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SEPTEMBER 1959 Vol 36 *new series* No 9

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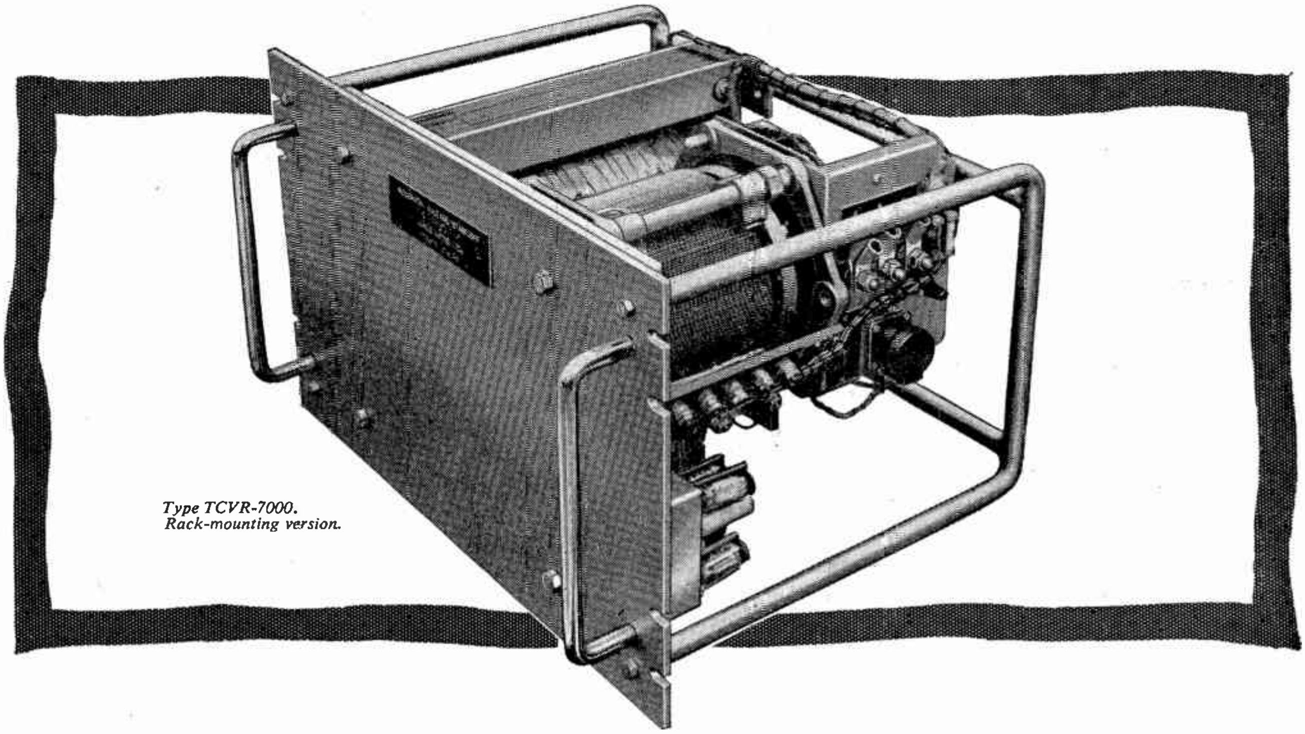

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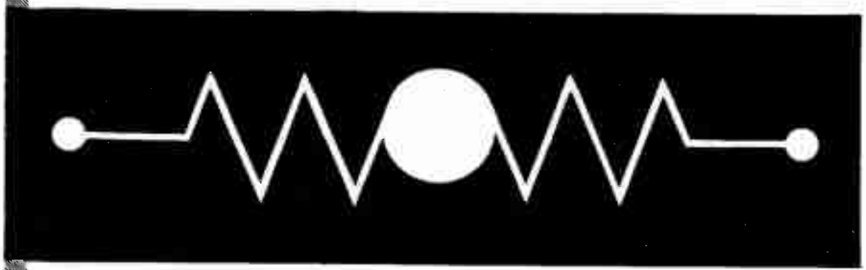

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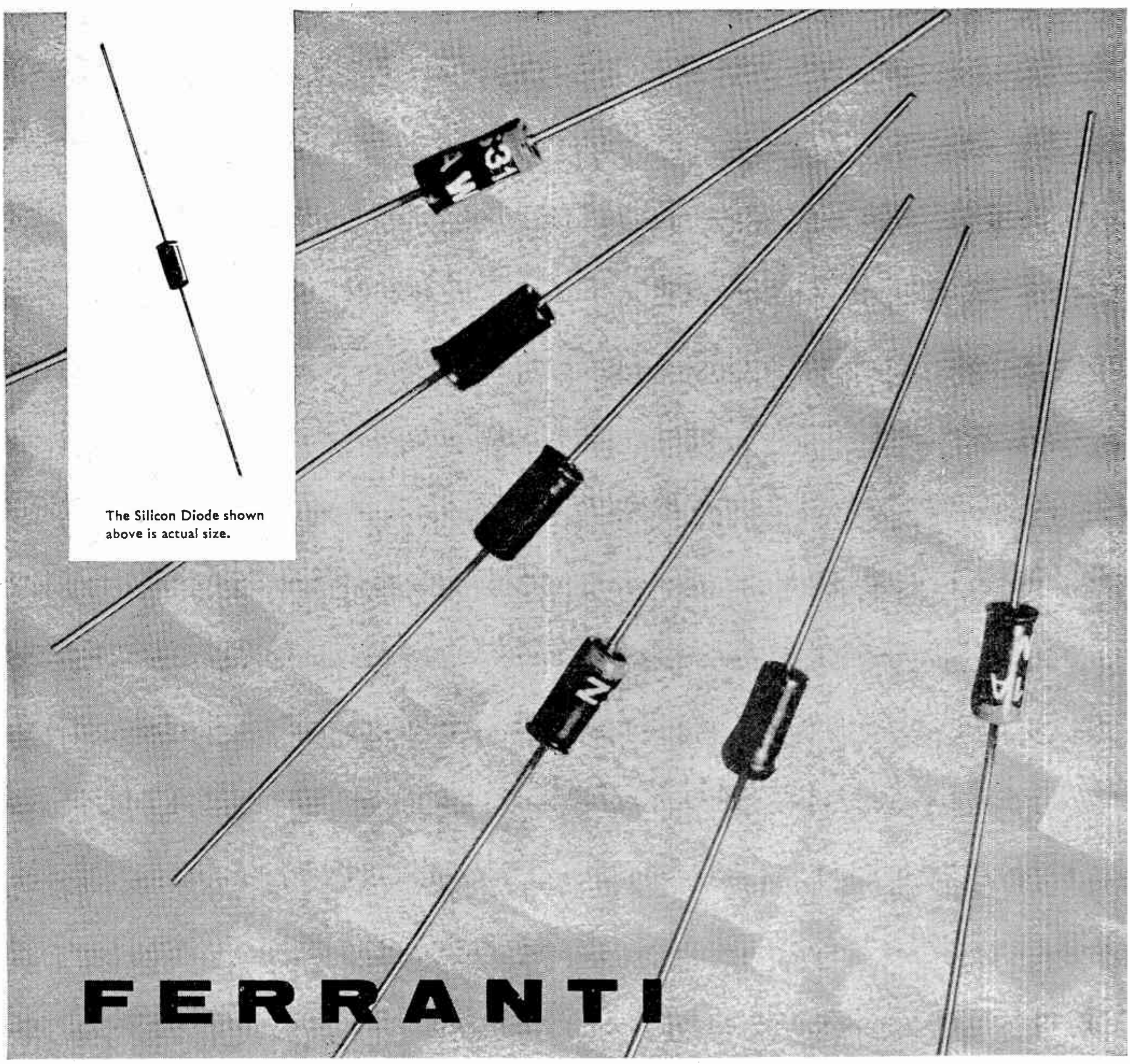

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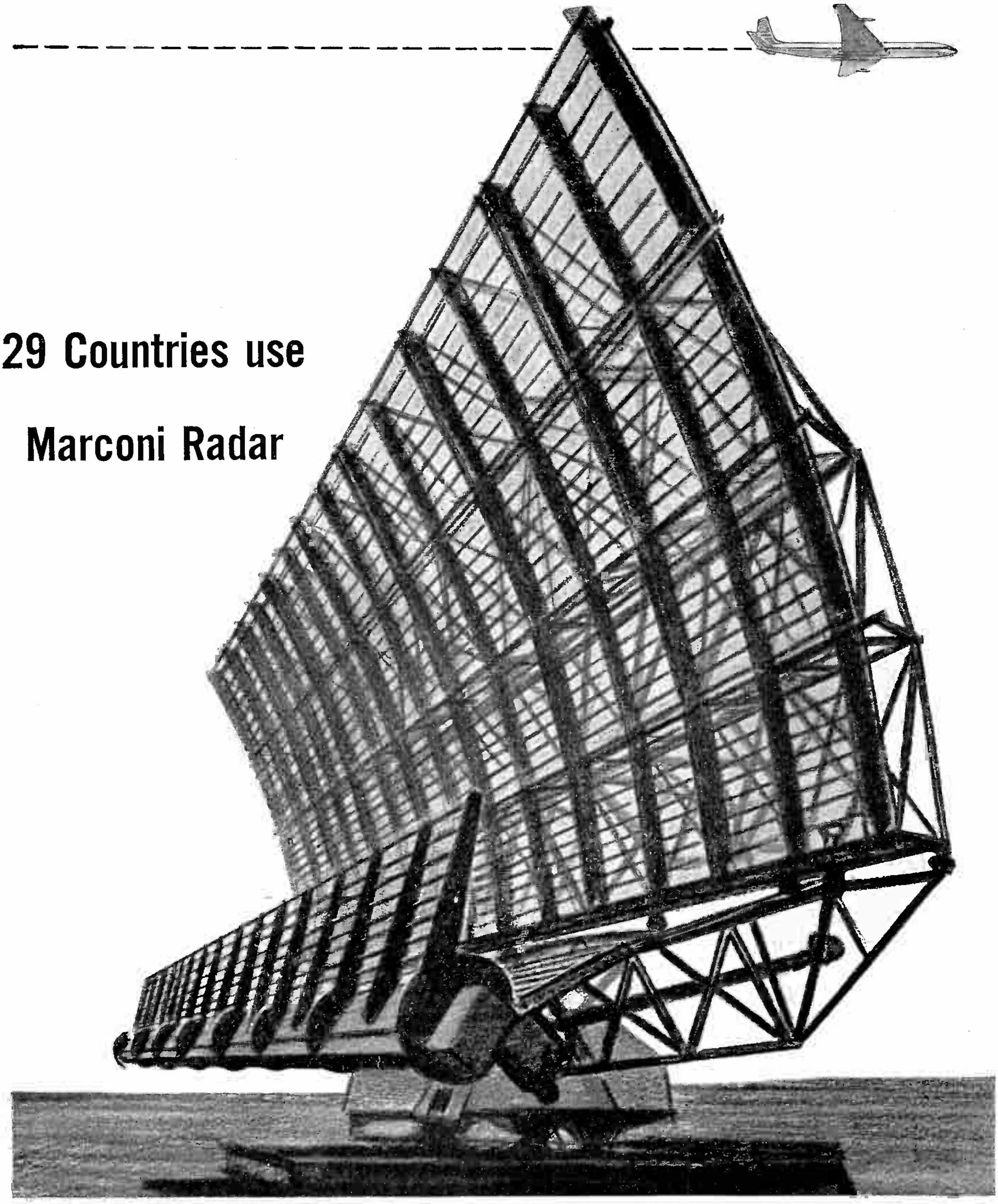

