*, Dec. 1957, Vol. 62, No. 4, pp. 565–571.) A model atmosphere has been computed from measurements of density and O_2 concentration using rocket-borne photon counters near 100 km. Inconsistencies have appeared and it is concluded that the density at 100 km is higher than that found using photon counters.

551.510.535 1415

Calculation of Group Indices and Group Heights at Low Frequencies.—J. J. Gibbons & B. R. Rao. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 151–162.) A formula is derived from which the 'group index' (designated $\mu' = \mu + f\delta\mu/\delta f$) for normal incidence, including collision effects, can be easily computed as a function of the real and imaginary parts of the refractive index for frequencies below 1 Mc/s. A set of curves can then be prepared from which the group height h' to be expected from a given electron-density profile can be quickly determined by graphical methods.

551.510.535 1416

The Movements of Sporadic-E-Layer Clouds.—G. L. Goodwin. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 177–186.) The drift speed of isolated clouds was measured by observing the beat between a ground-wave signal from a 1·55-Mc/s c.w. transmitter and the sky wave reflected from the moving cloud. Comparison of these observations, made at night, with other evidence suggests that scattering is greater than in the day. A method for determining the direction of drift is suggested.

551.510.535 1417

Relation between Virtual and Actual Heights in the Ionosphere.—G. A. M. King. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 209–222.) A mathematical discussion of the various methods of determining the distribution of electron density with height in the ionosphere and a treatment of the comparison and integral methods. An annotated bibliography with 39 references is given.

551.510.535 1418

The Coefficient of Diffusion of Ions in the F_2 Regions.—V. C. A. Ferraro. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 296–298.) The application of Sutherland's molecular model to the F_2 region gives too large a coefficient of diffusion if recent rocket estimates of F_2-layer molecular density are correct. If Langevin's formula for the diffusion coefficient is used instead, the discrepancy is less but, for an F_2 region in which diffusion is inappreciable, calculated values of the coefficient are still about 10 times too large. Possible influencing factors are discussed.

551.510.535 : 523.164 1419

The Origin of the Ionospheric Irregularities Responsible for Radio-Star Scintillations and Spread F: Part 1.—M. Dagg. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 133–138.) "The present state of knowledge about the irregularities responsible for radio-star scintillations is summarized, and the existing theories of the origin ot these irregularities are discussed. All of the suggestions are shown to be inadequate to explain the observed features of scintillations and spread F. It is shown that any ionizing agent from outside the earth's atmosphere is unlikely to be responsible for the ionospheric irregularities that cause radio-star scintillations, and that the mechanism for their production must be sought in the terrestrial atmosphere."

551.510.535 : 523.164 1420

The Origin of the Ionospheric Irregularities Responsible for Radio-Star Scintillations and Spread F: Part 2.—M. Dagg. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 139–150.) "A theory is presented which attributes the occurrence of ionospheric irregularities in the F region to turbulent wind motion in the dynamo region at a height of 110–150 km. The resulting turbulent component of the electric potential field produced is communicated to the F region, as suggested by Martyn [*The Physics of the Ionosphere*, 1955, pp. 163–165], where magneto-electric forces then cause the ionization to form eddies. It is suggested that the absence of daytime scintillations is due to the inhibition of turbulent flow by large temperature gradients during the day." The theory is then shown to explain the major features of radio-star scintillations, together with the long-term correlation of scintillation amplitude with magnetic activity and the variation of spread F and scintillations at different parts of the earth over the sunspot cycle.

551.510.535 : 523.164 **1421**

Diurnal Absorption in the D Region.—J. W. Warwick & H. Zirin. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 187–191.) An analysis of the diurnal variation of cosmic noise at 18 Mc/s, from which are derived the D-region electron density and an exponential approximation to the vertical distribution of nitric oxide.

551.510.535 : 523.164.83 **1422**

The Electron Content of the Ionosphere.—J. V. Evans. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 259–271.) Report of an investigation noted earlier (765 of 1957) using radio echoes from the moon to determine the electron content. The apparatus and the methods of analysis are described. Results for seven periods between October 1955 and September 1956 are given. An almost constant ratio (2 : 1) is found between observed electron content and that expected in a parabolic layer. There is some evidence for tidal effects.

551.510.535 : 523.746 : 621.396.11 **1423**

A Critical Discussion about Special Ionospheric Characteristics.—R. Eyfrig. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 163–176.) Twelve-month running means of (M3000) F_2 and R are compared for 37 locations and linear relations between the two are apparent for limited regions. Deviations from linearity may be genuine at some locations and due to magnetic effects, but may arise from observational errors and inconsistencies at others. Present data are inadequate for examination of M factors on a world-wide basis.

551.510.535 : 523.746 : 621.396.11 **1424**

The Sunspot Cycle and Radio Communications.—Millington. (See 1529.)

551.510.535 : 621.396.11 **1425**

Some Problems of the Physics of the Ionosphere : Part 1—Fluctuation of the Electron Density and Scattering of Radio Waves.—Ya. L. Al'pert. (*Usp. fiz. Nauk*, March 1957, Vol. 61, No. 3, pp. 423–450.) Electron density, u.s.w. scattering and turbulence of the ionosphere are discussed and experimental results are analysed. 19 references.

551.510.535 : 621.396.812.3 **1426**

Curvature-Induced Error in the Analysis of Fading Records.—N. J. Rumsey. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 255–258.) "Curvature of lines of maximum amplitude in a radio field-strength pattern drifting across an array of three receivers can introduce an error into the estimate of the drift velocity, but the error is expected to be large only infrequently. The mean error is smaller for an array of receivers at the corners of an equilateral triangle than for one at the corners of a right-angled triangle."

551.594.221 : 621.396.96 **1427**

Radar Observations of Lightning on 1·5 Metres.—J. L. Pawsey. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 289–290.) Details are given of observations made in 1943. The echo cross-section was approximately 40 m², the visually estimated echo duration approximately 1/4 sec, and the horizontal extent several miles. The associated atmospherics are described.

551.594.5 + 551.593 **1428**

Measurements of the Absolute Intensity of the Aurora and Night Airglow in the 0·9–2·0-μ Region.—A. W. Harrison & A. V. Jones. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 192–199.)

551.594.5 : 621.396.96 **1429**

Radio Reflections from Aurorae: Part 3.—K. Bullough, T. W. Davidson, T. R. Kaiser & C. D. Watkins. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 237–254.) A further study of radio echoes at 72 Mc/s following earlier work by Bullough and Kaiser (2622 of 1955). Good correlation is found between the daily frequency distribution of echoes and the mean daily variation in magnetic disturbance at Eskdalemuir. Results and conclusions conflict with the Chapman-Ferraro-Martyn theory.

551.594.5 : 621.396.96 **1430**

U.H.F. Radar Observations of Aurora.—S. J. Fricker, R. P. Ingalls, M. L. Stone & S. C. Wang. (*J. geophys. Res.*, Dec. 1957, Vol. 62, No. 4, pp. 527–546.) Radar echoes have been obtained on a frequency of 412·85 Mc/s at South Dartmouth, Mass. (41·5° N, 71° W). The diurnal and seasonal variations in the occurrence of echoes is discussed and also the conditions required to obtain echoes.

551.594.6 : 621.396.11.029.4 **1431**

The Waveforms of Atmospherics and the Propagation of Very-Low-Frequency Radio Waves.—Chapman. (See 1530.)

551.594.9 : 523.5 : 621.396.11.029.55 **1432**

V.H.F. Radar Echoes associated with Atmospheric Phenomena.—G. C. Rumi. (*J. geophys. Res.*, Dec. 1957, Vol. 62, No. 4, pp. 547–564.) During observations with radar equipment at 27·85 Mc/s, echoes were obtained which could not be attributed either to aurorae or to meteors. The characteristics of these echoes suggest that they may be due to 'upward discharges' from the troposphere to the ionosphere which may be triggered off by meteors.

LOCATION AND AIDS TO NAVIGATION

621.396.933 **1433**

The Latest Developments in Radio Navigation in Aeronautics.—E. Roessler. (*Elektrotech. Z.*, *Edn B*, 21st Aug. 1957, Vol. 9, No. 8, pp. 335–339.) Modern aids to navigation are described and attempts to develop more universal systems are discussed. 33 references.

621.396.933.2 **1434**

Bearing Memory Improves Direction Finder.—R. E. Anderson. (*Electronics*, 31st Jan. 1958, Vol. 31, No. 5, pp. 44–48.) A high-frequency direction-finding equipment employing Doppler principles, is described. The received wave is frequency-modulated by scanning round a fixed circular aerial array at 42 c/s. Gaps between the pulses of a coded transmission are filled in by the use of a recording drum rotating at the scanning frequency.

621.396.96 : 621.396.822 : 621.317.7 **1435**

Monitor displays Radar Noise Figures.—L. Young. (*Electronics*, 31st Jan. 1958, Vol. 31, No. 5, pp. 49–51.) The receiver noise is compared against a monitor pulse, by passing them through a logarithmic receiver followed by a difference amplifier. The noise figure is displayed directly on a meter calibrated in dB.

621.396.967 **1436**

An Integrated Airborne Radar.—J. H. H. Grover. (*Brit. Commun. Electronics*, Oct. 1957, Vol. 4, No. 10, pp. 628–632.) The airborne landing and approach aid described overcomes inadequacies of present ground-based landing aids.

621.396.969.3 **1437**

Measurement of the Radar Cross-Section of a Man.—F. V. Schultz, R. C. Burgener & S. King. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 476–481.) Doppler measurements were made at five frequencies from 410 Mc/s to 9 375 Mc/s using both vertical and horizontal polarization from various angles. The side view presented the smallest radar target and the back view the greatest. The difference between polarizations was greatest at the lowest frequency with horizontal polarization giving the smaller value.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215.5 : 537.312.5 **1438**

The Dependence of Photoelectric Currents on Electric Field Strength.—F. Stöckmann. (*Z. Phys.*, 6th Feb. 1957, Vol. 147, No. 5, pp. 544–566.) Photoconductors can be classified in four groups according to conduction mechanism. The differences in their photoelectric characteristics are analysed as a function of field strength and type of excitation, and the influence of the electrode contacts on photocurrents is discussed.

535.37 **1439**

Luminescence.—H. G. Jenkins. (*J. Telev. Soc.*, July/Sept. 1957, Vol. 8, No. 7, pp. 261–272.) After describing various forms of the phenomenon, the nature of luminescence and a qualitative theory are discussed. The characteristics of some important inorganic phosphors are tabulated and the methods of preparation are described. Some uses of these materials in electric discharge lamps, both low- and high-pressure types, is given with particular reference to tube loading and luminous efficiency. The application of electroluminescence in light amplifiers is described, and possible applications in the fields of television, astronomy and X-ray diagnosis are indicated.

535.37 **1440**

The Effect of H_2^+ Ions on the Luminescence Properties of Phosphors.—W. Martin. (*Z. Phys.*, 6th Feb. 1957, Vol. 147, No. 5, pp. 582–592.) The effects of ion bombardment on various phosphors are discussed with reference to experiments with an ion source of 45-keV maximum energy. From the glow curves obtained it is seen that electron traps are formed. The damage to the phosphors can be greatly reduced by subsequent irradiation by electrons.

535.37 : 53.082.5 **1441**

Instrument to Measure Fluorescence Lifetimes in the Millimicrosecond Region.—S. S. Brody. (*Rev. sci. Instrum.*, Dec. 1957, Vol. 28, No. 12, pp. 1021–1026.) Fluorescence decay is displayed on a high-speed oscilloscope; the observed fluorescence is corrected for the response of the hydrogen-discharge flash lamp and the detection equipment. Measured lifetimes are given for various photosynthetic pigments, some organic dyes and chlorophyll fluorescence in algae.

537.227/.228 : 061.3 **1442**

First Conference on Ferroelectricity (Leningrad, 19th–24th June 1956).—(*Izv. Ak. Nauk S.S.S.R., Ser. fiz.*, March 1957, Vol. 21, No. 3, pp. 295–472.) Texts are given of the following 26 papers presented at the conference. Others were noted in 2785 of 1957.

(*a*) Growth and Investigation of Ferroelectric Single Crystals.—N. S. Novosil'tsev, A. L. Khodakov, M. L. Sholokhovich, E. G. Fesenko & O. P. Kramarov (pp. 295–304).

(*b*) Some Properties of Single Crystals of $PbTiO_3$ and Single Crystals of Solid Solutions of (Ba, Pb) TiO_3.—E. G. Fesenko, O. P. Kramarov, A. L. Khodakov & M. L. Sholokhovich (pp. 305–310).

(*c*) Structure of the OH band in Crystals containing Hydrogen Bonds.—A. I. Stekhanov (pp. 311–321).

(*d*) Shape of the Potential Curve of Hydrogen Bonds in Certain Crystals.—A. N. Lazarev (pp. 322–328).