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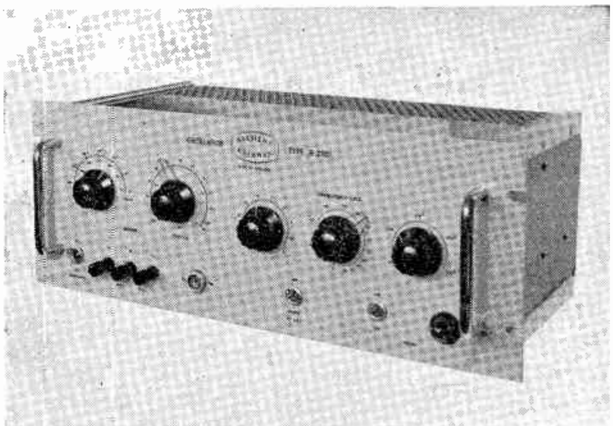

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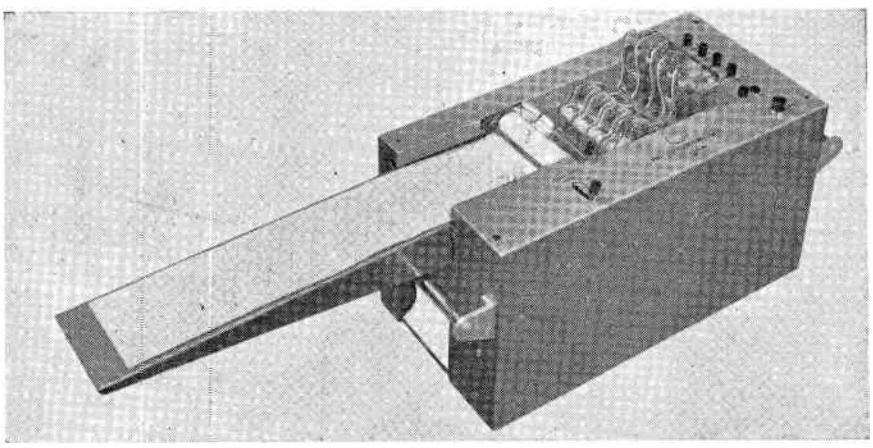

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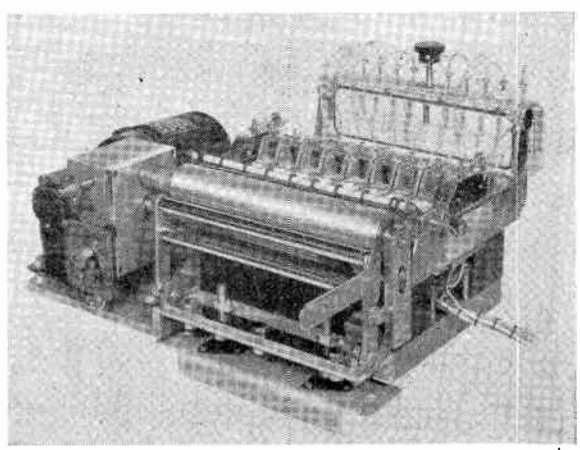
The unit is offered as shown in the photograph and is intended for incorporation into the users own equipment.
A 16 channel version of the above unit is also available.



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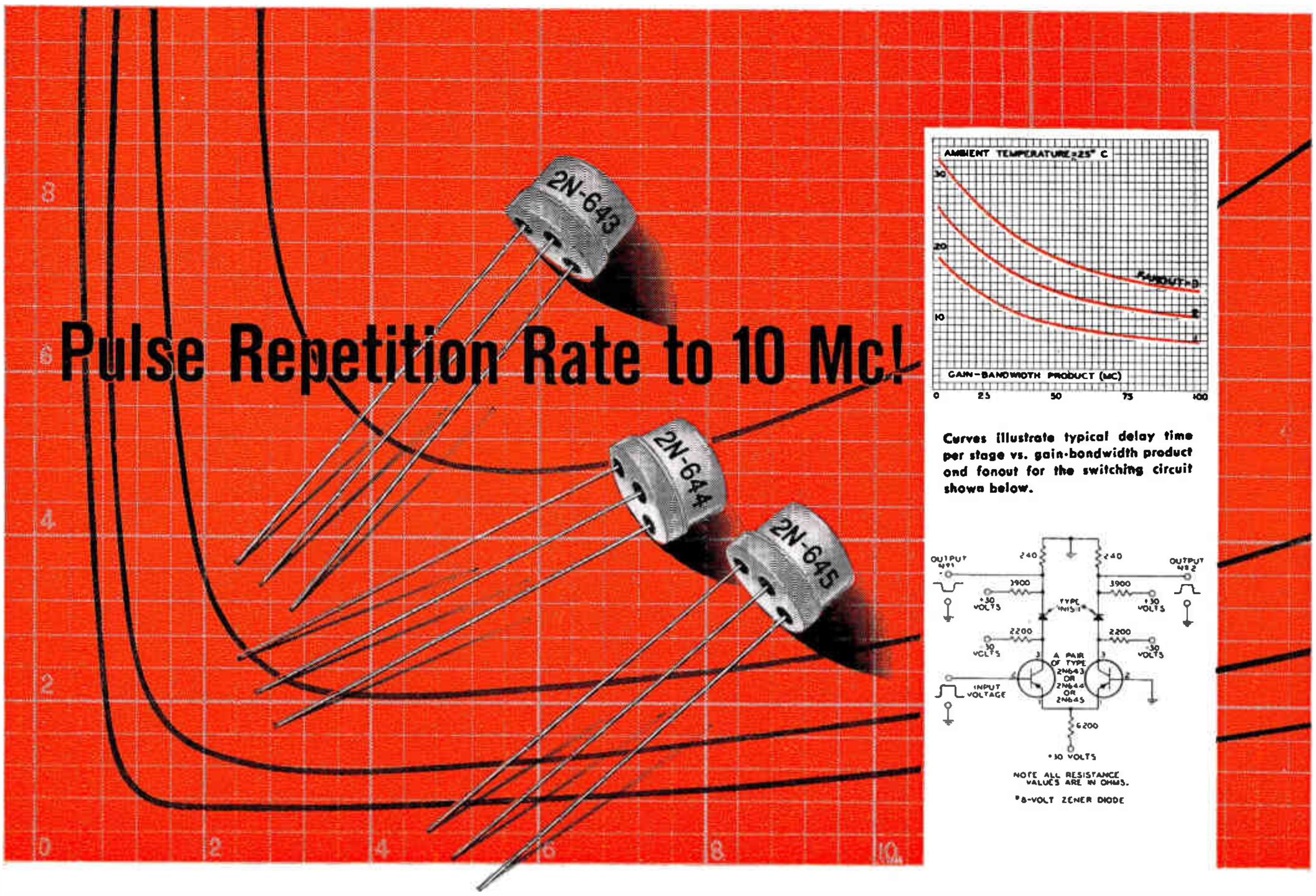

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*Collector Volts = -7, collector ma = -5
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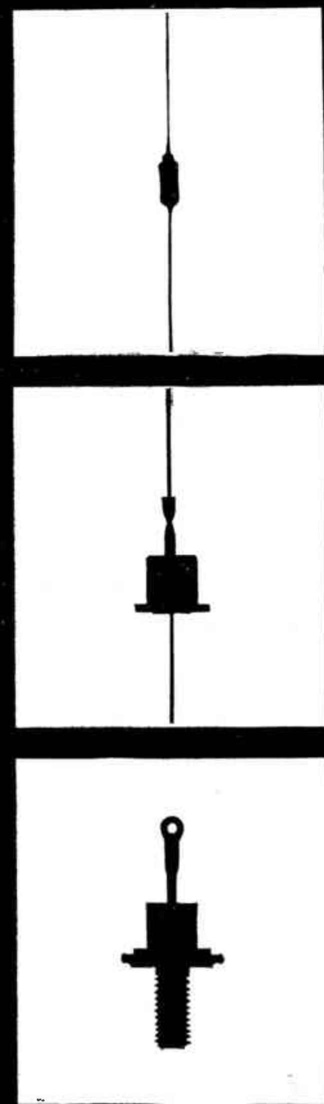