(*e*) Peculiarities of Ferroelectric Properties of Crystals of Rochelle Salt Exposed to Radioactivity.—V. A. Yurin (pp. 329–333).

(*f*) Some Properties of Dielectric Hysteresis of Rochelle Salt.—I. Ya. Eĭsner (pp. 334–339).

(*g*) Microscopic Theories of the Ferroelectric Properties of Barium Titanate.—R. E. Pasynkov (pp. 340–351).

(*h*) Dynamics of Ions and Electrostatic Energy of Ferroelectrics.—V. Kh. Kozlovskiĭ (pp. 352–358).

(*i*)—Theory of Orientational Ordering of Molecular Crystals.—V. I. Klyachkin (pp. 359–367).

(*j*) Theory of Hysteresis Phenomena in $BaTiO_3$.—L. P. Kholodenko (pp. 368–373).

(*k*) Relation between Dielectric, Piezoelectric and Elastic Properties of Polycrystalline Ceramics and Single Crystals.—S. V. Bogdanov, B. M. Vul & A. M. Timonin (pp. 374–378).

(*l*) Nonlinear Properties of Ferroelectrics.—B. M. Vul (pp. 379–381).

(*m*) Behaviour of Certain Ferroelectrics in Strong Electric Fields.—V. A. Bokov (pp. 382–389).

(*n*) Piezoelectric Properties of a Ferroelectric Ceramic of Barium Titanate with Certain Impurities.—S. V. Bogdanov (pp. 390–393).

(*o*) Reverse Piezoelectric Effect of Polycrystalline $BaTiO_3$ in Static-Type Measurements.—G. M. Kovalenko (pp. 394–396).

(*p*) Method of Measuring the Piezoelectric Coefficient d_{31} using the Radial Vibrations of a Disk.—S. V. Bogdanov & A. M. Timonin (pp. 397–398).

(*q*) Pyroelectric Effect and Piezoelectric Effect in Polycrystalline Barium Titanate.—M. S. Kosman & Z. A. Shamro (pp. 399–401).

(*r*) Permittivity of Niobates and Tantalates of Divalent Metals.—V. A. Isupov (pp. 402–410).

(*s*) Investigation of Antiferroelectric Properties of Certain Solid Solutions containing Lead Zirconate.—N. N. Kraĭnik (pp. 411–422).

(*t*) Study of Solid Solutions (Ba, Pb) (Ti, Sn)O_3 possessing Ferroelectric Properties.—I. E. Myl'nikova (pp. 423–432).

(*u*) Further Information on the $PbTiO_3$-$SrTiO_3$ Solid-Solution System.—A. G. Boganov & R. A. Khomutetskaya (pp. 433–438).

(*v*) Dependence of Permittivity of Polycrystalline Ferroelectrics on the Duration of Application of a Mechanical Load and a Constant Electric Field.—M. S. Lur'e (pp. 439–443).

(*w*) Study of Ultrasonic Radiators made from Crystals of Rochelle Salt.—K. A. Minaeva (pp. 444–449).

(*x*) Stabilized Piezoelectric Ceramic Materials.—R. E. Pasynkov & V. V. Vinogradov (pp. 450–454).

(*y*) Application of Ferroelectrics to Frequency Multipliers.—D. M. Kazarnovskiĭ & V. P. Sidorenko (pp. 455–465).

(*z*) Apparatus for Exploratory Investigations in Ferroelectric Regions in Small Samples.—I. S. Rez (pp. 466–472).

537.227 : 546.431.824-31 **1443**

The Effect of an Electric Field on the Transitions of Barium Titanate.—M. E. Drougard & E. J. Huibregtse. (*IBM J. Res. Develpm.*, Oct. 1957, Vol. 1, No. 4, pp. 318–329.) A review is presented of the effects of electric fields on the ferroelectric phase transitions of $BaTiO_3$ at 120°C and 5°C. The double hysteresis loop observed at the Curie point and the triple hysteresis loop and dielectric constant measured at the 5°C transition are examined in the light of Devonshire's thermodynamic theory of ferroelectricity in $BaTiO_3$. The data and various published experimental results are shown to agree with calculations based on the Devonshire free-energy function. The discrepancy between the coercive fields predicted by the theory and those actually observed is discussed.

537.311.3 **1444**

Screening of Coulomb Fields by Free Charges in Metals and Semiconductors.—I. Z. Fisher. (*Zh. tekh. Fiz.*, April 1957, Vol. 27, No. 4, pp. 638–650.)

537.311.33 **1445**

On the Theory of the Thermal Capture of Electrons in Semiconductors.—G. Rickayzen. (*Proc. roy. Soc. A*, 10th Sept. 1957, Vol. 241, No. 1227, pp. 480–494.) A new formula is obtained for the thermal capture rate in semiconductors when E_1/k is very much greater than the Debye temperature, E_1 being the ionizing potential of the bound electrons. It is found that the ratio of the probability of the impurity being ionized to that of a free electron being captured is exp $(-E_1/kT)$. Applying this theory to a model of an impurity in a continuum, the capture rate is strongly dependent on the radius of the bound electron, the electron-lattice coupling and the temperature; this agrees qualitatively with experiment.

537.311.33 **1446**

Effect of Neutral Impurities on Mobility in Nondegenerate Semiconductors.—M. S. Sodha & P. C. Eastman. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1373–1375.) The theoretical variation of mobility with electric field is studied, taking into account scattering by lattice vibrations and by both ionized and neutral impurities.

537.311.33 **1447**

Mobility of Carriers in Nondegenerate Semiconductors at Low Electric Fields.—M. S. Sodha. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1375–1376.) "By using the velocity distribution of carriers in the presence of an electric field E, due to Yamashita & Watanabe [see 3093 of 1956 (Yamashita)], it is shown that the mobility μ is given by $\mu = \mu_0\,(1 + \beta E^2)$ for low fields."

537.311.33 : 535.34 **1448**

Intensity of Optical Absorption by Excitons.—R. J. Elliott. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1384–1389.) The intensity of optical absorption close to the edge in semiconductors is examined using band theory together with the effective-mass approximation for the excitons. The cases of both direct transitions, which occur when the band extrema on either side of the forbidden gap are at the same **K** and indirect transitions involving phonons, are considered. The experimental results in Cu_2O and Ge are in good qualitative agreement with direct forbidden and indirect transitions respectively.

537.311.33 : 535.34-1 **1449**

Oscillatory Magneto-absorption in Semiconductors.—S. Zwerdling, B. Lax & L. M. Roth. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1402–1408.) Infrared magneto-absorption has been investigated in thin samples ($\approx 10\,\mu$) of Ge, InAs and InSb in magnetic fields up to 37 kG. Accurate determinations of the energy gaps and effective masses have been made. The anisotropy of the magneto-absorption effect was measured for Ge and InSb.

537.311.33 : [546.28 + 546.289 **1450**

Drift Mobility Measurements.—M. Green. (*J. appl. Phys.*, Dec. 1957, Vol. 28, No. 12, pp. 1473–1478.) Measurements on Ge and Si have been made by observing the transit time of a pulse of carriers over the distance between the point of photo-injection and a point of detection. The detector point may be a reverse-biased junction, a constriction in the cross-sectional area or a point-contact electrode.

537.311.33 : [546.28 + 546.289 **1451**

The Direct Observations of Dislocations in Germanium and Silicon.—G. A. Geach, B. A. Irving & R. Phillips. (*Research, Lond.*, Oct. 1957, Vol. 10, No. 10, pp. 411–412.)

537.311.33 : [546.28 + 546.289 **1452**

Optical Measurement of Film Growth on Silicon and Germanium Surfaces in Room Air.—R. J. Archer. (*J. electrochem. Soc.*, Oct. 1957, Vol. 104, No. 10, pp. 619–622.) "The thickness and growth kinetics of oxide films on polished Si and Ge exposed to room air after having been rinsed in hydrofluoric acid were obtained by measuring the ellipticity of reflected polarized light. Film growth obeys the Elovich equation."

537.311.33 : 546.28 **1453**

Effect of Oxygen on Etch-Pit Formation in Silicon.—R. A. Logan & A. J. Peters. (*J. appl. Phys.*, Dec. 1957, Vol. 28, No. 12, pp. 1419–1423.) The rate of etching is smaller the larger is the concentration of dissolved O_2 in the crystal. Etch-pit formation is correspondingly impeded. Observations have been made on virgin and heat-treated crystals. See also 3906 of 1957.

537.311.33 : 546.28 **1454**

Lifetime in Pulled Silicon Crystals.—C. A. Bittmann & G. Bemski. (*J. appl. Phys.*, Dec. 1957, Vol. 28, No. 12, pp. 1423–1426.) "Lifetime data of 46 pulled Si crystals are interpreted in terms of the Shockley-Read recombination theory. The data are consistent with a single recombination level and a constant concentration of recombination centres independent of the resistivity of the crystals."

537.311.33 : 546.28 **1455**

Effect of Heat Treatment upon the Electrical Properties of Silicon Crystals.—C. S. Fuller & R. A. Logan. (*J. appl. Phys.*, Dec. 1957, Vol. 28, No. 12, pp. 1427–1436.) Studies have been made of the process by which donors are introduced into Si by heating in the temperature range 300–500°C and are caused to disappear on heating at higher temperature. It is shown that O_2 is the impurity from which the donors are formed. See also 2808 of 1957 (Kaiser).

537.311.33 : 546.28 **1456**

Double-Acceptor Behaviour of Zinc in Silicon.—R. O. Carlson. (*Phys. Rev.*, 15th Dec., 1957, Vol. 108, No. 6, pp. 1390–1393.) Evidence is presented to show that, under proper doping conditions, Zn acts as a double-acceptor impurity with levels at 0·31 eV from the valence band and 0·55 eV from the conduction band.

537.311.33 : 546.28 **1457**

Properties of Silicon Doped with Iron or Copper.—C. B. Collins & R. O. Carlson. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1409–1414.) It was found that Fe introduced a donor level into Si at 0·40 eV from the valence band. The electrically active solubility of Fe was $1 \cdot 5 \times 10^{16}$ cm^{-3} at 1 200°C; the distribution coefficient was 8×10^{-6}. Studies of lifetime indicated a larger capture cross-section for electrons than for holes. Cu introduced a donor level at 0·24 eV and an acceptor level at 0·49 eV, both as measured from the valence band. The maximum electrical activity in quenched samples was 5×10^{14} cm^{-3} out of a total concentration of 10^{18} cm^{-3} at 1 200°C.

537.311.33 : 546.28 **1458**

Conductivity Mobilities of Electrons and Holes in Heavily Doped Silicon.—G. Backenstoss. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1416–1419.) The samples used had impurity concentrations up to 6×10^{19} cm^{-3} and 6×10^{18} cm^{-3} for *n*- and *p*-type Si, respectively. The conductivity mobilities were calculated by considering the percentage of ionized impurities. A comparison with the existing theory of impurity scattering yielded better agreement for *n*-type than for *p*-type Si.

537.311.33 : 546.28 **1459**

Thermal Generation of Recombination Centres in Silicon.—B. Ross & J. R. Madigan. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1428–1433.) The measurement of minority-carrier lifetime versus bulk resistivity in diffused silicon *p-n* junctions showed that Hall-Shockley-Read statistics are obeyed. A trap level of approximately 0·1 eV above the valence band in both conductivity types of silicon was deduced from lifetime versus temperature data on junctions which were annealed, quenched, and re-annealed.

537.311.33 : 546.28 : 537.533 **1460**

Field Emission from Silicon.—L. A. D'Asaro. (*J. appl. Phys.*, Jan. 1958, Vol. 29, No. 1, pp. 33–34.) A description of field-emission patterns obtained using a single crystal of *p*-type Si. Stable patterns were obtained only after the point was distorted by heating in the presence of an electric field.

537.311.33 : 546.28 : 537.533 **1461**

Electron Emission from Avalanche Breakdown in Silicon.—J. A. Burton. (*Phys. Rev.*, 1st Dec. 1957, Vol. 108, No. 5, pp. 1342–1343.) A new kind of electron emission has been observed, which arises from the energetic electrons produced in avalanche breakdown in a Si *p-n* junction at room temperature, when the Si work function is lowered by adsorbed Cs.

537.311.33 : [546.28 + 546.289] : 537.534.9 **1462**

Positive-Ion Bombardment of Germanium and Silicon.—S. P. Wolsky. (*Phys. Rev.*, 1st Dec. 1957, Vol. 108, No. 5, pp. 1131–1136.) A very sensitive vacuum microbalance has been used to study the sputtering of Ge and Si by argon ion bombardment. Current densities of 1 to 12 μA/cm^2 were used.

537.311.33 : 546.289 **1463**

Fine Structure in the Absorption-Edge Spectrum of Ge.—G. G. Macfarlane, T. P. McLean, J. E. Quarrington & V. Roberts. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1377–1383.) Measurements of the absorption spectrum of Ge, made with high resolution, near the main absorption edge, at various temperatures between 4·2°K and 291°K, have revealed a fine structure on the long-wavelength side of this edge. This structure has been analysed and can be interpreted in terms of indirect transitions involving phonons with energies corresponding to temperatures of 90°K and 320°K. The initial energy dependence of the components of the absorption coefficient associated with the 320°K phonons is interpreted as being due to the formation of excitons with a binding energy of 0·005 eV.