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MAXIMUM RATINGS							
Peak Inverse Voltage at −65°C to +150°C	PIV	200V	600V	200V	600V	200V	600V
Average Rectified Forward Current at +50°C	I_o	750mA	750mA	† 400mA	† 400mA	*3A	*3A
Average Rectified Forward Current at +150°C	I_o	250mA	250mA	150mA	150mA	*1A	*1A
Recurrent Peak Forward Current at +50°C	i_f	† 2·5A	† 2·5A	† 1·25A	† 1·25A	*10A	*10A
Surge Current for 10 Milliseconds	I_{PK}	16A	16A	6A	6A	33A	33A
Operating Temperature, Ambient	T_A	—65°C to +150°C					
SPECIFICATIONS							
Minimum Breakdown Voltage at +150°C	V_z	240V	720V	240V	720V	240V	720V
Maximum Reverse Current at P.I.V. at +25°C	LI_b	10μA	10μA	0·2μA	0·2μA	10μA	10μA
Maximum Forward Voltage Drop at +25°C	E_b	1·0V	1·0V	1·0V	1·0V	1·1V	1·1V
		(I_o=500mA)		(I_o=400mA)		(I_b=1Amp)	

* Rectifier mounted on 2" x 2" x 1/16" aluminium Heat Sink † @ 25°C

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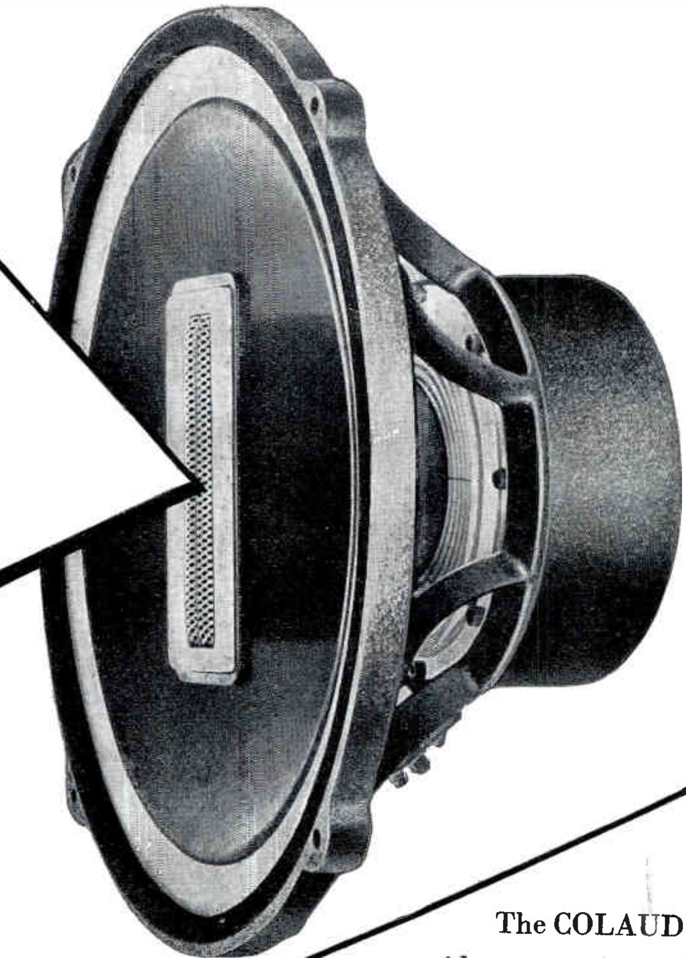

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VOLUME 36 NUMBER 9 SEPTEMBER 1959

Established 1923

Published on the fifth of each month

ANNUAL SUBSCRIPTION
(including Annual Index to Abstracts and References)
Home and Overseas £2 9s 0d Canada and U.S.A. $7.50
Second-class mail privileges authorized at New York, N.Y.

Published by
ILIFFE & SONS LTD. DORSET HOUSE STAMFORD STREET LONDON S.E.1
Telephone · Waterloo 3333 Telegrams · Wirenger, Sedist, London

Branch Offices
COVENTRY · *8-10 Corporation Street–Telephone · Coventry 25210:* BIRMINGHAM · *King Edward House, New Street, 2–Telephone · Midland 7191*
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ELECTRONIC & RADIO ENGINEER

VOLUME 36 NUMBER 9

SEPTEMBER 1959 *incorporating WIRELESS ENGINEER*

Parametron

IN our field, strange new words crop up almost daily and few people will be startled by this one. Some may guess that it is a device operating on the principle of the parametric amplifier, and they will be right.

Basically, the parametron is a resonant circuit in which either the inductance or capacitance varies periodically. When an exciting current of a certain frequency is applied to the inductance, say, an oscillation of one-half the frequency builds up in the circuit and this oscillation has one of two possible phase relations with the exciting current. These two phases can be used to represent 0 or 1 binary digits and so the parametron finds application in computers.

It appears to be widely used in this way in Japan and the parametrons employed have ferrite cores to furnish non-linear inductances. Exciting frequencies up to 6 Mc/s are used. Logical operations can be carried out and binary counters, adders and multipliers obtained without the use of valves or transistors. Even diodes are said to be unnecessary, since limiting effects are obtained by core saturation.

Quite an extensive literature on the subject exists, going back to 1954, and mainly in the *Journal of the Institute of Electrical Communication Engineers of Japan*. A recent article in *Control Engineering* (April 1959) gives a good deal of general information on the subject.

Devices of the type described do not appear to be electronic at all, any more than a magnetic-core memory is electronic. Parametric principles are being applied, however, with the capacitance of junction diodes as non-linear capacitance elements, and these are certainly electronic. It is rather uncertain whether or not these devices should be called parametrons. We ourselves think not and suggest that the term be reserved for non-electronic elements.

Is it being pedantic to point out that parametric, which is actually used in the sense of 'variable parameter', is really quite the wrong word? A parameter is a quantity which is constant in the case being considered, but which may vary in different cases. Inductance, capacitance and resistance are all parameters of a circuit; more strictly, they are parameters in the describing equation. As soon as one of them is made a variable, surely it ceases to be a parameter!

Magnetic Tape Recording

HOW IS TAPE MAGNETIZED?

By L. H. Bedford, C.B.E. M.A.*

In view of the highly developed state of the tape-recording art and of the existence of a number of advanced analytical papers on the subject, the writer has been puzzled for some years by the apparent absence of a clear and convincing account of the basic mechanism of the process. That such is indeed the position is confirmed by the fact that much questioning on the subject has invariably produced a negative answer and, further, by the following quotation from a recent comprehensive account of the subject[1]:

"Three interpretations of the mechanism of h.f. bias have been given. Either through a suspicion of over-simplification or through unavoidable complication none is thought to be completely satisfactory". The writer would go further by saying that all are highly unsatisfactory.

This state of affairs is somewhat surprising in view of the fact that the introduction of the h.f. bias method was the 'break-through' on which the useful development of magnetic recording is based.

The situation is somewhat analogous to that in television in which the break-through occurred with the introduction of the storage camera tube, the Iconoscope, by Zworykin. The mechanism of the Iconoscope, however, proved to be quite different from what Zworykin imagined when he first conceived this epoch-making tube. Similarly, in the case of magnetic recording, the writer suspects that the h.f. bias method was tried out on the basis of a loose or inaccurate theory, and that its immediate success caused practical application to go ahead on an empirical basis, and to hell with the theory.

Some two years ago the writer, in desperation, formulated for his own use a half-baked theory of the recording process. Recently the baking operation has been continued to a stage where, although incomplete, the theory seems to offer a sufficiently coherent picture to be worth presenting. It is accordingly given below but, as the conclusions are rather striking, it may be desirable to state these in advance:

* English Electric Aviation Ltd.

Conclusions

1. What is fundamentally written on the tape is a distorted version of the *bias waveform*, consisting of alternately polarized quarter-cycles of *constant magnetization* separated by quarter-cycles of transition.
2. In the case of saturation bias, a possible but unusual condition, the *signal* is written as a variation of the mark : space ratio of this distorted bias waveform.
3. In the case of normal bias, the above mechanism also applies, but to it is added a variation in the relative magnitudes of opposite quarter cycles of constant magnetization.

Axiom

Recording takes Place at the Trailing Edge of the Recording Gap.

This is to say that the length of the recording gap is not of primary importance; it is possible to write a pattern whose wavelength relative to the length of the recording gap is indefinitely short. This means in particular that the bias frequency is recorded on the tape in toto though subject to attenuation in the permanent record by the mechanism of 'self-demagnetization of short magnets'. [Daniel[2], has shown that this attenuation does not increase indefinitely with reduction of wavelength but reaches a saturation value, which for practical tape constants may amount to about 8 dB.]

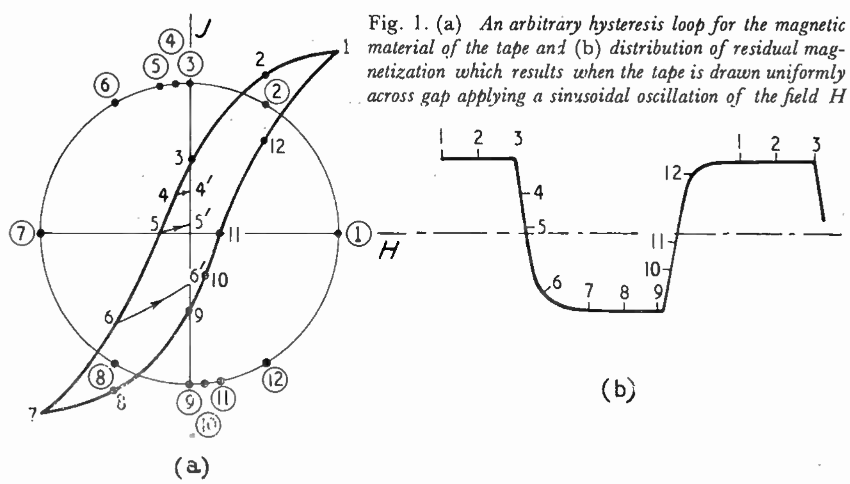

Fig. 1. (a) *An arbitrary hysteresis loop for the magnetic material of the tape and* (b) *distribution of residual magnetization which results when the tape is drawn uniformly across gap applying a sinusoidal oscillation of the field H*

Theory

Fig. 1 (a) represents an arbitrary hysteresis loop for the magnetic material of the tape. It is slightly non-standard in that the ordinate plotted is 'intensity of magnetization' J, rather than the usual 'flux density' B.

Consider now what is the distribution of residual magnetization J_r, which results when the tape is drawn uniformly across a recording gap applying a sinusoidal oscillation of the field H. The frequency of this oscillation is not important, but to fix our ideas let us suppose that this frequency is the bias frequency, whose wavelength on the tape is small compared to the gap length. Then any one element of tape finds itself cycled round the hysteresis loop some finite number of times during its passage through the gap until it arrives at the trailing edge where the field collapses abruptly from its current value to zero. (We here discount fringing effects.)

Points 1–12 have been numbered round the hysteresis loop and we consider the value of J_r corresponding to the collapse of the field to zero from each of these points in turn. Consider the conditions corresponding to point 1, that is to say the state of affairs for an element which arrives at the trailing edge when H is a maximum. The residual condition of the tape thereafter is that corresponding to point 3. The same applies to *any* point 2 intermediate between 1 and 3. It follows that the whole of this quarter cycle writes as *constant intensity of magnetization*, the remanence corresponding to H_{max}.

The next quarter cycle is more difficult to analyse because we do not know to what values of remanent magnetization the points 4, 5 and 6 collapse. They are arbitrarily shown as the points 4′, 5′ and 6′.

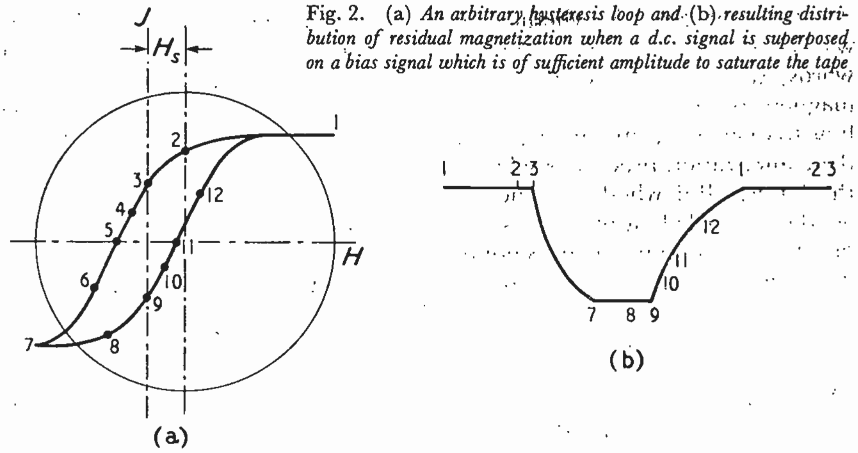

Fig. 2. (a) *An arbitrary hysteresis loop and* (b) *resulting distribution of residual magnetization when a d.c. signal is superposed on a bias signal which is of sufficient amplitude to saturate the tape*

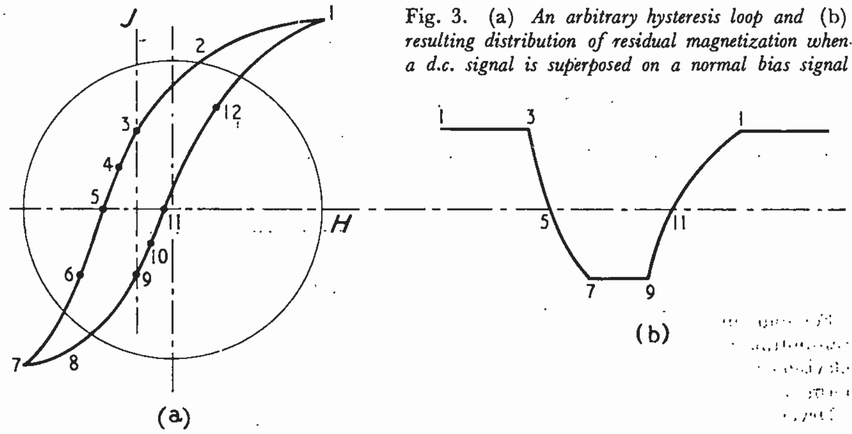

Fig. 3. (a) *An arbitrary hysteresis loop and* (b) *resulting distribution of residual magnetization when a d.c. signal is superposed on a normal bias signal*

The following two quarter cycles are repeats of the above in mirror image.

This figure allows us to plot the distribution of residual magnetization. For clarity, we introduce a circle whose radius describes H in vector fashion, and points (1) to (12) on the circle correspond to points 1 to 12 on the hysteresis loop. The distribution pattern then follows as Fig. 1(b). [The careful drawing out of this waveform is recommended as far more instructive than any amount of reading!]

As already remarked, the frequency is not of primary importance. If we regard it as signal frequency then the nature of the distortion revealed by Fig. 1(b) would indicate the uselessness of any attempt at direct (unbiased) recording. Note that the main feature of this distortion, namely the quarter-cycle flats, is quite unavoidable.

Now turn attention to Fig. 2, in which we regard the oscillation of H as occurring at bias frequency, and consider the effect of superposing a *signal* of relatively low amplitude and frequency—in fact we consider a d.c. signal. To simplify the discussion, and also to bring out the point that this is a perfectly possible mode of operation, we also consider initially the case of saturation bias; i.e., a bias amplitude sufficient to take the tape material well into saturation.

Again, points 1–12 are numbered around the hysteresis loop and again the circle indicates the magnetizing field in vector fashion. The centre of the circle is now off-set from the zero of H by the amount H_s, the d.c. signal field.

Fig. 2(b) plots the resultant distribution of remanent magnetization. Note now that the regions of opposite constant magnetization are now of unequal length. The waveform thus contains a d.c. component of remanent magnetization. Thus it is that the signal is written in a form which is most conveniently described as a variation of mark : space ratio.

Finally, in Fig. 3, we revert to the bias conditions relevant to Fig. 1 and indicate the effect of superposing a d.c. field H_s. It is clear that we now have two effects:

(a) The unequal mark : space ratio as before, and
(b) A difference of magnitude of the opposite values of constant magnetization.

Both effects co-operate to produce a d.c. signal component in the written waveform.

At this stage, it may be well to introduce a distinction between the terms 'written' and 'recorded'. By the former we mean the state of magnetization occurring immediately after the geometrical and magnetic discontinuity at the trailing edge; by the latter, whatever magnetization may finally result after any self-demagnetization has occurred.

It has already been indicated that vanishingly short magnets; e.g., of $\frac{1}{4}$ bias-wavelength, may be expected to decay in magnetization to the extent of some 8 dB.

What is not clear is whether or not the long-signal wavelengths are exempt from such decay; in other words, whether it is legitimate to resolve the written magnetization into a low-frequency component and bias-frequency components, and to consider the demagnetization process as selective to the detriment of the latter. But whether or not the signal components of the recorded waveform survive better than the bias-frequency components is not of ultimate importance since the latter are subsequently lost in the reproducing system in at least two other ways. First they are attenuated by the usual 'aperture effect' of the reproducing gap, which is several bias wavelengths long. Secondly, bias frequencies are well attenuated in the normal audio circuits of the reproducing amplifier.

In a very simplified experimental approach, whose unexpected results gave rise to the above theory, the writer examined the waveform resulting from a low-frequency sinusoidal signal without bias. The immediate and striking observation was that the waveform changed very little *in shape* over a wide range of amplitudes. 'Flats' on the waveform were a prominent feature and these retained a constant proportion of the cycle with increase of amplitude. However, in other respects, the actual waveform differed markedly from what is predicted above. The discrepancy can be explained by assuming a phase error in the reproducing amplifier, this being compensated only for amplitude. Alternatively, the discrepancy may turn on the fact that the recording gap is short compared to the audio wavelength so that the tape elements are not subject to their normal cycling exercise[3].

The above theory is aimed at clarifying the basic process of recording, and does not cover the more subtle points. Further, it has the following shortcomings:

1. Although it renders plausible the linear amplitude characteristic of a biased recording, it does not give a quantitative treatment of this.
2. Fringing effects, which may have serious repercussions, are ignored.
3. It is still not impossible that some minority effect (such for example as fringing) may over-ride the mechanism here described.

If the above theory has any value this may rest less on either novelty or mode of expression than on the fact that it is expressed at all.

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MOTION PICTURE FACSIMILE EQUIPMENT

For some months the B.B.C. has been using a special system for transmitting brief television news-picture sequences and other short television films over a circuit of the transatlantic telephone cable normally used for sound.

Developed by the B.B.C. Engineering Division, the process employs a slow-speed flying-spot film scanner, the video signal from which is used to modulate a carrier for transmission over the cable. At the receiving end the signals are demodulated and used to operate a slow-speed film telerecording equipment.