537.311.33 : 546.289 : 538.22 **1464**

Surface Paramagnetism of Germanium Films.—Y. L. Sandler. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1642.) Experiments suggest that a clean Ge surface is paramagnetic and that there is roughly one unpaired electron per Ge surface atom.

537.311.33 : 546.682.86 **1465**

Width of the Forbidden Band in InSb.—V. V. Galavanov. (*Zh. tekh. Fiz.*, April, 1957, Vol. 27, No. 4, pp. 651–655.) The relation is considered of temperature to conductivity and Hall constant in semiconductors with a large electron/hole mobility ratio. At T = 0°K the width of the forbidden band in *p*-type samples appears nearly twice as large as that of *n*-type specimens. Tables and graphs of results are given.

537.311.33 : 546.682.86 **1466**

Indirect Transitions at the Centre of the Brillouin Zone with Application to InSb, and a Possible New Effect.—W. P. Dumke. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1419–1425.) The theory of indirect optical transitions is extended to the case where both the valence band and the conduction band extrema occur at the centre of the Brillouin zone. The experimental evidence on InSb is reviewed and found to be consistent with degenerate valence bands at the centre of the Brillouin zone. A new effect is predicted involving the modulation of the indirect absorption constant by the selective excitation of the long-wavelength optical modes.

537.311.33 : 546.682.86 : 535.215 **1467**

Lifetime of Excess Carriers in InSb.—P. T. Landsberg. (*Proc. phys. Soc.*, 1st Dec. 1957, Vol. 70, No. 456B, pp. 1175–1176.) A discussion of the results of measurements giving a value of the ratio of bulk to radiative lifetime at room temperature. See also 2825 of 1957 (Moss).

537.311.33 : 546.682.86 : 538.63 **1468**

Galvanomagnetic Effects in *n*-Type Indium Antimonide.—H. P. R. Frederikse & W. R. Hosler. (*Phys. Rev.*, 1st Dec. 1957, Vol. 108, No. 5, pp. 1136–1145.) The magnetic-field dependence of the magneto-resistive effects and the Hall coefficient have been investigated at 78°K and at liquid-He temperatures. Results at very low magnetic field strength are in agreement with the assumption of an isotropic conduction band. Quantization of the electron orbits causes deviations from the conventional theory at large field strengths. Oscillations in the magnetoresistance observed at 4·2°K and lower are attributed to these quantum effects. An effective mass value of $0{\cdot}01m_0$ is obtained from the field and temperature dependence of the amplitude of the oscillations. The magnitude of the magnetoresistance effects appears to depend considerably on the geometry and inhomogeneity of the sample.

537.311.33 : 546.682.86 : 538.63 **1469**

Galvanomagnetic Effects in *p*-Type Indium Antimonide.—H.P.R. Frederikse & W. R. Hosler. (*Phys. Rev.*, 1st Dec. 1957, Vol. 108, No. 5, pp. 1146–1151.) The conductivity and Hall effect have been measured as a function of magnetic field strength and of temperature. Hall coefficient and magnetoresistance characteristics at 78°K are consistent with a valence band which consists of two bands with different effective masses and has degenerate maxima at the centre of the Brillouin zone. Negative magnetoresistance has been observed at liquid-He temperatures; the effect is positive for very pure samples when the magnetic field strength exceeds $\approx 10^3$ G.

537.311.33 : 546.873.241 **1470**

Optical and Electrical Investigation of Bismuth Telluride Bi_2Te_3.—J. Lagrenaudie. (*J. Phys. Radium*, March 1957, Vol. 18, Supplement to No. 3, *Phys. appl.* pp. 39A–40A.)

537.311.33 : 546.873.241 : 537.32 **1471**

Electrical and Thermal Properties of Bi_2Te_3.—C. B. Satterthwaite & R. W. Ure, Jr. (*Phys. Rev.*, 1st Dec. 1957, Vol. 108, No. 5, pp. 1164–1170.) The phase diagram for Bi-Te in the region Bi_2Te_3 has been investigated. The Hall mobilities parallel to cleavage planes vary as $T^{-1\cdot5}$ for holes and $T^{-2\cdot7}$ for electrons. Room temperature values are $\mu_p = 420$, $\mu_n = 270$ cm²/V. sec. The energy gap is 0·2 eV. The lattice conductivity is $5{\cdot}10 \times 10^{-2}/T$ W/deg cm.

537.311.33 : 621.317.733 **1472**

Experimental Determination of the Mean Lifetime of Minority Carriers in Semiconductors.—V. Andresciani & G. Della Pergola. (*Ricerca sci.*, Sept. 1957, Vol. 27, No. 9, pp. 2663–2673.) A light-spot method using a Wheatstone bridge circuit is described. Results are compared with those obtained by means of a Many bridge (2129 of 1954) and are found to be adequate for practical purposes.

537.311.33 : 621.357.8 **1473**

Control of Optimum Conditions for Electrolytic Polishing of Semiconductors.—I. Epelboin & M. Froment. (*J. Phys. Radium*, March 1957, Vol. 18, Supplement to No. 3, *Phys. appl.*, pp. 60A–61A.) Polished Ge and Si semiconductors are examined by an interference contrast method using two polarized waves. Four micrographs are shown obtained with Ge samples polished in a mixture of 500 cm³ glycerine, 50 cm³ water, 50 cm³ ethyl alcohol.

537.533.8 **1474**

Effect of Reflected Electrons in Secondary Electron Emission.—L. N. Dobretsov & T. L. Matskevich. (*Zh. tekh. Fiz.*, April 1957, Vol. 27, No. 4, pp. 734–744.) Specimens of mica, LiF, SiO_2, Ca_2CO_3 etc., were tested by means of a single-pulse circuit. The coefficients of secondary emission are tabulated and graphs shown.

538.22 **1475**

Theory of Antiferromagnetic-Ferromagnetic Transitions in Dilute Magnetic Alloys and in the Rare Earths.—G. W. Pratt, Jr. (*Phys. Rev.*, 1st Dec. 1957, Vol. 108, No. 5, pp. 1233–1242.) Both the molecular-field theory and a cluster theory due to Oguchi (*Prog. theor. Phys.*, Feb. 1955, Vol. 13, No. 2, pp. 148–159) are applied. Each leads to a magnetic transition and both predict that for all such transitions the ferromagnetic state must have a lower free energy at 0°K than the antiferromagnetic state. A comparison is made between the present theory and recent experimental results for Cu-Mn alloys.

538.221 **1476**

Some Magnetothermal Relations for Ferromagnetics.—R. W. Teale & G. Rowlands. (*Proc. phys. Soc.*, 1st Dec. 1957, Vol. 70, No. 456B, pp. 1123–1134.) An expression is derived which relates magnetic and thermal changes for reversible rotation of the intrinsic magnetization or reversible domain wall motion. Experiments are proposed to differentiate between the possible energy changes which accompany these processes.

538.221 **1477**

Criterion for Ferromagnetism from Observations of Magnetic Isotherms.—A. Arrott. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1394–1396.) "A criterion is proposed for determining the onset of ferromagnetism in a material as its temperature is lowered from a region in which the linearity of its magnetic moment *versus* field isotherm gives an indication of paramagnetism."

538.221 **1478**

Specific Heat of a Ferromagnetic Substance Above the Curie Point.—C. Domb & M. F. Sykes. (*Phys. Rev.*, 15th Dec. 1957, Vol. 108, No. 6, pp. 1415–1416.) "High-temperature expansions for the specific heat of the Ising model are compared for the triangular and f.c.c. lattices. It is concluded that the 'tail' of the specific heat curve above the Curie point is much smaller for the f.c.c. lattice, but is steeper in the immediate neighbourhood of the Curie point."

538.221 : [621.318.124+621.318.134 **1479**

Convention on Ferrites.—(*Proc. Instn elect. Engrs*, Part B, 1957, Vol. 104, Supplement No. 6, pp. 267–398.) The following papers were included among those read at the I.E.E. Convention held in London 29th October–2nd November 1956. See also 1202 of April.

Microwave Introductory Session:

(*a*) A Survey of the Theory and Applications of Ferrites at Microwave Frequencies.—P. J. B. Clarricoats, A. G. Hayes & A. F. Harvey (pp. 267–282).

Discussion (pp. 283–285).

Microwave Theory and Measurements:

(*b*) Some Properties of Circular Waveguides containing Ferrites.—P. J. B. Clarricoats (pp. 286–296).

(*c*) The Measurement of Complex Permittivity and Complex Tensor Permeability of Ferrite Materials at Microwave Frequencies.—I. G. MacBean (pp. 296–306).

(*d*) Theory of the Measurement of the Elements of the Permeability Tensor of a Ferrite by means of a Resonant Cavity.—R. A. Waldron (pp. 307–315).

(*e*) Nonreciprocal Network Theory applied to Ferrite Microwave Devices.—H. J. Carlin (pp. 316–319).

Discussion (pp. 320–323).

Microwave Measurements and Properties:

(*f*) Microwave Faraday Effect and Conductivity in Nickel Ferrites and Ferrite-Aluminates.—R. Derry & M. S. Wills (pp. 324–330).

(*g*) Some Properties and Applications of Ferrites at 3-cm Wavelength.—S. Boronski (pp. 331–337).

(*h*) Measurement of Ferrite Properties in a Rectangular Cavity at 10 000 Mc/s.—J. Roberts & C. M. Srivastava (pp. 338–341).

(*i*) The Quantum Theory of Spontaneous Magnetization of Ferrites at Low Temperatures.—E. I. Kondorskiĭ (p. 342). See also 3930 of 1957 (Kondorski et al.).

Discussion (pp. 343–345).

Microwave Apparatus:

(*j*) Ferrite Structures for Millimetre Wavelengths.—A. F. Harvey (pp. 346–354).

(*k*) Applications of Ferrites at 3-cm Wavelength.—R. M. Godfrey, B. L. Humphreys, P. E. V. Allin & G. Mott (pp. 355–361).

(*l*) Development of a Rotation Isolator for 6-cm Wavelength.—P. E. Ljung (pp. 362–363).

(*m*) A Resonance Absorption Isolator in Microstrip for 4 Gc/s.—L. Lewin (pp. 364–365).

(*n*) Notes on Microwave Ferromagnetics Research.—A. G. Fox (pp. 371–378).

(*o*) Some Measurements and Applications of the Microwave Properties of a Magnesium-Manganese Ferrite in the 8–9-mm Waveband.—E. Laverick & A. Rivett-Carnac (pp. 379–382).

(*p*) The 45°-Faraday-Rotation Ferrite Isolator.—A. L. Morris (pp. 383–387).

(*q*) Some Applications of Ferrites to Microwave Directional Couplers, Switches, and Cavity Filters.—E. Strumwasser (pp. 388–394).

Discussion (pp. 366–370, 395–398).

538.221 : 621.318.134 **1480**

Preparation of Polycrystalline Ferrimagnetic Garnet Materials for Microwave Applications.—W. D. Wolf & G. P. Rodrigue. (*J. appl. Phys.*, Jan. 1958, Vol. 29, No. 1, pp. 105–108.) A simple chemical method is described for preparing high-density, polycrystalline, magnetic garnets having the formula $3M_2O_3.5Fe_2O_3$, where M is a rare earth from Sm to Lu, or yttrium. Results of measurements of ferrimagnetic resonance line width and dielectric loss tangent are given.

538.221 : 621.318.134 **1481**

Granular Structures with Superficial Layer in Ceramics with Iron Oxide Base.—J. Suchet. (*J. Phys. Radium*, March 1957, Vol. 18, Supplement to No. 3, *Phys. appl.*, pp. 10A–18A.) In ceramics with Fe_2O_3 base particularly Mn-Zn ferrite there are two types of resistive surface layer formed by oxidation during the cooling process.

538.221 : 621.318.2 **1482**

Fine-Particle Magnets.—T. O. Paine, L. I. Mendelsohn & F. E. Luborsky. (*Elect. Engng, N.Y.*, Oct. 1957, Vol. 76, No. 10, pp. 851–857.) The basic factors which determine the behaviour of permanent magnets made from fine particles are reviewed. Alignment and packing of single-domain particles are discussed and the properties of manganese-bismuth, barium ferrite and fine-particle iron as permanent-magnet materials are described. 36 references.

538.221 : 621.385.833 **1483**

Study of the Magnetic Leakage Field in Cobalt by means of a Divergent Electron Beam.—M. Blackman & E. Grünbaum. (*Nature, Lond.*, 30th Nov. 1957, Vol. 180, No. 4596, pp. 1189–1190.) An electron beam diverges from a small movable aperture of 6–25 μ in a direction parallel to the crystal edge and is deflected by the leakage field. Curves obtained at 20° – 265°C are given. See 205 of 1957.