Transmission is over a normal cable which has a nominal bandwidth of 6·4 kc/s but, in order to limit the variation in the group delay/frequency characteristic to a value which can be corrected, it is necessary to restrict the usable video bandwidth to 4·5 kc/s. It has therefore been necessary to effect as many economies in the bandwidth of the video signal as are compatible with acceptable picture quality. These economies are: restriction of the horizontal definition to that corresponding with a bandwidth of 1·75 Mc/s in the 405-line system; a reduction to 200 lines using sequential scanning, and the scanning at the transmitting end of only alternate film frames with each frame-scan reproduced on two adjacent film frames at the receiving end.

These measures result in reducing the 3-Mc/s bandwidth of the British system to approximately 450 kc/s, the remainder of the bandwidth reduction is obtained by decreasing the scanning speed until the maximum video frequency corresponds with the available 4·5-kc/s upper limit. The time required to scan the film is approximately 100 times the normal and thus a half-minute news flash takes approximately 50 minutes to transmit.

The effective picture repetition frequency of 12½ per second results in satisfactory reproduction of most material excepting that in which rapid movement occurs.

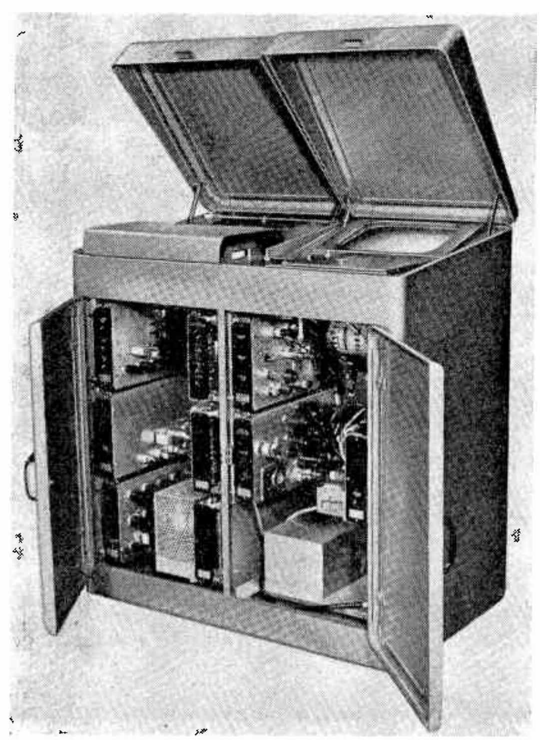
Vestigial-sideband transmission is used with a special form of negative-going amplitude modulation. The carrier frequency is 5 kc/s and the whole of the lower sideband is transmitted, the vestige of the upper sideband extending from 5 kc/s to 5·5 kc/s.

A special form of modulation has been used in which the maximum depth of modulation considerably exceeds 100%. This method results in an increase in the effective depth of modulation and thus also in the signal-to-noise ratio of the system—a necessary improvement, particularly as volume-range compressors and expanders are not used.

In order to achieve the synchronous detection needed, a regenerated carrier at the receiving terminal is used and is locked in phase to the original transmitted carrier.

The full amplitude of the video signal is used for the triggering edge of the synchronizing signal. The full synchronization signal consists of four similar pulses and protection is provided against these pulses interfering with the bursts of reference carrier which are used for oscillator locking.

Film-scanning equipment with doors open to show the electronic apparatus



Linear Amplifier for Decimicrosecond Pulses

By J. F. Golding* and L. G. White*

SUMMARY. *This article deals with a novel linear amplifier for pulse signals where rise times of the order of* 0·1 *microsecond are required into fairly large capacitive loads. The conventional method of amplifying such pulses is by the use of low value anode load resistors or by the application of negative feedback to obtain the required bandwidth. In the system described, the bandwidth is increased by increasing the output power of the amplifier for the duration of the leading and trailing edges of the pulse.*

The conventional methods of designing pulse amplifiers devolve upon the analysis of a step function into its constituent frequency components; the amplifier is then designed to have a frequency response of such a form as to produce minimal degradation of the pulse shape. The aspects of the design of such amplifiers have been dealt with very comprehensively by Brockelsby and others[1,2,3,4]. The amplifier described in this article, however, was devised after considering its action from a rather different viewpoint.

In any amplifier intended for use with pulse waveforms the limit to the steepness of the edges of the output pulse is imposed by the charging time of the output capacitance. This charging time can be reduced by making the source impedance of the amplifier (when regarded as a voltage generator) as low as possible. And this is normally done either by the application of negative feedback or by the reduction of the value of the anode load resistor.

A brief quantitative analysis of the behaviour of a simple amplifier may be illuminating as an introduction to the line of reasoning adopted by the authors. Fig. 1(a) shows a typical pentode output stage with the stray output capacitance C indicated by dotted lines. The equivalent circuit of this amplifier is shown in Fig. 1(b).

The valve is regarded as a constant-current generator in which I is equal to $g_m e_g$. Now, if e_g takes the form of an instantaneous step function, the voltage developed across the load will be equal to RI only after the capacitance C has fully charged; that is to say, when the charging current has dropped to zero. Theoretically, of course, the capacitor takes infinite time to charge completely; but it will charge to a given proportion of the final output voltage in the time t given by

$$t = CR\,.\log_e (I/i_c) \qquad (1)$$

where I is the output current of the valve, i_c is the instantaneous charging current.

If the time of rise is to 90% of the pulse height, time t is given by

$$t = CR \log_e (I/0{\cdot}1I) = 2{\cdot}3026CR \qquad (2)$$

Now, C is determined by the stray capacitance. So, in order to achieve a specified time of rise, R must be adjusted accordingly. If, then, a particular pulse height is required, the necessary current will be given by V/R; where V is the required pulse height.

Apart from the large valve required to handle this current, the total current drawn from the power supply becomes uneconomically high. Furthermore, it can be reasoned from the above argument that the rise time of the output pulse is inversely proportional to the

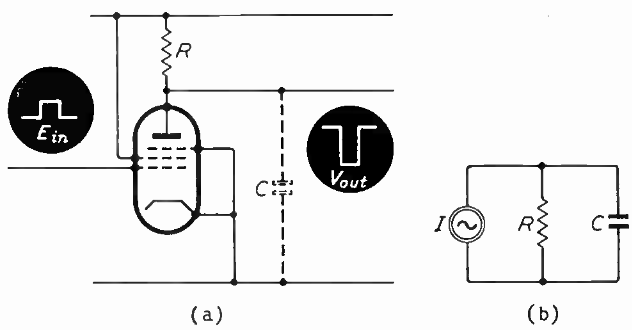


Fig. 1. (a) *Typical pentode output stage*; (b) *equivalent circuit regarding the valve as a constant-current generator having negligible shunt conductance*

available output current from the valve regardless of any conventional means of achieving wide frequency bandwidth, such as negative feedback.

As an example, consider an amplifier for supplying a 100-volt pulse to a capacitive load which, together with circuit strays, amounts to 100 pF. And let us suppose that a rise time of 0·1 μsec. is required.

From (2) we can calculate R.

$$R = t/2{\cdot}3026C = 10^{-7}/(2{\cdot}3026 \times 10^{-10}) = 460\ \Omega.$$

Therefore, for 100 volts pulse height

$$I = 100/460 = 0{\cdot}2176\ \text{A}.$$

If the amplifier is to handle positive and negative-going pulses, the valve must be operated under class A conditions, and this implies a standing anode current of the order of half an amp.

The difficulty can be overcome by the use of a separate valve which supplies the charging current for the output capacitance. Such an arrangement is shown in Fig. 2. Valve V_1 is the pulse amplifier. The total capacitance shunting the output is represented by capacitor C_s, shown dotted. The current in the shunt capacitance is sampled by inserting a low-value resistor in series with part of it. This is done by means of the

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network C_1 and R_1, where the capacitance of C_1 actually forms part of the shunt capacitance. Providing the time constant of this network is small compared with the rise time of the output pulse, the instantaneous voltage across R_1 will be directly proportional to the instantaneous current in the total shunt capacitance.

The differentiated voltage pulse developed across R_1 is amplified and inverted by valve V_2; and the output from the anode of this valve is fed to the grid of a class B amplifier V_3 connected in parallel with V_1.

If, then, a sharp positive-going step voltage is applied to its grid, valve V_1 will immediately begin to draw an increased current, discharging C_s and C_1. The pulse output voltage, however, will not increase—in the negative direction—to its peak until the shunt capacitance has fully discharged. But, due to the amplified differentiated pulse appearing at its grid, valve V_3 will conduct very heavily during the discharge period, giving a very rapid leading edge to the output pulse.

Quantitative Analysis

The circuit shown in Fig. 2 can be represented as that shown in Fig. 3(a). Valve V_1 is a constant-current generator, its output I being equal to $g_m e_g$. The current i_a is equal to the product of the voltage developed across R_1 and the effective mutual conductance of the auxiliary boost amplifier (V_2 and V_3); i.e.,

$$i_a = A \,.\, i_{C1} R_1 \quad \ldots \quad (3)$$

where i_{C1} is the current in capacitor C_1, A is the effective mutual conductance of the auxiliary amplifier; i.e., the current output of V_3 divided by the voltage input to V_2 and

$$i_{C1} = i_{Cs}[C_1/(C_1 + C_s)] \quad \ldots \quad (4)$$

where i_{Cs} is the current flowing in the total shunt capacitance. N.B. The total shunt capacitance includes C_1.

Therefore

$$i_a = i_{Cs}[A \,.\, R_1 \,.\, C_1/(C_1 + C_s)] \quad \ldots \quad (5)$$

For convenience let us call the factor within the large brackets k. So i_a then becomes $k \,.\, i_{Cs}$.

The circuit in Fig. 3(a) is, in turn, equivalent to that shown in Fig. 3(b). If the input voltage to the grid of V_1 is assumed to be an instantaneous step function, we can say that I is equal to V/R_L, where V is the height of the output pulse.