538.222 : 538.569.4 **1484**

Research on the Paramagnetism of Solids at the Institute of Physics of Palermo University.—M. Santangelo. (*Ricerca sci.*, Sept. 1957, Vol. 27, No. 9, pp. 2768–2772.) Microwave equipment for the measurement of magnetic resonance absorption is briefly described.

538.222 : 621.318.134 **1485**

Investigation of the Paramagnetism of the Ferrites $5Fe_2O_3.3M_2O_3$, where M = Gd, Dy, Er.—R. Aléonard & J. C. Barbier. (*C. R. Acad. Sci., Paris*, 19th Aug. 1957, Vol. 245, No. 8, pp. 831–834.) Investigation of the thermal variation of susceptibility above the Curie point of rare-earth ferrites of the garnet type.

621.315.615 : 537.528 **1486**

The Breakdown of Liquid Dielectrics and its Dependence on Oxidation of the Electrodes.—R. Hancox. (*Brit. J. appl. Phys.*, Dec. 1957, Vol. 8, No. 12, pp. 476–480.) Theoretical considerations and experiments with pre-treated transformer oil show that oxide layers on the electrodes increase the recorded breakdown strength of the dielectric.

MATHEMATICS

519.283 **1487**

Nonparametric Definition of the Representativeness of a Sample—with Tables.—M. Sobel & M. J. Huyett. (*Bell Syst. tech. J.*, Jan. 1958, Vol. 37, No. 1, pp. 135–161.) The problem is to determine how large a random sample is needed to guarantee with preassigned probability that the sample will have a specified amount (or a specified degree) of representativeness of the true, unknown (cumulative) distribution F under study. The solution given is nonparametric (i.e. distribution-free) so that the results obtained and the tables and graphs constructed are valid for any true underlying distribution.

MEASUREMENTS AND TEST GEAR

529.786 + 621.3.018.41(083.74) **1488**

The 'Time Centre' at the Milan Polytechnic.—C. Mazzon. (*Ricerca sci.*, Sept. 1957, Vol. 27, No. 9, pp. 2727–2747.) Time- and frequency-standard equipment and control and recording apparatus are described. Details are given of a system for improving the accuracy of calibration on the basis of standard-frequency signal reception.

529.786 : 621.317.4 **1489**

A Small Quartz Clock with Transistor Drive.—D. E. Cridlan & J. E. Thwaites. (*P.O. elect. Engrs' J.*, Oct. 1957, Vol. 50, Part 3, pp. 189–191.) A quartz tuning fork gives a frequency of 800 c/s which is divided down in four identical binary stages to drive a 50-c/s mains clock movement. Transistors are used in the oscillator drive circuit, the frequency dividers and amplifier.

621.317.2 : 621.374.3 **1490**

A Versatile Pulse Pattern Generator.—P. H. Cutler & L. R. Peters. (*Electronic Engng*, Jan. 1958, Vol. 30, No. 359, pp. 39–42.) "Two independent pulse pattern generators are used to produce any sequence of pulses of either polarity ; either sequence contains up to ten pulses, and the pulse duration may be varied from 45 μs to 1 s. The two separate patterns may be combined to give a third pattern whose maximum length is ninety pulses."

621.317.3 : 621.314.7 **1491**

Measuring Transistor 'Power Gain' at High Frequencies.—W. N. Coffey. (*Electronic Ind. Tele-Tech*, Oct. 1957, Vol. 16, No. 10, pp. 66–68 . . 169.) A method of measuring directly the common-emitter power gain of transistors in the 40–300-Mc/s range when driven by a resistive generator.

621.317.3.029.63 : 621.396.822 **1492**

The Precise Measurement of Noise Temperatures of Two-Terminal Networks in the Decimetre Wavelength Range by a Substitution Method.—L. Mollwo. (*Arch. elekt. Übertragung*, July 1957, Vol. 11, No. 7, pp. 295–306.) General formulae are derived for errors caused by impedance mismatch of network to measuring system. A new substitution method for reducing the effect of these errors is described. Mismatch corrections are considered for the case of a saturated-diode noise generator.

621.317.329 : 621.316.8 **1493**

Practical Applications of a Resistance Network for Determining Plane Potential or Space-Charge Fields.—G. Čremošnik & M. J. O. Strutt. (*Arch. Elektrotech.*, 20th May 1957, Vol. 43, No. 3, pp. 177–186.) The reduction of errors in using a resistance-network analogue is discussed on the basis of theoretical investigations. See e.g. 974 of March.

621.317.331 : 621.316.721.078.3 **1494**

A Current Regulator to Facilitate Resistance Measurements at Low Temperature.—M. W. Thompson. (*J. sci. Instrum.*, Dec. 1957, Vol. 34, No. 12, p. 515.)

621.317.341.3(083.57) **1495**

A Chart for Return Loss Determination.—L. Kitajewski. (*Electronic Engng*, Jan. 1958, Vol. 30, No. 359, pp. 42–43.) Curves are shown from which the return loss or the reflection coefficient can be determined quickly from bridge measurements of impedances. The curves are applicable only to the case when the return loss is required between an unknown impedance and a characteristic impedance of 125 $\angle 0°$ Ω.

621.317.343.2 : 621.314.22 **1496**

Measurement of the Characteristic Impedance of a Coaxial Cable.—L. B. D'Alton. (*Electronic Engng*, Jan. 1958, Vol. 30, No. 359, pp. 37–38.) "A method is described for measuring the characteristic impedance of a coaxial cable and the velocity of propagation, the only equipment required being a radio receiver, a signal generator and a calibrated capacitor."

621.317.361.018.756 **1497**

Errors in the Measurement of Pulse Frequency Spectra by means of Stagger-Tuned Resonant Circuits.—G. Seeger & H. G. Stäblein. (*Arch. elekt. Übertragung*, Aug. 1957, Vol. 11, No. 8 pp. 325–330.) The type and magnitude of the errors due to the losses in the resonant circuits are investigated for circuits of equal absolute and equal relative bandwidth. For a given permissible error the maximum frequency spectrum is covered by circuits suitably staggered with regard to bandwidth.

621.317.39 : 531.771 : 621.387 **1498**

A Very-High-Speed Precision Tachometer.—J. K. Goodwin. (*Electronic Engng*, Jan. 1958, Vol. 30, No. 359, pp. 18–24.) Describes fully a portable instrument that counts up to 40 000 rev/min. It may also be used to count pulses up to 20 000/s with an accuracy of ±1/s, or random pulses to a total of 999 999. See 1153 of 1954 (Bland & Cooper).

621.317.39 : 531.78 **1499**

Strain-Gauge Oscillator for Flight Testing.—W. H. Foster. (*Electronics*, 31st Jan. 1958, Vol. 31, No. 5, pp. 40–42.) The frequency of a small transistor oscillator is modulated in proportion to the stress or pressure applied to a strain gauge incorporated in a feedback loop.

621.317.39 : 536.53 : 621.316.825 **1500**

Temperature Measurement with Thermistors.—J. C. Anderson. (*Electronic Radio Engr*, March 1958, Vol. 35, No. 3, pp. 80–84.) "Characteristics of thermistors are discussed, and three temperature-measuring devices described:—an industrial thermometer for 0°–100°C using a Wheatstone bridge, a medical thermometer covering 85°–105°F incorporating a balanced transistor amplifier and a high-sensitivity device using a two-stage transistor amplifier. Some observations on thermistor stability are included."

621.317.39 : 537.312.9 **1501**

Use of Piezoresistive Materials in the Measurement of Displacement, Force and Torque.—W. P. Mason & R. N. Thurston. (*J. acoust. Soc. Amer.*, Oct. 1957, Vol. 29, No. 10, pp. 1096–1101.) "The use of piezoresistive materials as strain gauges and in the measurement of displacement, force, and torque is discussed generally. A torsional transducer which has been constructed from *n*-type Ge is described, and the experimentally obtained voltage/torque characteristic is given."

621.317.4 : 621.317.755 **1502**

***B-H* Tester measures Memory Core Parameters.**—T. H. Bonn, R. D. Torrey & F. Bernstein. (*Electronics*, 17th Jan. 1958, Vol. 31, No. 3, pp. 76–80.). This instrument measures the hysteresis properties of small magnetic toroids. The flux, drive current, ratio of remanent flux to maximum flux, squareness ratio and ratio of coercive force to maximum magnetizing force are read from window potentiometers as the *B-H* loop is presented on a c.r. tube.

621.317.4 : 621.372.413 **1503**

A Re-entrant Cavity for Magnetic Measurements.—E. A. Faulkner. (*J. sci. Instrum.*, Dec. 1957, Vol. 34, No. 12, pp. 514–515.) An open-ended resonant cavity is used to measure magnetic permeability of small toroidal specimens in the range 250–3 300 Mc/s.

621.317.431 **1504**

New Technique for Measuring Rotational Hysteresis in Ferromagnetic Materials.—J. M. Kelly, Jr. (*Rev. sci. Instrum.*, Dec. 1957, Vol. 28, No. 12, pp. 1038–1040.) A technique for use in the range 3–30 c/s using a sample disk of material mounted on a top rotating in a magnetic field.

621.317.723 : 621.375.024 **1505**

A Feedback Electrometer Amplifier.—D. Allenden. (*Electronic Engng*, Jan. 1958, Vol. 30, No. 359, pp. 31–33.) The inherent feedback loop gain is used to stabilize the electrometer-valve filament supply. The zero drift at full-scale voltage sensitivity of 2 V is less than ± 1 part in 1 000 over several hours.

621.317.733 **1506**

The Accuracy of Determination of Capacitance and Loss Factor by means of A.C. Bridges.—H. Hoyer & W. Wiessner. (*Arch. Elektrotech.*, 20th May 1957, Vol. 43, No. 3, pp. 169–177.) Simple formulae are derived for determining the limits of accuracy and sensitivity of conventional capacitance bridges, taking account of matching between bridge and indicating device.

621.317.74 : 621.385.029.64 **1507**

S.H.F. Frequency Sweeper uses Backward-Wave Tube.—D. E. Wheeler & P. D. Lacy. (*Electronics*, 3rd Jan. 1958, Vol. 31, No. 1, pp. 76–78.) "Swept-frequency signal source using backward-wave oscillator tube offers sweep rates from 40 Mc/s to 400 kMc/s in the microwave region between 8·2 and 12·4 kMc/s. Rapid wide-range evaluations of reflection, gain and attenuation are possible, as well as permanent records of measured data on an ink recorder. Sweep width is continually adjustable from 3 Mc/s to 4·2 kMc/s and unit may be modulated with a.m. or f.m."

621.317.75 : 621.317.715 : 534.1 **1508**

Response Spectra by means of Oscillograph Galvanometers.—R. W. Conrad & I. Vigness. (*J. acoust. Soc. Amer.*, Oct. 1957, Vol. 29, No. 10, pp. 1110–1115.) The principles of design and calibration of a response or shock-spectrum analyser are described. It comprises twelve galvanometer elements with natural frequencies in the range 10–2 500 c/s, each with an associated amplifier and damping network. Damping is adjustable between about 3 and 50% of critical. An example is given of its operation in the analysis of tape-recorded accelerometer signals played back at different speeds.

621.317.755.001.6(091) **1509**

The Development of the Cathode-Ray Oscillograph since 1923.—P. Hochhäusler. (*Elektrotech. Z.*, *Edn A*, 1st Aug. 1957, Vol. 78, No. 15, pp. 514–521.) A survey with 36 references, mainly to German literature.

621.317.755.087.5 **1510**

Continuous Recording of Waveforms on Photographic Film.—V. B. Hulme. (*Electronic Engng*, Jan. 1958, Vol. 30, No. 359, pp. 10–14.) The limitations on the information capacity of the deflected-spot c.r. tube waveform recorder are overcome by using a ribbon-beam tube and variable-area recording.

621.317.79 : 538.632 : 537.311.33 **1511**

A Simple Specimen Holder and Apparatus for Measurement of Conductivity and Hall Voltage over a Temperature Range.—A. A. Brooker, R. A. Clay & A. S. Young. (*J. sci. Instrum.*, Dec. 1957, Vol. 34, No. 12, pp. 512–513.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

537.533.35(091) **1512**

25 Years of Electron Microscopy.—E. Ruska. (*Elektrotech. Z.*, *Edn A*, 1st Aug. 1957, Vol. 78, No. 15, pp. 531–543.) An outline of the scientific background and the history of the technique including the latest developments. 94 references.

538.74 : 538.632 **1513**

The Hall-Effect Compass.—I. M. Ross, E. W. Saker & N. A. C. Thompson. (*J. sci. Instrum.*, Dec. 1957, Vol. 34, No. 12, pp. 479–484.) A description of the use of the Hall-effect voltage from a semiconductor in the earth's magnetic field as the basis for an electrical compass. Expressions are derived for the voltage and power outputs, and the sensitivity and the relative merits of various semiconductors are reviewed. A practical design of compass is described and illustrated.

551.508.8 : 621.316.825 **1514**

Response of Radiosonde Thermistors.—F. I. Badgley. (*Rev. sci. Instrum.*, Dec. 1957, Vol. 28, No. 12, pp. 1079–1084.) The thermistors are estimated to have lag coefficients of about 25 s (10 × the ground level value) at heights of about 70 000 ft. The radiation error at these heights could be several degrees.

621.317.755 : 003.35 **1515**

Generating Characters for Cathode-Ray Read-Out.—K. E. Perry & E. J. Aho. (*Electronics*, 3rd Jan. 1958, Vol. 31, No. 1, pp. 72–75.) The necessary X and Y deflection voltages for representation of the Arabic numerals 0 to 7 on a c.r. tube screen are obtained by Fourier synthesis technique involving the combination of sine and cosine terms of the first five harmonics from a 30-kc/s fundamental frequency. Each character is traced in about 30 μs.

621.384.6 **1516**

Fields in Gap-Excited Rectangular Ducts.—J. Van Bladel. (*J. appl. Phys.*, Dec. 1957, Vol. 28, No. 12, pp. 1479–1483.) "The e.m. field in a rectangular waveguide, cut in two by a plane perpendicular to its longitudinal axis, is investigated. A voltage applied across the two halves of the guide generates the field structure, which is analyzed for several values of the frequency (between zero and cut-off) and of the aspect ratio of the cross-section. The problem is of interest for the design of particle accelerators."

621.384.611 **1517**

A New Particle Accelerator.—Y. P. Varshni. (*Indian J. Phys.*, July 1957, Vol. 31, No. 7, pp. 384–386.) In a cyclotron of conventional form it is not possible to accelerate ions beyond a certain limit on account of their relativistic increase in mass at high velocities and consequent departure from resonance. This difficulty may be overcome using a cyclotron with spiral-shaped 'dees' called a spiratron.

621.385.833.001.6(091) **1518**

The History of the Development of the Electron Microscope.—D. Gabor. (*Elektrotech. Z.*, *Edn A*, 1st Aug. 1957, Vol. 78, No. 15, pp. 522–530.) An illustrated review with 83 references.

621.398 **1519**

Telecontrol.—E. L. Gruenberg. (*Trans. Inst. Radio Engrs*, May 1957, Vol. TRC-3, No. 2, pp. 5–8. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1168–1169.)

621.398 : 061.3 **1520**

Proceedings of the 1957 National Symposium on Telemetering.—(*Trans. Inst. Radio Engrs*, April 1957, Vol. TRC-3, No. 1.) The text is given of 36 papers, with abstracts of seven others, presented at a symposium held at Philadelphia, Pa, April 14th–16th. Abstracts of most of the papers are given in *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1166–1168. The following papers were included:

(*a*) A Wide-Band Microwave Link for Telemetering.—R. E. Glass (Section 1.2, 13 pp.).

(*b*) The Transmission of Pulse-Width-Modulated Signals over Restricted-Band-width Systems.—H. J. Heffernan (Section 2.3, 4 pp.).

(*c*) Extension of F.M./F.M. Capabilities. —H. O. Jeske (Section 2.4, 10 pp.).

(*d*) Telemetering System for the X-17 Missile.—J. A. Cox (Section 2.5, 14 pp.).

(*e*) Transistor Circuits Applied to Telemetering.—J. H. Smith (Section 3.1, 11 pp.).

(*f*) Low-Level Transistorized Chopper Amplifier.—H. F. Harris & T. E. Smith (Section 3.5, 8 pp.).

(*g*) Progress Report on a Solid-State F.M./F.M. Telemetering System.—E. Y. Politi (Section 3.6, 19 pp.).

(*h*) A Ruggedized R.F. Power Amplifier for Use in the 200-Mc/s Telemetry Band.—D. D. McRae (Section 6.1, 4 pp.).

(*i*) A New Transistor Magnetic F.M./F.M. Subcarrier Discriminator.—G. H. Barnes & R. M. Tillman (Section 6.3, 9 pp.).

(*j*) A Transistorized Pulse-Width Keyer. —J. A. Riedel, Jr, (Section 6.5, 6 pp.).

(*k*) P.D.M. Bandwidth Requirements.—F. E. Rock (Section 7.2, 6 pp.).

(*l*) Noise and Bandwidth in P.D.M./F.M. Radio Telemetering.—K. M. Uglow (Section 7.5, 10 pp.).

(*m*) Design of All-Channel Ultra-stable F.M. Discriminator.—S. Rigby (Section 8.2, 8 pp.).

(*n*) P.D.M./P.A.M. Conversion System. —R. L. Kuehn & W. L. Johnston (Section 8.5, 11 pp.).

621.398 : 621.376.3 **1521**

A Note on the Frequency Distribution of an F.M./F.M. Signal.—P. B. Arnstein. (*Trans. Inst. Radio Engrs*, May 1957, Vol. TRC-3, No. 2, pp. 13–16. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, p. 1169.)

621.398 : 621.376.3 **1522**

Noise and Bandwidth in F.M./F.M. Radio Telemetering.—K. M. Uglow. (*Trans. Inst. Radio Engrs*, May 1957, Vol. TRC-3, No. 2, pp. 19–22. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, p. 1169.)

621.398 : 621.376.56 : 621.314.7 **1523**

Transistorized Time Multiplexer for Telemetering.—J. M. Sacks & E. R. Hill. (*Trans. Inst. Radio Engrs*, May 1957, Vol. TRC-3, No. 2, pp. 26–30. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, p. 1169.)

621.398 : 621.396.934 : 621.317.7 **1524**

Special Timing Techniques Employed on Guided-Missile Ranges.—R. J. Garvey. (*Electronic Engng*, Jan. 1958, Vol. 30, No. 359, pp. 2–9.) The timing and reference signals are derived from a 10-kc/s crystal oscillator driving a series of frequency-dividing circuits, and are transmitted to the measuring stations by underground telephone cables. One of the timing signals indicates time intervals from an arbitrary zero.

621.398 : 629.19 **1525**

Transistorized Memory monitors Earth Satellite.—C. S. Warren, W. G. Rumble & W. A. Helbig. (*Electronics*, 17th Jan. 1958, Vol. 31, No. 3, pp. 66–70.) In the reception of telemetered data the circuits required to translate input information numerically and to present modified output information, use alloy-junction transistors as current drivers, gated-pulse amplifiers, voltage amplifiers, high-speed switches and flip-flops. Storage capacity is 6 400 bits arranged as 256 characters of 25 bits each.

655.3.024 : 621.385.832 **1526**

The Scanatron : an Electronic Instrument for Preparing Colour Separations for Multicolour Printing.—P. E. Klein. (*Elektronik*, Aug. 1957, Vol. 6, No. 8, pp. 238–239.) The equipment described comprises a single c.r. beam scanning tube and electronic circuitry for the production of corrected colour-separation plates. The resolution is 200 lines/cm. See also 1563 of 1957 (Shapiro & Haynes).

PROPAGATION OF WAVES

621.396.11 **1527**

Spectrum of Turbulent Mixing.—R. Bolgiano, Jr. (*Phys. Rev.*, 1st Dec. 1957, Vol. 108, No. 5, p. 1348.) It is argued that the conclusions presented in a recent paper [2881 of 1957 (Wheelon)], that the spectral dependence of molecular fluctuations in the initial subrange should and do obey a k^{-3} law, are incorrect. A $k^{-5/3}$ law is more appropriate.

621.396.11 : 551.510.535 **1528**

Some Problems of the Physics of the Ionosphere : Part 1 — Fluctuation of the Electron Density and Scattering of Radio Waves.—Al'pert. (See 1425.)

621.396.11 : 551.510.535 : 523.746 **1529**

The Sunspot Cycle and Radio Communications.—G. Millington. (*Point to Point Telecommun.*, June 1957, Vol. 1, No. 3, pp. 7–21.) The characteristics of the ionosphere during a sunspot cycle and the consequent effects on h.f. radio communication circuits are discussed with particular attention to the problem of interference, at high sunspot numbers, to circuits operating in the lower end of the v.h.f. band and to forward-scatter transmissions. Sunspot cycles since 1749 are examined but it is concluded that any precise predictions of future trends resulting from analysis of past behaviour should be treated with great caution in planning future frequency allocations for radio communication.

621.396.11.029.4 : 551.594.6 **1530**

The Waveforms of Atmospherics and the Propagation of Very-Low-Frequency Radio Waves.—J. Chapman. (*J. atmos. terr. Phys.*, 1957, Vol. 11, Nos. 3/4, pp. 223–236.) An analysis of waveform and frequency spectra observations, and comparison with theory in terms of 'waveguide' propagation between earth and ionosphere. A new classification of atmospheric waveforms is used, which relates to frequency spectrum, day or night conditions, and source distance. Appreciable differences are indicated between the spectra of individual flashes at the source.

621.396.11.029.6 : 621.397.26 **1531**

Scatter Propagation and its Application to Television.—J. A. Saxton. (*J. Telev. Soc.*, July/Sept. 1957, Vol. 8, No. 7, pp. 273–284.) The fundamental processes common to both ionospheric and tropospheric scatter propagation and the application of the mechanisms to point-to-point links are described. The dependence of performance on frequency, bandwidth and aerial characteristics is given and it is shown that whereas v.h.f. ionospheric scatter links are useful primarily for telegraphy over paths of 1 000–2 000 km, u.h.f. tropospheric scatter links may possibly be used for relaying television over paths of a few hundred km. 33 references.

621.396.11.029.62/.64 **1532**

Scatter Propagation.—(*Wireless World*, March 1958, Vol. 64, No. 3, pp. 124–125.) A digest of 23 papers on ionospheric and tropospheric forward-scatter propagation delivered at an I.E.E. symposium held on 28th January 1958.

621.396.11.029.62 : 551.510.535 **1533**

Radio-Frequency and Scattering-Angle Dependence of Ionospheric Scatter Propagation at V.H.F.—R. Bolgiano, Jr. (*J. geophys. Res.*, Dec. 1957, Vol. 62, No. 4, pp. 639–640.) Comment on 2576 of 1957 (Wheelon). The conclusion that the spectrum of mean square fluctuations produced by turbulent mixing of an established gradient is proportional, in the inertial subrange, to k^{-3}, where $k = \dfrac{4\pi}{\lambda \sin \theta/2}$, is shown to be based on an inconsistent argument.

RECEPTION

621.376.233 : 621.314.7 **1534**

Transistor Regenerative Detectors.—I. Gottlieb. (*QST*, Oct. 1957, Vol. 41, No. 10, pp. 30–31.) Details are given of the design and construction of a two-stage transistor receiver for the 80-m band. Its overall performance is claimed to be better than that of an equivalent valve set.

621.376.33 : 621.396.82 **1535**

F.M. Demodulator Time-Constant Requirements for Interference Rejection.—E. J. Baghdady. (*Proc. Inst. Radio

Engrs, Feb. 1958, Vol. 46, No. 2, pp. 432–440.) The upper bounds of permissible values of low-frequency time constants in the limiter and discriminator circuits operating under conditions of high-level interference are calculated. Severe restrictions are indicated which conflict with other fundamental requirements. Results show that these restrictions can be alleviated by simple schemes which enhance the capture performance of the f.m. receiver.

621.376.4 : 621.396.3 **1536**

Practical Elimination of 'Reverse Operation' in an Amplitude-Phase Detector due to Pulse Interference.—Yu. S. Lezin. (*Radiotekhnika, Mosk.*, Nov. 1956, Vol. 11, No. 11, pp. 45–52.) Change of polarity of the output voltage due to single-pulse or pulse-train interference can be eliminated by narrowing the pass band of the grid circuit of the detector. See also 927 of 1957.

621.396.62 : 061.43(43) **1537**

Novelties and Development Trends in the Construction of Receivers.—C. Reuber. (*Elektrotech. Z., Edn B*, 21st Aug. 1957, Vol. 9, No. 8, pp. 321–328.) Survey of the German Radio Show in Frankfurt with details of some of the circuit refinements and new ideas incorporated in the sound and television receivers exhibited there.

621.396.62 : 621.314.7 **1538**

Transistor Reflex Circuit trims Receiver Costs.—E. Gottlieb. (*Electronics*, 3rd Jan. 1958, Vol. 31, No. 1, pp. 66–68.) These circuits, in which the second i.f. stage doubles as the a.f. amplifier, do not suffer from the disadvantages inherent in earlier valve versions. Further circuit simplifications may be effected by coupling an *n-p-n* reflex stage to a *p-n-p* output amplifier.

621.396.62 : 621.372.632 **1539**

Low-Noise Converter for I.G.Y. Propagation Study.—L. F. Garrett. (*Electronics*, 31st Jan. 1958, Vol. 31, No. 5, pp. 52–54.) A 400-Mc/s converter, of 4-Mc/s bandwidth, with gain of 36 dB and noise figure of 2·5 dB, is described in detail. Possible applications include scatter propagation and meteoric and auroral studies.