It will readily be appreciated that ideally k should be equal to unity. For, if this is so, the whole of the charging current will be supplied by the boost amplifier (V_2 and V_3) so that the pulse output voltage rises instantaneously with the input voltage. This is, of course, not a practical possibility; but it is interesting to analyse the action of the circuit in order to assess how nearly the ideal condition can be approached.

The current in R_L is given by the expression

$$i_R = I + k \,.\, i_C - i_C = I + i_C(k-1) \quad \ldots \quad (6)$$

where i_R is the current in R_L; i_C is the current in C_s.

From basic energy-transfer theory we can derive an expression for the instantaneous voltage as follows:

$$I = i_R + i_C(1-k) = \frac{q}{CR} + \frac{dq}{dt}(1-k)$$

where q is the charge in C_s.

This can be rewritten

$$\frac{dq}{q - CRI} = \frac{dt}{CR(1-k)}$$

Integrating both sides,

$$\log_e(q - CRI) = \frac{-t}{CR(1-k)} + K$$

where K is the constant of integration.

To evaluate K, take the condition when $t = 0$; then q also equals 0.

Therefore

$$K = \log_e(-CRI)$$

so that

$$(q - CRI)/-CRI = e^{-t/CR(1-k)}$$

This can be rewritten

$$1 - (q/CRI) = e^{-t/CR(1-k)}$$

But RI is the pulse height V; and q/C is the instantaneous voltage v.

Therefore

$$v = V\,[1 - e^{-t/C_sR_L(1-k)}] \quad \ldots \quad (7)$$

It would appear from the above that, if $k = 1$, the voltage across R_L will be equal to the pulse height and independent of time. So long as k is less than unity the circuit will remain stable; but, if k is allowed to exceed unity, the factor within the large brackets becomes negative and the circuit will tend to ring. Taken to extremes, of course, if the gain of V_2 and V_3 is increased sufficiently the circuit will oscillate.

It must be remembered, however, that the derivation of expression (7) is based upon the assumption that the time constant C_1R_1 is negligible. This approximation simplified the reasoning and is virtually true for most practical pulses. But it is obvious that it is not possible to make v equal to V unconditionally. To establish the ultimate limitations it is necessary to take all the circuit parameters into consideration. This may not be entirely possible because it is difficult to account for all the stray impedances. Nevertheless, a close approximation can be made because by far the most important limitation is due

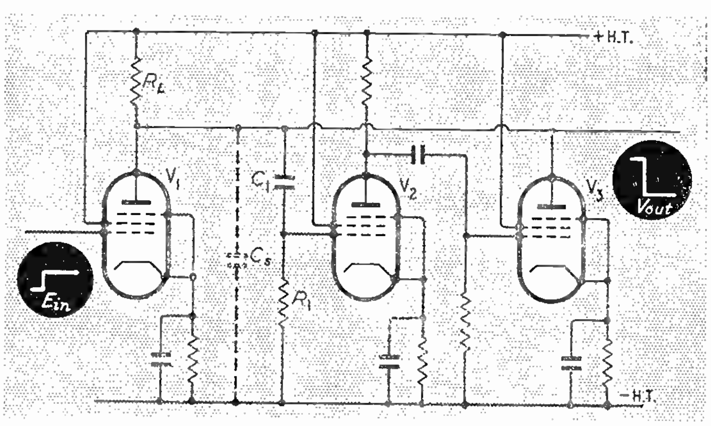

Fig. 2. *Basic arrangement of auxiliary boost circuit*

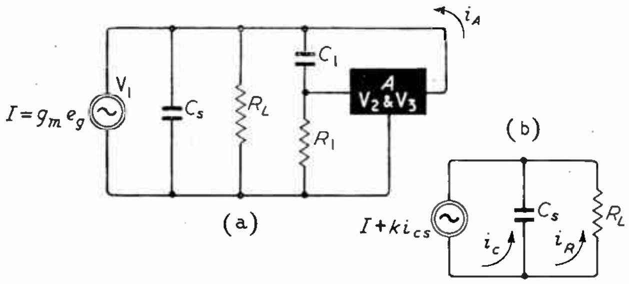

Fig. 3. *Equivalent circuits of Fig.* 2

to the time constant C_1R_1; and, if this parameter is taken into account, it can be shown that the fastest rise time obtainable is given by the expression

$$v = V\left[1 - \left\{1 + (\sqrt{x} - 1)\,\frac{t}{T}\right\} e^{\frac{-t\sqrt{x}}{T}}\right] \quad .. \quad (8)$$

where x is C_sR_L/C_1R_1; T is C_sR_L

It can also be shown that the ultimate condition of stability is given by the expression

$$k \leqslant 1 + [C_1R_1/R_L(C_1 + C_s)] \quad .. \quad .. \quad (9)$$

As the time constant C_1R_1 tends to zero so the limiting value of k tends to unity; but, so long as the value of C_1R_1 is not negligible, k can exceed unity slightly without producing instability.

The mathematical derivations of expressions (8) and (9) are given in the appendix to this article.

The Positive-Going Edge of the Output Pulse

The circuit shown in Fig. 2 provides for negligible deterioration of the negative-going edge of the output pulse. It does not, however, operate when the input voltage to the grid of V_1 is a negative-going step. The complete circuit of a system suitable for linear amplification of positive-going and negative-going pulses is shown in Fig. 4.

Two additional valves, V_4 and V_5, form a second boost circuit which provides the charging current for the shunt capacitance during the positive-going output step. The operation of valves V_4 and V_5 is similar to that of V_2 and V_3. Since the second pair of boost valves operates in the reverse direction from the first pair, it is necessary to connect them between the output line and a separate 500-volt h.t. line.

The circuit shown in Fig. 4 is of an experimental amplifier designed to use type EF91 valves. This amplifier was designed to provide a 50-volt output pulse with a rise time and fall time of 0·1 μsec across a capacitive load of the order of 100 pF.

With a 10,000-Ω anode load and an h.t. of 250 V, valve V_1 has a dynamic g_m of 2·5, giving a stage gain of 25. The shunt capacitance having been set artificially at 100 pF, the value 10 pF was chosen for capacitor C_1. Then, if the time constant of the sampling network is to be small compared with 0·1 μsec, a series resistance of the order of 500 Ω can be used for each of the boost circuits, giving an overall time constant of 0·01 μsec. In practice, a pair of 1,000-Ω variable resistors (VR_1 and VR_2) were used.

The figure for k can then be obtained by substituting the constants given above in (5).

Thus

$$k = A\,\frac{5 \times 10^2 \times 10^{-11}}{11 \times 10^{-10}} = 50.A$$

Therefore, if $k = 1$, $A = 0{\cdot}02$.

This means that 1-V input at the grid of V_2 or V_4 must give an anode current of 20 mA in V_3 or V_5. This figure is only about three times the g_m of the valve so that the voltage gain of V_2 and V_4 need only be of the order of 4. This gain is easily achieved with the use of a 1,000-Ω anode load. The stray capacitance shunting the anode loads of V_2 and V_4 should not exceed 10 pF even allowing for wiring strays. This gives a time constant for the anode circuits of these valves of the order of 0·01 μsec so that there will be negligible deterioration of the differentiated pulse if the rise time of 0·1 μsec is adequate.

In order to obtain linear amplification of the pules

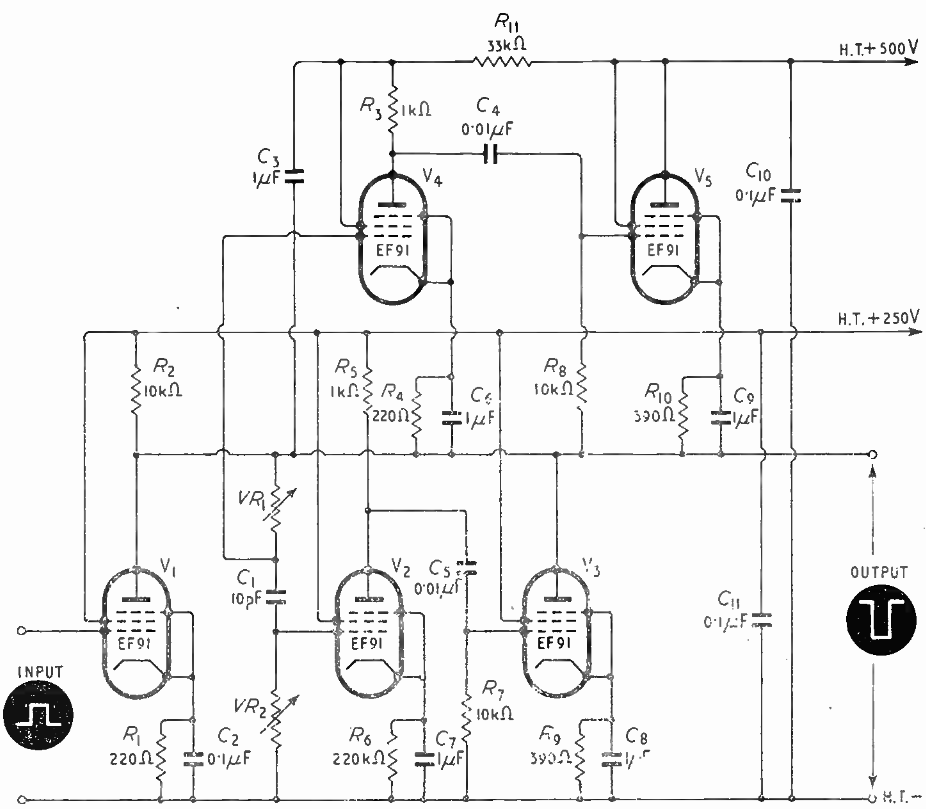

Fig. 4. *Practical circuit of amplifier*

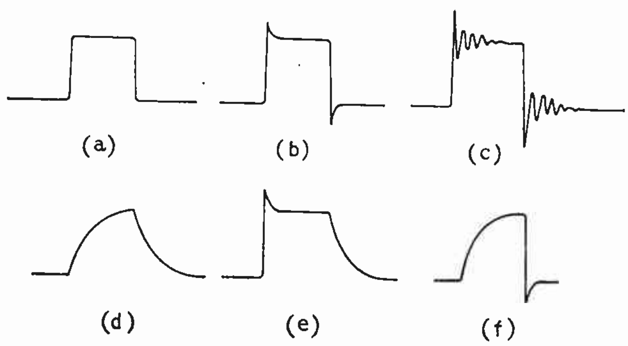

Fig. 5. *Output pulses for various settings of linearity controls for positive output pulse; i.e., negative input pulse.*
(a) *VR_1 and VR_2 correctly adjusted;*
(b) *VR_1 and VR_2 too high;*
(c) *VR_1 and VR_2 very much too high, causing ringing;*
(d) *VR_1 and VR_2 too low;*
(e) *VR_1 too low and VR_2 too high;*
(f) *VR_1 too high and VR_2 too low.*
N.B.—VR_1 controls negative-going edge; VR_2 controls positive-going edge