621.396.62.001.6 **1540**

Problems of Modern Radio-Receiver Development.—W. Kausch. (*Elektrotech. Z., Edn B*, 21st Aug. 1957, Vol. 9, No. 8, pp. 329–330.) Brief assessment of recent technical improvements and their effect on production techniques.

621.396.8 : 621.376.3 **1541**

Signal-to-Noise Ratios in Strong-Carrier F.M. Systems.—H. Urkowitz. (*Commun. & Electronics*, Nov. 1957, No. 33, pp. 599–602.) Ratios are derived without use of high-order probability density functions. General formulae are obtained by determining the signal/noise ratio with periodic modulation or with pulse modulation and numerical results are given for the special case of a flat symmetrical r.f. passband. The effect of a mistuned frequency detector is taken into account.

621.396.828 : 681.142 **1542**

Radio-Interference Control as applied to Business Machines.—J. M. Sarley & R. J. Hendery. (*IBM J. Res. Developm.*, Oct. 1957, Vol. 1, No. 4, pp. 363–372.) The characteristics of the interference from machines are discussed. Some of the problems encountered in locating the various sources, and of reducing the interference to a satisfactory level, are described.

STATIONS AND COMMUNICATION SYSTEMS

621.391 **1543**

Double-Sampling Theorems in Continuous Signals.—N. Honda. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, June 1956, Vol. 8, No. 1, pp. 23–34.) Sampling theorems are given for continuous signals whose frequency spectra are $(2k + 1)$ bands in the frequency region

$$kf_0 - f_m \leqslant f \leqslant kf_0 + f_m$$
$$(k = -K, \ldots, 0, \ldots, K \text{ and } f_0 \geqslant 2f_m).$$

It is proved that the signal is completely determined by $(2k+1)$ unique functions spaced $1/2f_m$ seconds apart. If f_0/f_m is a integer the signal is completely determined by giving its $(2k+1)$ values spaced $1/(2k+1)f_0$ seconds apart.

621.391 **1544**

The Sequential Error-Correcting Code.—N. Honda. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, Dec. 1956, Vol. 8, No. 3, pp. 113–124.) A practical sequential error-correcting code is proposed in which, if the number of errors is below a definite number, then the code may be corrected.

621.391 **1545**

Geometrical Proof of Shannon's Theorem.—E. L. Blokh & A. A. Kharkevich. (*Radiotekhnika, Mosk.*, Nov. 1956, Vol. 11, No. 11, pp. 5–16.) The attempt to provide a geometrical proof of Shannon's theorem made in two previous papers (259 of 1956 and *ibid.*, July 1955, Vol. 10, No. 7, pp. 3–7) led to results different from those of Shannon. It is shown that this discrepancy was due to the choice of an incorrect geometric model.

621.391 : 621.396.822 **1546**

Fluctuations of Random Noise Power.—D. Slepian. (*Bell. Syst. tech. J.*, Jan. 1958, Vol. 37, No. 1, pp. 163–184.) "The probability distribution of the power, y, of a sample of Gaussian noise of time duration T is considered. Some general theory is presented along with curves for the cumulative distribution and probability density of y for several different power spectra and values of T."

621.391.5.029.53 : 621.376.3 **1547**

Wireless Microphone uses F.M. Modulation.—G. F. Montgomery. (*Electronics*, 3rd Jan. 1958, Vol. 31, No. 1, pp. 54–55.) A transistor circuit generating a low-power induction field at 460 kc/s. An f.m. system was chosen because of its inherent a.v.c. action thus limiting the field strength during times of peak modulation.

621.396.1 **1548**

A Canadian Point of View on Radio-Frequency Spectrum Management.—C. M. Brant. (*Commun. & Electronics*, Sept. 1957, No. 32, pp. 455–461.) Future frequency allocations for the various services are discussed.

621.396.3 : 621.396.43 : 523.5 **1549**

V.H.F. Propagation by Ionized Meteor Trails.—W. R. Vincent, R. T. Wolfram, B. M. Sifford, W. E. Jaye & A. M. Peterson. (*Electronic Ind. Tele-Tech*, Oct. & Nov. 1957, Vol. 16, Nos. 10 & 11, pp. 52–55..146 & 84–88, 98; *Wescon Convention Record Inst. Radio Engrs*, 1957, Vol. 1, Part 1, pp. 263–282.) Data collected at a receiving station in California using signals from television transmitters give information on the nature of the signals, their level, duration, fading and frequency of occurrence and also on the optimum aerial direction. An experimental 820-mile link operating at 40 and 32 Mc/s between Bozeman, Montana and Palo Alta, California, is described with details of W/T and R/T equipment and the magnetic-tape storage systems.

621.396.4 : 621.315.212 **1550**

Trial Model of Super Wide-Band Repeater for Coaxial Cable.—Y. Shigei, A. Ishii, G. Marubayashi & T. Iwase. (*Rep. elect. Commun. Lab., Japan*, Aug. 1957, Vol. 5, No. 8, pp. 1–3.) A capacity of (*a*) 2 700 telephone channels, or (*b*) one 4·3-Mc/s television channel and 1 200 telephone channels, or (*c*) two 4·3-Mc/s television channels, is aimed at. The characteristics are given of two new types of valve developed for this purpose. The system is briefly described.

621.396.41 **1551**

Design Factors for the Optimization of Multichannel Radio Systems.—C. A. Parry. (*Commun. & Electronics*, Nov. 1957, No. 33, pp. 606–620.) Satisfactory design needs evaluation of both linear and thermal noise, optimum design being obtained with these noise powers equal. Essential performance factors required for this evaluation are considered. The effects of carrier power, channel spacing, speech-power distribution and traffic activity on the signal/noise ratio are examined. Total reliability as a function of traffic fluctuations, propagation reliability and carrier power is established. Theoretically optimum distributions as well as typical operating distributions are given. Standards are suggested both for systems which must conform to requirements of existing communication networks and for systems which exist independently. Overall system testing by means of multiple tones is discussed and related basic requirements are outlined.

621.396.41 : 551.510.52 (083.57) **1552**

Tropo-scatter System Design Charts.—L. P. Yeh. (*Electronics*, 17th Jan. 1958, Vol. 31, No. 3, pp. 91–93.) In a frequency-division multiplex tropospheric scatter system, the unweighted signal/noise power ratio for a single-hop system may be obtained by consecutive use of the graphs provided.

621.396.43 **1553**

Microwave Radio Communication under Severe Winter Conditions on the

Bonneville Power Administration System.—E. M. Strong, E. J. Warchol & S. E. Benson. (*Commun. & Electronics*, Nov. 1957, No. 33, pp. 655–662.) The general layout of the system and terrain and weather conditions are described. Design factors are considered for protection of aerials and supporting structures from winds, snow and ice.

621.396.44 : 621.314.22 **1554**

Contribution of Statistics to the Development Program of a Transformer for the L3 Carrier System.—G. J. Levenbach. (*Bell. Syst. tech. J.*, Jan. 1958, Vol. 37, No. 1, pp. 23–54.) Statistical methods played a significant part in the development program of the L3 system which can transmit a television signal over a distance of approximately 1 000 miles and telephone signals approximately 4 000 miles. Experiments were designed to assist in improving the manufacture of the input and output transformers of the amplifiers. Detailed analysis of a few of these experiments is presented.

621.396.65 **1555**

Wide-Band Microwave Transmission Systems.—S. Fedida. (*Point to Point Telecommun.*, June 1957, Vol. 1, No. 3, pp. 26–50.) The concept of an ideal wide-band channel is developed and the shortcomings of practical systems, due mainly to the type of modulation employed, are enumerated. The requirements of a particular system depend on the type of intelligence to be transmitted, and the effect of such requirements on the system's performance is discussed. Variations in the transmission medium and their effect on the system are also examined. Typical practical equipment and techniques are described.

621.396.65 : 621.396.8 **1556**

Some Statistical Characteristics for Over-Reach Propagation and Co-frequency Interference in 2-Frequency-System Microwave Multi-relay Circuits.—S. Ugai & T. Nomura. (*Rep. elect. Commun. Lab., Japan*, July 1957, Vol. 5, No. 7, pp. 10–15.) From tests made in 1951–1953, the variation of received signal power at 4 kMc/s, for the optical path (50 km) alone, approximates to a gamma distribution. The distribution of the received power in diffraction regions (100–230 km), however, was found (1953–1955) to be classifiable into three types. The interference between signals received optically and after diffraction depends on the receiving system used, but the order of the effect—the cumulative probability—is found from the correlation between the gamma distribution for the optical path and each of the three types of distribution for the diffracted signals. This information assists the design of relay routes to minimize interference.

621.396.65.029.64 : 621.376.3 **1557**

A 4 000-Mc/s Radio System for the Transmission of Four Telephony Supergroups (240 Circuits).—(*P.O. elect. Engrs' J.*, July & Oct. 1957, Vol. 50, Parts 2 & 3, pp. 106–119 & 150–158.)

Part 1—Outline Description of the System and Detailed Description of Radio and Intermediate-Frequency Equipment.—R. L. Corke, E. V. Ephgrave, J. Hooper & D. Wray. A description of equipment for f.m. transmission over a single-hop link of 55 miles.

Part 2—The Baseband and Supervisory Equipment.—R. P. Froom, J. D. C. Madder & C. G. Hilton. Preliminary overall performance data for the link as a whole are given.

621.396.822.1 : 621.396.41 **1558**

Crosstalk Problems in Radio Relays with Double Modulation: P.P.M. and F.M.—E. Katz. (*Bul. Inst. polit. Bucuresti*, Jan./June 1956, Vol. 18, Nos. 1/2, pp. 331–352.) A special demodulation method is described which reduces crosstalk and effectively doubles the signal/noise ratio.

SUBSIDIARY APPARATUS

621-526 : 621.314.7 **1559**

Semiconductors Shrink Servo-System Size.—H. L. Aronson & W. R. Lamb. (*Electronics*, 3rd Jan. 1958, Vol. 31, No. 1, pp. 69–71.) A velocity-type servo system in which the network design is based on the constant-current driving source and low-impedance load conditions imposed by transistor operation. Output impedance is reduced considerably by using a double common-collector power stage with inverse feedback.

621.3.066.6 : 537.311.4 **1560**

The Effects of Dust and Force upon certain Very Light Electrical Contacts.—A. J. Maddock, C. C. Fielding, J. H. Batchelor & A. H. Jiggins. (*Brit. J. appl. Phys.*, Dec. 1957, Vol. 8, No. 12, pp. 471–476.) A quantitative relation is established between dust concentration and contact failure. An examination of contact loading shows that contact resistance may rise rapidly at loadings less than 1 mg unless surface films can be permanently removed.

621.314.63 : 537.311.33 **1561**

Progress Report on Semiconductor Rectifiers.—N. F. Bechtold. (*Electronic Ind. Tele-Tech*, Oct. 1957, Vol. 16, No. 10, pp. 70–71 . . 174.) "Findings indicate that silicon and germanium rectifiers are more desirable in high-temperature areas while selenium retains its superiority in high-current uses."

621.318.56 **1562**

Design of Magnetic Circuits for Miniature Relays.—W. J. Richert. (*Electronic Ind. Tele-Tech*, Oct. 1957, Vol. 16, No. 10, pp. 56–57 . . 156.) The polarized type of relay with a rotary armature is suggested as the most suitable type for miniaturization.

621.352 : 541.135.6 **1563**

The Solion: an Electrochemical Transducer.—(*Brit. Commun. Electronics*, Oct. 1957, Vol. 4, No. 10, p. 617.) The operation of this device is based on concentration polarization where an electric current passing through an electrochemical system is limited by diffusion and convection variables such as fluid flow. The solion consists of a small cylinder of plastic material containing a potassium-iodide solution in which two or more electrodes are immersed; polarization is effected by a 0·9-V battery. When the unit is stimulated by light, heat, sound, pressure or movement the resultant hydraulic flow within the cell produces a current output. These reactions are reversible.

621.352.7 **1564**

Wax-Electrolyte Batteries.—(*Tech. News. Bull. nat. Bur. Stand.*, Oct. 1957, Vol. 41, No. 10, pp. 149–150.) Two types of 37·5-V punched-cell battery have been developed. They are 3 in. long and respectively 0·25 and 0·5 in. in diameter, with short-circuit current 0·03 and 0·3 μA. A cell is stamped from a three-layer sandwich consisting of a Zn sheet, a conductive vinyl film and between the two layers a separator impregnated with a $ZnCl_2$ polyethylene glycol mixture.

621.396.662.6 : 621.374.3 **1565**

Self-Setting Servo Gate.—E. R. Schmerling. (*Electronics*, 17th Jan. 1958, Vol. 31, No. 3, p. 71.) "Simple circuit, used in ionospheric pulse experiments, picks out pulses transmitted at a fixed repetition frequency in the presence of random noise and improves reliability of synchronizing link by factor of 50."

TELEVISION AND PHOTOTELEGRAPHY

621.397.26 : 621.396.11.029.6 **1566**

Scatter Propagation and its Application to Television.—Saxton. (See 1531.)

621.397.5 : 621.317](083.74) **1567**

I.R.E. Standards on Television: Measurement of Luminance Signal Levels, 1958.—(*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 482–486.) Standard 58 I.R.E. 23. S1.

621.397.5 : 621.395.625.3 **1568**

The Ampex Video Tape-Recording System.—R. H. Snyder. (*Brit. Commun. Electronics*, Oct. 1957, Vol. 4, No. 10, pp. 612–616.) See 4018 of 1957.

621.397.6 : 621.372.55 **1569**

A New Video Differential Phase-and-Gain Equalizer.—J. H. Clark. (*Commun. & Electronics*, Nov. 1957, No. 33, pp. 674–676.) The equalizer uses the nonlinear impedance characteristics of devices such as Ge or Si diodes to compensate undesirable nonlinearity.

621.397.61 **1570**

Highlight Equalizer Sharpens TV Pictures.—M. V. Sullivan. (*Electronics*, 17th Jan. 1958, Vol. 31, No. 3, pp. 72–74.) "Equalization of only the gray-to-white highlight region in the video signal provides better signal-to-noise ratio and improved definition over conventional aperture equalizers covering the full brightness range. Since most image-orthicon noise is in the lowlight region, the improvement stems from a division of the signal into two parts with only the relatively quiet highlight portion equalized for better tonal reproduction."

621.397.61 : 535.623 **1571**

A Modified Microwave System for Colour Television Transmission.—F. F. McClatchie. (*Commun. & Electronics*, Nov. 1957, No. 33, pp. 626–633.) N.T.S.C. colour television signals may be transmitted on portable microwave radio relay units in a routine manner if an adequate system is available and standardized operation and maintenance instructions are provided. Necessary modifications to existing equipment are described.

621.397.62 : 535.88 **1572**

Large-Scale Projection of the Television Image.—H. Jensen. (*Elektrotech. Z., Edn B*, 21st Aug. 1957, Vol. 9, No. 8, pp. 331–334.) Outline of methods proposed and adopted in practice, particularly those using a small high-intensity picture tube with an optical projection system.

621.397.621 : 621.385.832 **1573**

90° Scanning.—R. H. C. Morgan & K. E. Martin. (*J. Telev. Soc.*, July/Sept. 1957, Vol. 8, No. 7, pp. 285–297.) The sensitivity and raster quality problems are discussed and two types of scanning coil assembly that reduce the energy required for full deflection are described. Improvements in line-timebase techniques give 90° scanning without an increase in the power required.

TRANSMISSION

621.376.32 : 621.396.41.029.6 **1574**

An Improved Frequency Modulator for Broad-Band Radio Relay Systems.—I. A. Ravenscroft. (*P.O. elect. Engrs' J.*, Oct. 1957, Vol. 50, Part 3, pp. 186–188.) The linearity is improved by negative feedback so that the modulator may be used in 600-channel telephone circuits conforming to C.C.I.R. standards. A method of reducing distortion at high modulation frequencies (up to 2·5 Mc/s) is discussed. See also 286 of 1956 (Ravenscroft & White).

621.396.61 : 621.314.7 **1575**

Simple Transistor Transmitter for 1·8 Mc/s.—N. Waite. (*R.S.G.B. Bull.*, Oct. 1957, Vol. 33, No. 4, p. 177.) Circuit and constructional details of a single-stage c.w. transmitter deriving its power supply from a 4·5-V battery.

621.396.712.029.62 : 621-523.8 **1576**

The Automatic 3-kW U.H.F. Transmitter 'Hoher Bogen'.—P. G. Zehnel & J. Brose. (*Elektronik*, Aug. 1957, Vol. 6, No. 8, pp. 240–242.) Two 250-W transmitters, one being in reserve, and a 3-kW amplifying stage are controlled by means of the automatic equipment described.

VALVES AND THERMIONICS

621.314.63 : 621.318.57 : 546.28 **1577**

***p-n-p-n* Switching Diodes.**—A. K. Jonscher. (*J. Electronics Control*, Dec. 1957, Vol. 3, No. 6, pp. 573–586.) "The paper describes silicon diodes of *p-n-p-n* structure which exhibit rapid switching from a high-resistance to a low-resistance state, similar to that described recently by Moll et al. [3899 of 1956]. Two types of characteristics are shown, those switching on both the 'forward' and 'reverse' branches and those giving ordinary diode forward behaviour and switching on the 'reverse' branch only. A theoretical treatment is given accounting for this behaviour and discussing the nature of the conduction mechanism in the low-resistance state for both directions of current flow."

621.314.63 : 621.372.632 **1578**

Semiconductor Diodes Yield Converter Gain.—A. Uhlir, Jr, & N. Bronstein. (*Bell Lab. Rec.*, Oct. 1957, Vol. 35, No. 10, p. 412.) Gains up to 6 dB (with adequate bandwidth for some applications) have been achieved with gold-bonded germanium diodes when converting from 75 Mc/s to 6 kMc/s. In 'down-conversion' stages using diffused silicon diodes gains up to 45 dB have been obtained.

621.314.7 **1579**

Injection Coefficient and Forward Current/Voltage Characteristic of a Spherical Contact.—Z. S. Gribnikov & K. B. Tolpygo. (*Zh. tekh. Fiz.*, April 1957, Vol. 27, No. 4, pp. 625–629.) The injection coefficient of a transistor *p-n* junction is examined, and the effect of increasing the radius of the metallic contact, and the corresponding increase in donor concentration are discussed.

621.314.7 : 539.169 **1580**

Analysis of the Effect of Nuclear Radiation on Transistors.—J. J. Loferski. (*J. appl. Phys.*, Jan. 1958, Vol. 29, No. 1, pp. 35–40.) A description of the permanent changes produced in Ge transistors. Information on the effect of radiation on semiconductors is reviewed, and the results are combined with transistor theory. The amplification factor of transistors and the effect of the fast neutron field of a reactor are discussed in detail.

621.314.7 : 546.289 **1581**

Germanium Junction Transistors.—H. Frank. (*Slab. Obz., Praha*, Dec. 1956, Vol. 17, No. 12, pp. 680–687.) The properties of Czech junction transistors with maximum power loss 20–50 mW and maximum operating frequency 500 kc/s are considered.

621.314.7 : 621.3.018.75 **1582**

The Passage of Single and Periodic Current Pulses through a Transistor.—V. G. Kolotilova. (*Zh. tekh.Fiz.*, April 1957, Vol. 27, No. 4, pp. 630–637.) Two cases are considered: (*a*) transistors with earthed base, (*b*) transistors with earthed emitter or collector.

621.314.7 : 621.317.3 **1583**

Measurement of High-Frequency Equivalent-Circuit Parameters of Junction and Surface-Barrier Transistors.—A. R. Molozzi, D. F. Page & A. R. Boothroyd. (*Trans. Inst. Radio Engrs*, April 1957, Vol. ED-4, No. 2, pp. 120–125. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, p. 1163.)

621.314.7 : 621.317.3 **1584**

Measuring Transistor 'Power Gain' at High Frequencies.—Coffey. (See 1491.)

621.314.7 : 621.396.822 **1585**

Transistor Noise in the Low-Frequency Region.—J. Schubert. (*Arch. elekt. Übertragung*, Aug.–Oct. 1957, Vol. 11, Nos. 8–10, pp. 331–340, 379–385 & 416–423.) The validity of an equivalent circuit based on earlier work [see e.g. 3393 of 1954 (van der Ziel)] is confirmed by measurements of noise characteristics on *p-n-p*-type transistors in the frequency range 86 c/s–100 kc/s. The optimum operating conditions for the minimum noise figure are derived for the earthed-base, earthed-emitter and earthed-collector circuits and the noise parameters of the equivalent noise quadripole of a transistor are given. 23 references.

621.314.7 : 621.396.822 **1586**

Behaviour of Noise Figure in Junction Transistors.—W. N. Coffey. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 495–496.) Noise-figure expressions are modified to include the effect of partial correlation of the emitter and collector noise generators.

621.314.7.002.2 **1587**

Alloy-Diffusion: a Process for Making Diffused-Base Junction Transistors.—J. R. A. Beale. (*Proc. phys. Soc.*, 1st Nov. 1957, Vol. 70, No. 455B, pp. 1087–1089.) In the process described the base width is determined by the difference in the diffusion depths of two impurities and is practically independent of the alloying depth. A reasonably substantial metal contact to the recrystallized emitter is automatically produced. Examples are quoted of the characteristics achieved in a group of transistors obtained using *p*-type Ge and a carrier metal, such as Pb, containing about 1% Sb and 2% Ga.

621.314.7 + 621.385].012.8 **1588**

High-Frequency Parameters of Transistors and Valves.—J. Zawels. (*Electronic Engng*, Jan. 1958, Vol. 30, No. 359, pp. 15–17.) The high-frequency equivalent circuits of junction transistors and valves are developed; the exact open-circuit, short-circuit, and hybrid parameters are tabulated.

621.314.7.012.8 **1589**

Equivalent Circuit of a Transistor Operating at High Frequencies.—I. I. Litvinov. (*Radiotekhnika, Mosk.*, Oct. 1956, Vol. 11, No. 10, pp. 25–29.) Formulae are derived for calculating the parameters of the equivalent circuits which are valid over a wide frequency range. The accuracy of the formulae is confirmed by experiment.

621.383.2.032.217.2 **1590**

Photoelectric Emission of Oxide-Coated Cathodes.—T. Yabumoto & S. Yamada. (*J. phys. Soc. Japan*, Oct. 1957, Vol. 12, No. 10, p. 1163.) A new peak at 4·7 eV was found in the photoelectric emission of Ba-Sr oxide-coated cathodes exposed at room temperature to an oxygen atmosphere at a pressure of 10^{-5}–10^{-6} mm Hg for about five minutes.

621.383.27 **1591**

Spectral Response and Linearity of Photomultipliers.—H. Edels & W. A. Gambling. (*Brit. J. appl. Phys.*, Dec. 1957, Vol. 8, No. 12, pp. 481–482.) Spatial variations in spectral response are shown to change their form with wavelength. With suitably designed circuits, linearity of output with input intensity is achieved for output currents up to at least 10 μA.

621.383.27.032.21 **1592**

Characteristics of the Dark Current of Unfocused Secondary - Electron Multipliers with Cs_3Sb Photocathodes.—F. Eckart. (*Ann. Phys, Lpz.*, 20th Dec. 1956, Vol. 19, Nos. 3–5, pp. 133–144.) The temperature dependence of the thermionic emission of the photocathode was investigated in the temperature range from +20° to +50°C. The work function calculated from this is 1·2 eV which is 0·2 eV less than the photoelectric energy derived from the cut-off frequency of the external photoeffect. See also 930 of 1956.

621.383.4 : 535.371.07 **1593**

Solid - State Image Amplifiers. — G. F. J. Garlick. (*J. sci. Instrum.*, Dec. 1957, Vol. 34, No. 12, pp. 473–479.) The large-area solid-state light amplifier is built up from sintered layers of photoconductor and phosphor, or from layers of microcrystalline material bonded in a suitable resin. A simple device uses a single evaporated phosphor layer. Image conversion may be possible in the infrared up to 6 μ, in the ultraviolet and in the X-ray regions.

621.385.029.6 **1594**

Plug-In Reflex Klystrons for Microwaves.—A. F. Pearce, K. H. Kreuchen, C. Baron, N. Houlding & S. Ratcliffe. (*J. Electronics Control*, Dec. 1957, Vol. 3, No. 6, pp. 535–563.) Plug-in klystrons have the advantages of low replacement cost and improved consistency of characteristics. The design of the cavity is flexible and a smaller number of types is required to cover a wide frequency band. A discussion of the design of plug-in klystrons is included and details are given of the construction and characteristics of two British types: CV2116 for the S band and CV2346 for the X band. Both these have useful performances over the range 2–12 kMc/s.

621.385.029.6 **1595**

Space-Charge Waves along Magnetically Focused Electron Beams.—W. W. Rigrod: J. Labus. (*Proc. Inst. Radio Engrs.*, Jan. 1958, Vol. 46, No. 1, pp. 358–360.) Comment on 2961 of 1957 and author's reply.

621.385.029.6 **1596**

Fabrication of Multicavity Magnetrons.—A. Singh & N. C. Vaidya. (*J. sci. industr. Res.*, April 1957, Vol. 16A, No. 4, pp. 169–175.) Details of techniques and equipment used.

621.385.029.6 **1597**

Design and Performance of a High-Power Pulsed Magnetron.—E. C. Okress, C. H. Gleason, R. A. White & W. R. Hayter. (*Trans. Inst. Radio Engrs*, April 1957, Vol. ED-4, No. 2, pp. 161–171. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, p. 1164.)