signals it is, of course, important that the circuit should be so adjusted that k is in fact equal to unity. This adjustment is made by means of the variable resistors VR_1 and VR_2. These resistors control the voltages applied to the respective boost circuits, and thus they control the effective gain of each of these circuits.

The amplifier is set up by empirical means. A pulse signal having a rise and fall time of less than 0·1 μsec is fed to the grid of V_1. The output pulse is monitored by means of a suitable cathode-ray oscilloscope. With the desired capacitive load connected, variable resistors VR_1 and VR_2 are adjusted for the sharpest obtainable output pulse with no overshoot on the leading and trailing edges. Overshoot indicates that k is greater than unity. Fig. 5 indicates the forms of oscillograms of the output pulse for various settings of the variable controls. It will be found that the settings of the controls are interdependent, and that it is necessary to adjust both controls simultaneously.

If the value of k is adjusted to exceed unity by an appreciable amount, the circuit becomes unstable. This instability takes the form of damped oscillation superimposed upon the pulse or upon the baseline following the pulse.

The EF91 is not by any means the ideal valve for this purpose; it was used because it was the most suitable valve available to the authors when the experimental amplifier was constructed. The maximum instantaneous cathode current of this valve is of the order of only 300 mA. With a valve such as the 6F17, which is specially designed for exceedingly heavy instantaneous currents, a very high standard of performance should be obtainable with large capacitive loads.

Conclusion

The circuit described has several advantages over the conventional feedback type of amplifier. The most important of these is probably the fact that both positive-going and negative-going transients are amplified by driving a valve into conduction.

When a positive-going step voltage is applied to the grid of a feedback amplifier, the valve will conduct very heavily due to absence or reduction of feedback during the transient period. But, when the negative-going step is applied to the grid, the anode current will be reduced—perhaps to cut-off—and the stray capacitance will charge through the load resistance at a rate determined by the time constant C_sR_L. This means, of course, that R_L must be a comparatively low value to produce a steep edge with the result that the standing current of the feedback amplifier will probably be very little different from that of the simple amplifier in Fig. 1. For, even if the amplifier is required for positive-going input pulses only, it cannot be run fully in class B; it would be driven beyond cut-off during the negative-going trailing edge of the pulse.

To the best of the authors' knowledge, the system devised, using a boost amplifier to provide the charging current for the stray capacitance, is original. The system is perhaps related to the shunt-regulated amplifier devised by Cooper[5,6], in which a boost valve is connected in series or in parallel with the output valve in order to compensate for a load which varied with voltage applied to it.

Also, the method of sampling the charging by means of a small RC circuit in parallel with the stray capacitance is not unlike the system used by Gouriet[7] for compensating for frequency distortion in a transmitted signal.

APPENDIX

Mathematical Analysis of the Amplifier

Referring to Fig. 3(a), let i_{cs} be the current in C_s, let i_r be the current in R_L, and let i_c be the current in C_1 and R_1.

Then

$$g_m e_g + AR_1 i_{c1} = i_r + i_{cs} + i_{c1}$$

$$v = i_r R_L = i_{cs}/p_r C_s = i_{c1}(R_1 + 1/pC_1)$$

where v is the instantaneous output voltage; p is the Heaviside operator.

$$\therefore g_m e_g = v\,[1/R_L + pC_s + (1-AR_1)]/(R_1 + 1/pC_1) \qquad (10)$$

Then

$$\frac{v}{e_g} = g_m R_L \frac{p/C_sR_L + 1/C_1R_1C_sR_L}{p^2 + p[1/C_1R_1 + 1/C_sR_L + (1-AR_1)/CsR_1] + 1/C_1R_1C_sR_L} \qquad (11)$$

Let $C_sR_L/C_1R_1 = x$

and $\quad C_sR_L = T$

So that

$$\frac{v}{e_s} = g_m R_L \frac{p/T + x/T^2}{p^2 + \dfrac{p}{T}\left[1 + x + \dfrac{R_L}{R_1}(1 - AR_1)\right] + \dfrac{x}{T^2}} \qquad (12)$$

$$= g_m R_L \frac{p/T + \omega_0^2}{p^2 + 2\alpha p + \omega_0^2} \qquad (13)$$

This is a standard form which is readily interpretable as a time function by means of a table of Heaviside transforms. There are three solutions, depending on the relative values of α and ω_0. The condition for stability is that both roots of the denominator must be negative and real or have negative real parts. The roots are:

$$p_1, p_2 = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2} \qquad \text{if } \alpha^2 > \omega_0^2$$

$$p_1, p_2 = -\alpha \pm j\sqrt{\omega_0^2 - \alpha^2} \qquad \text{if } \alpha^2 < \omega_0^2$$

In both cases stability demands that α be a positive number, and this requires

$$1 + x + \frac{R_L}{R_1} > AR_L \qquad (14)$$

If α^2 is less than ω_0^2 the step response will be oscillatory. In order to avoid this α^2 must be equal to or greater than ω_0^2. For circuits having this form of characteristic equation, the fastest rise time for a non-oscillatory response is obtained with $\alpha^2 = \omega_0^2$. For this condition

$$\frac{v}{e_g} = g_m R \left[\frac{t}{T} e^{-\alpha t} + 1 - (1 + \alpha t)\, e^{-\alpha t}\right]$$
$$= g_m R\,[1 - \{1 + (\alpha - 1/T)t\}\, e^{-\alpha t}] \qquad \ldots \quad (15)$$

Since $\alpha^2 = \omega_0^2$, we can write $\alpha = \sqrt{x}/T$; so that

$$\frac{v}{e_g} = g_m R_L \left[1 - \left\{1 + (\sqrt{x} - 1)\frac{t}{T}\right\} e^{-\sqrt{x}t/T}\right]$$

The condition for $\alpha^2 = \omega_0^2$ amounts to

$$\left|\frac{\sqrt{x}}{T}\right| = \left|\frac{1}{2T}\left[1 + x + \frac{R_L}{R_1}(1 - AR_1)\right]\right|$$

or $2\sqrt{x} = 1 + x + \dfrac{R_L}{R_1}(1 - AR_1)$

$$\therefore\ 0 = (1 - \sqrt{x})^2 + \frac{R_L}{R_1}(1 - AR_1)$$

or $AR_L = \dfrac{R_L}{R_1} + (1 - \sqrt{x})^2 \qquad \ldots \quad (16)$

From (14) we can find the limiting value of k for stability.

$$k = AR_1 \cdot \frac{C_1}{C_1 + C_s} = AR_L \cdot \frac{R_1/R_L}{1 + C_s/C_1}$$

But stability demands

$$AR_L \not> 1 + x + \frac{R_1}{R_L}$$

So the limiting value of k

$$= \left[1 + x + \frac{R_L}{R_1}\right] \cdot \frac{R_1/R_L}{1 + C_s/C_1}$$
$$= 1 + C_1R_1/R_L(C_1 + C_s) \qquad \ldots \quad (17)$$

However, the limiting condition for a non-oscillatory step response is given in (16), and this can be interpreted as a lower value of k as follows:—

$$k < \left[\frac{R_L}{R_1} + (1 - \sqrt{x})^2\right] \cdot \frac{R_1/R_L}{1 + C_s/C_1}$$
$$= \left[\frac{R_L}{R_1} + 1 - \frac{2\sqrt{C_sR_L}}{\sqrt{C_1R_1}} + \frac{C_sR_L}{C_1R_1}\right] \cdot \frac{C_1R_1}{R_L(C_1 + C_s)}$$
$$= 1 + \frac{C_1R_1 - 2\sqrt{C_1R_1C_sR_L}}{R_L(C_1 + C_s)} \qquad \ldots \quad (18)$$

It is evident that the limiting values of k as determined in (17) and (18) tend to unity as the time constant C_1R_1 tends to zero. But, whereas the limiting value for circuit stability exceeds unity when C_1R_1 is not negligible, the limiting value for a non-oscillatory step response is slightly less than unity for values of C_1R_1 less than C_sR_L.

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ELECTROCHEMICAL RELAY

A recent discovery by Stanford R. Ovshinsky of Ovitron Corporation, U.S.A., promises a new and interesting control component—the electrochemical relay.

It comprises two large electrodes immersed in an electrolyte and a third central control electrode. Initially, the a.c. resistance between the two large electrodes is high but, when a direct current is passed through the control electrode, it falls to a very low value. When the direct control current is interrupted, the relay reverts to its initial condition.