621.385.029.6 **1598**

Travelling-Wave-Tube Propagation Constants.—G. R. Brewer & C. K. Birdsall. (*Trans. Inst. Radio Engrs*, April 1957, Vol. ED-4, No. 2, pp. 140–144. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, pp. 1163–1164.)

621.385.029.6 **1599**

Effect of Magnetic Field on Coupled Helix Attenuators.—M. H. Miller, B. Hershenov & J. R. Black. (*J. appl. Phys.*, Nov. 1957, Vol. 28, No. 11, pp. 1363–1364.) In a travelling-wave valve, a considerable variation of attenuation with magnetic field strength was observed, using a trifilar coupling helix wound from 0·002-in. Kanthal wire.

621.385.029.6 **1600**

Backward-Wave-Oscillator Starting Conditions.—R. D. Weglein. (*Trans. Inst. Radio Engrs*, April 1957, Vol. ED-4, No. 2, pp. 177–179. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, p. 1164.)

621.385.029.6 **1601**

Backward-Wave Oscillators for the 8 000–18 000-Megacycle Band.—H. R. Johnson & R. D. Weglein. (*Trans. Inst. Radio Engrs*, April 1957, Vol. ED-4, No. 2, pp. 180–184. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, p. 1164.)

621.385.029.6 **1602**

A High-Power Periodically Focused Travelling-Wave Tube.—O. T. Purl, J. R. Anderson & G. R. Brewer. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 441–448.) The design considerations, construction and performance of an S-band, pulsed, kilowatt-level travelling-wave valve, focused by means of periodic permanent magnets are described. The results of studies on the electron-beam defocusing effect of strong r.f. fields and on the effect of attenuator design on power build-up and saturation level are reported. Factors affecting the design of a high-power travelling-wave valve using periodic magnetic focusing are described in order to show the design constraints imposed by the periodic focusing system.

621.385.029.6 : 537.533 **1603**

Some Characteristics of a Cylindrical Electron Stream in Immersed Flow.—G. R. Brewer. (*Trans. Inst. Radio Engrs*, April 1957, Vol. ED-4, No. 2, pp. 134–140. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, p. 1163.)

621.385.029.6 : 537.533 **1604**

Use of Scanning Slits for Obtaining the Current Distribution in Electron Beams.—K. J. Harker. (*J. appl. Phys.*, Nov. 1957, Vol. 28, No. 11, pp. 1354–1357.) In axially symmetric electron beams, the current density is related to the current through a slit by an integral equation. This equation is solved and a technique for rapid numerical evaluation is given.

621.385.029.6 : 621.372.2 **1605**

Analysis of Coupled-Structure Travelling - Wave Tubes. — N. Rynn. (*Trans. Inst. Radio Engrs*, April 1957, Vol. ED-4, No. 2, pp. 172–177. Abstract, *Proc. Inst. Radio Engrs*, Aug. 1957, Vol. 45, No. 8, p. 1164.)

621.385.029.64 : 537.533 : 621.375.9 **1606**

A Parametric Electron-Beam Amplifier.—T. J. Bridges. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 494–495.) An amplifier similar to the solid-state amplifier proposed by Suhl (3076 of 1957) can be devised using an electron beam instead of the ferrite. Such an amplifier has the possibility of very-low-noise operation since the fundamental limitations of noise performance of conventional microwave amplifiers do not apply. An amplifier has been built and initial experimental results are given.

621.385.029.65 **1607**

Experimental 8-mm Klystron Power Amplifiers.—T. J. Bridges & H. J. Curnow. (*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 430–432.) A c.w. output of 75 W was obtained with operation limited by the maximum current density of 1·5 A/cm² that could be attained with sprayed-oxide cathodes.

621.385.832 : 621.397.621 **1608**

90° Scanning.—Morgan & Martin. (See 1573.)

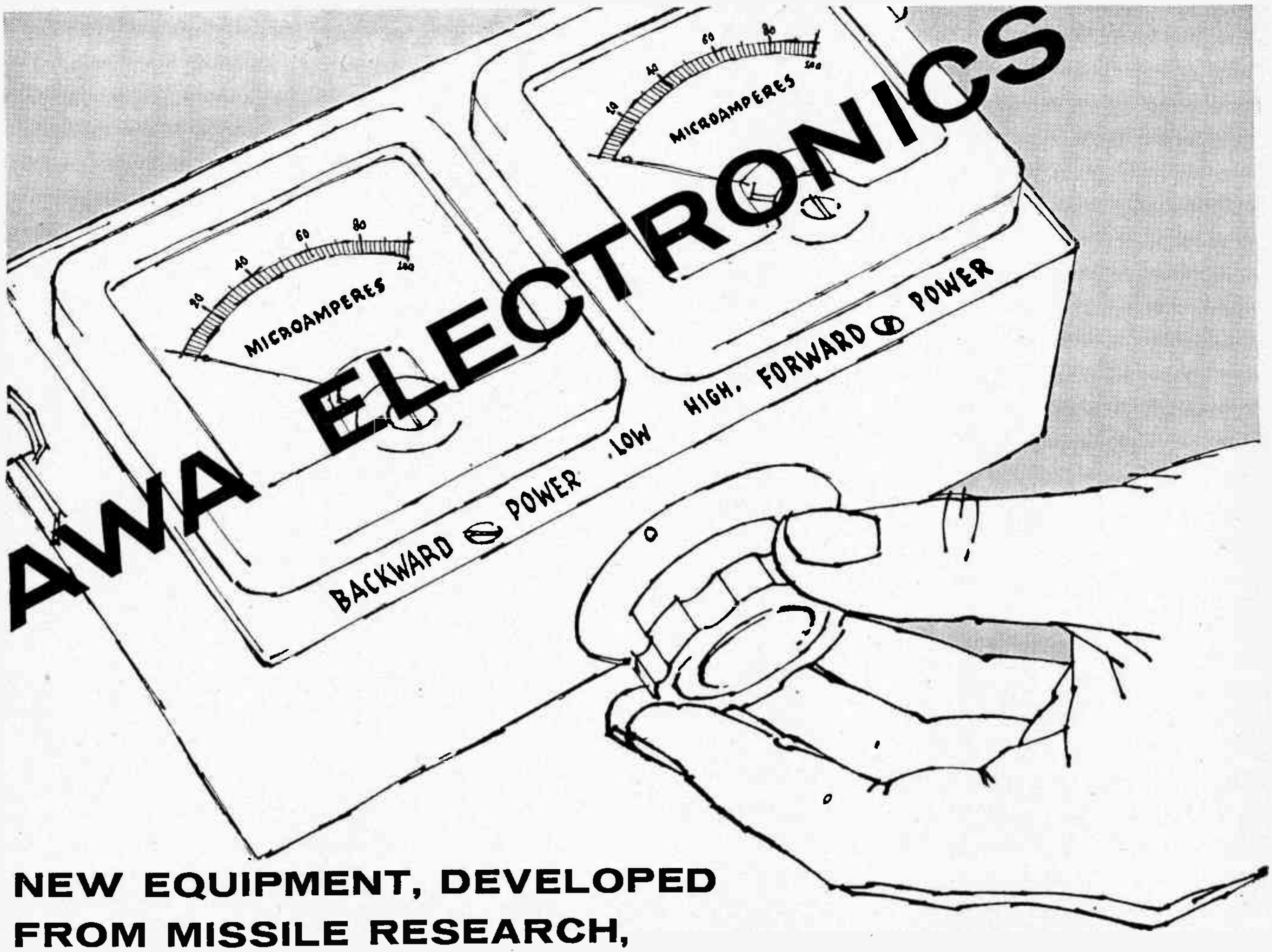
MISCELLANEOUS

061.6 : 621.3 **1609**

Electronics Research Laboratory.—(*Engineer, Lond.*, 25th Oct. 1957, Vol. 204, No. 5309, pp. 604–606.) Review of work carried out at the Mullard Research Laboratories in Surrey, England.

621.3(083.74)(083.86) **1610**

Index to I.R.E. Standards on Definitions of Terms 1942–1957.—(*Proc. Inst. Radio Engrs*, Feb. 1958, Vol. 46, No. 2, pp. 449–476.) Standard 58 I.R.E. 20.S1 containing an alphabetical list of approximately 3 500 technical terms with the code number of the appropriate I.R.E. standard and its date of publication.



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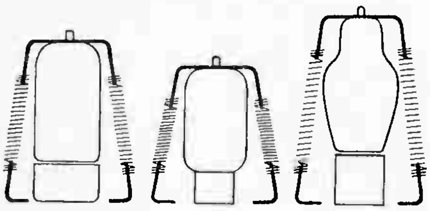

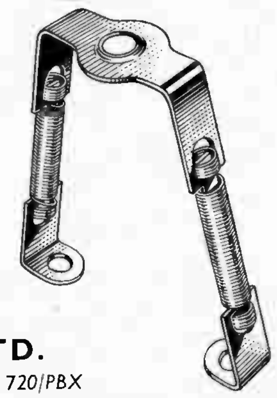

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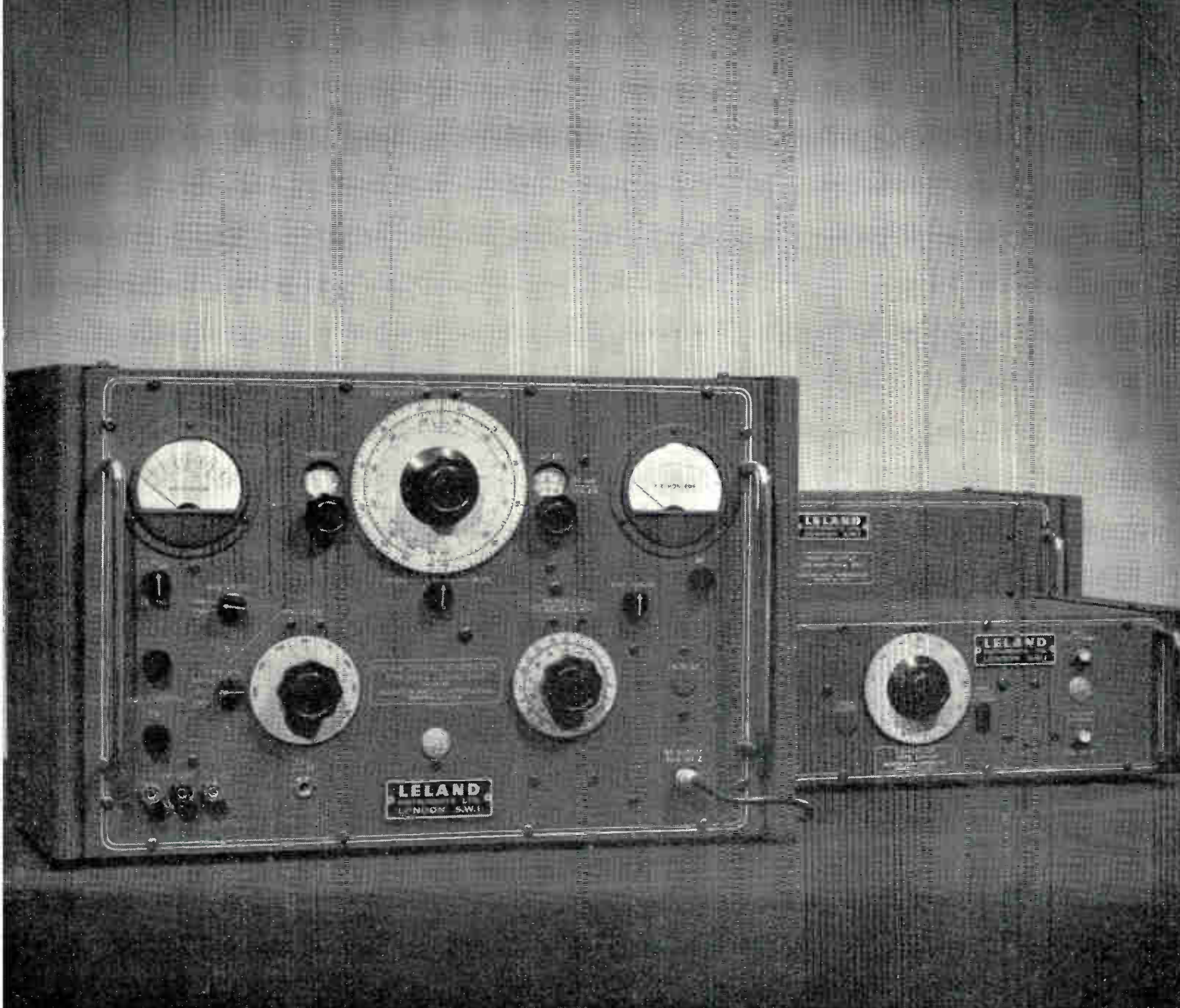
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