The schematic diagram of Fig. 1 shows the necessary circuitry for the on/off mode of operation and the component parts of the relay. The relay chamber contains a solution of acid and free ions, immersed in which are the load electrodes which are made of a film-forming material such as tantalum. The control electrode is an acid-resistant platinum rod, located half-way between the load electrodes. The large electrodes are connected to the load and the a.c. supply in series. Two rectifiers are connected back to back to the large electrodes to provide the d.c. bias for the control electrode. With the switch S_1 open there is no energizing voltage applied to the control electrode and, therefore, the relay is 'open' and presents a high resistance between its load terminals.

With S_1 closed, the control electrode becomes positive with respect to the load electrodes and the resistance between the main electrodes falls to a low value. The alternating current then depends mainly on the magnitude of the load resistance.

One prototype model is completely sealed in an inert plastic case measuring 1·5 in. high by 1·5 in. diameter, with a plug-in base termination. It has a contacts rating of 4 A, 70 V r.m.s. The peak voltage that can be handled is 140 V; if the supply voltage exceeds this, the electrolyte conducts regardless of whether or not the control electrode is energized. The minimum supply voltage is 3 V.

Typically, with an applied voltage of 30 V a.c. and a load resistance of 65 Ω, the alternating load current is 450 mA and the direct control current 18 mA. The load current remains a true sine wave and is apparently unaffected by passage through the electrolyte. When the relay is energized and current is flowing, the

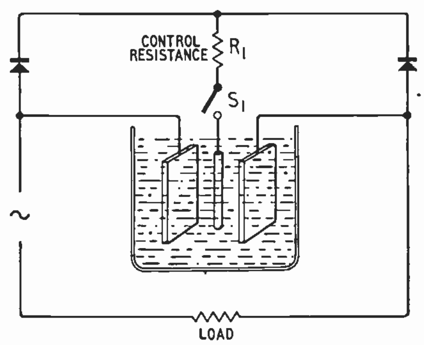


Fig. 1. *Construction of electrochemical relay and circuitry for on/off mode of operation*

impedance between the electrodes is approximately 2 Ω. At the instant of make the impedance is higher but it stabilizes at a constant value after a short time.

The impedance changes slightly with variations of load current, but this characteristic is less marked for high values of load current.

The load current varies with the magnitude of its control current. In consequence, the electrochemical unit will function not only as a relay but also as a power-modulating device. The design of a given relay can be modified to provide any one of a wide range of ratios between the load current and control current; at present, typical values range from 10 : 1 to 50 : 1 and, as would appear logical, the speed of response is greater at the lower ratios.

The speed of response of load current to control current of the electrochemical relay is somewhat similar to the magamp in that the response is definitely related to the frequency of the applied voltage. During tests, the load circuit has been opened within ½ to 3 c/s of the 60-c/s applied voltage. The magnitude of the applied voltage does have a slight effect on the speed of de-energization but varying the load current, within limits, has no measurable effect.

Initial tests of the electrochemical unit show that the rated temperature rise is 50 °C and the operation is relatively stable over ambient temperatures from −10 °C to 150 °C. These tests also show that the units are unaffected by vibration, moisture, mounting position, external electrostatic or electromagnetic fields.

* Based on an article "The Electrochemical Relay: A Remarkable New Switching Form", by John. D. Cooney, *Control Engineering*, July 1959, p. 121.

NEWS FROM NEUTRONS

Some of the matters to be mentioned here recapitulate what was said about strong and weak interactions earlier this year. Be patient about this. It is not an easy sort of subject, and it is something even to get the vocabulary straight. I do not profess to be able to follow the details of the theory of β-decay, but I began to be worried when the mere volume of experimental information about it (or the fraction that has come my way, to be honest) got beyond me to sort out at all. Then a bit of sense broke in, and I realised that I was trying to do things the hard way. For the main principles are, I think, laid bare by some not over-involved experiments on one particle only—the neutron.

Since the article on Glasstone 1958 that appeared in this journal in April, two very good articles on elementary particles have been published. The first of these, "Elementary Particles—the Present Situation", by P. E. Hodgson, appeared in *Science News*, Vol. 52, May 1959. The author concentrates on the experimental side of the production and classification of the thirty-odd named particles. He gives a table of the various modes of formation and decay of the charged and neutral K-mesons; magnificent bubble-chamber pictures of typical events—mentioning incidentally that results are pouring out from the high-energy machines so abundantly that the bottle-neck appears to be in scanning the pictures, for which automatic processes have been devised. He refers to the new conservation laws, and to the new 'strangeness' quantum number attaching to certain hyperons which, so to speak, outlive their welcome, and gives a table of the particles with their spins, isotopic spins, strangeness (where applicable), Q-values for decays, and energies of decay products. But he does not say much about what some of these attributes mean.

The second, a contribution by Prof. D. H. Wilkinson to the most admirable book, "Turning Points in Physics" (North-Holland Publishing Co., 1959), approaches the matter from the other side. His article, "Towards New Concepts—Elementary Particles", explains the ideas that have emerged from the experimental work. He does go very fully into the origin of the terms isotopic spin and strangeness, and also mentions the matters of parity conservation (which amounts to the assumption that space is symmetrical towards events) and time-reversal (which amounts to saying that if we could run time backwards, a process would be expected to happen in the reverse order). The importance of the latter is quite considerable, for the uncertainty principle shows that there are 'holes' in observable time in which virtual processes can occur; if it doesn't behave itself when we are standing over it with a stop-watch, where are we? Fortunately it appears that time does behave symmetrically as far as experiments go; it seems to stand the test of time.

He also explains the difference between strong and weak interactions, a point taken up in the next section of this article. If you take together Mr. Hodgson's account and that of Prof. Wilkinson, you have a good picture of the theoretical and the practical sides, both expressed lucidly in simple terms. For those of you who would look further, there is an article on "The New Particles" by Prof. O. R. Frisch in the June 1959 number of the *Bulletin of the Institute of Physics*, which discusses schemes for correlating slow decay processes and predicting those that might be found. And I should mention also the publication in June of J. Hamilton's book, "The Theory of Elementary Particles" (Clarendon Press: Oxford University Press), which is on the scale of Heitler and Dirac, and which at a first glance I found far too difficult for me. I shall have to try to do my duty by you and get round to this in time if I can. It confirmed my belief that the best way to start on this sort of topic at my level is to take on something relatively simple like a single solitary neutron.

Strong and Weak Interactions

The most familiar particle-particle interaction is the electrostatic action between a proton and an electron. It is also the easiest for the mathematician to handle, as the figure which can be taken to represent its size is $2\pi e^2/hc$, which is the fine-structure constant 1/137 whose square and higher powers can be neglected. Actions between nucleons—n, n; n, p; p,p—appear to be independent of charge, to involve a high energy, to happen very quickly, and to be represented on the same scale by a figure of the order 1 to 10. They are called strong interactions. The third class, of which the β-decays of the π^--meson and the μ^--meson and the neutron are typical, involve very much less energy, take place more slowly in the sense that the excited particle has a relatively long half-life (that of the neutron, for example, is about 10^3 seconds though the

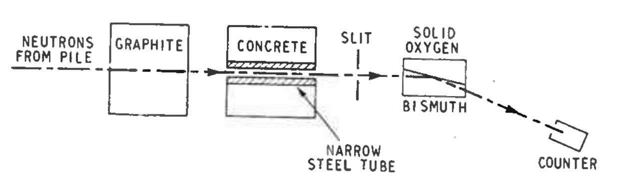


Fig. 1. *Scheme of apparatus used to measure the neutron-electron interaction by determining the relative refractive index between bismuth and liquid oxygen. The critical angle for total internal reflection at the interface enables this refractive index to be calculated, as in simple geometrical optics*

others mentioned come nowhere near this) and are represented by a figure more like 10^{-12}. They are called weak interactions. The Λ° hyperons and other 'strange' particles were given this name originally because their decay releases a great deal of energy, but their half-life is consistent with a weak interaction. Any kind of β-emission, such as that of ^{60}Co, is weak.

Now, once the meson had been introduced as the means by which strong interactions occurred, it was a more or less straightforward task to frame a theory which seemed to fit them. The weak interactions gave, and are giving, all the difficulty. It was realized that they probably involved some hitherto unsuspected principles, or departures from accepted ones.

Strong interactions treat all directions in space alike, and have always been regarded as conforming admirably with the laws of conservation of energy and of angular momentum. Weak interactions did not fit in with these conservation laws, and the suspected reason, namely the neutrino (or antineutrino), was eventually found. Weak interactions do not treat all directions in space alike, or need not necessarily do so. In seeking a reason for this, it may be that the ground shifts somewhat from the properties of particles and the nature of their interactions by means of fields to the properties of space—which may amount, I suppose, to the same thing in the end.

The β-decay of the neutron,

$$n \rightarrow \bar{e} + p + \bar{\nu},$$

which releases about 1 Mev of energy, of which the antineutrino and the recoiling proton take an unpredictable share, is the simplest weak interaction for experimental study.

Optics of Neutrons

The optics of neutrons is a much less geometrical-optics affair than that of electrons. They cannot be focused by electric and magnetic fields, or made to do Newtonian-particle tricks. On the other hand, their Compton or de Broglie wavelength $\lambda = h/mv$ can be altered by moderating their speed, and beams of a homogeneous velocity (monochromatic neutrons) can be obtained by reflecting them at nearly grazing incidence from a crystal. The analogue of the X-ray 'Bragg angle' depends on v (or on λ), so that those coming off in a given direction are monochromatic. Collimation is done, as with X-rays, by using a long thin tube; and, indeed, the whole job is much more like X-ray optics than electron optics.

With this difference, that the neutron's magnetic moment is a major significant property. X-rays are undeviated by a magnetic field, and electrons go round in circles; but neutrons tend to set with their magnetic axes in line with the field (either parallel or antiparallel), and so can be polarized by it.

Study of Weak Interactions

In the classical Lorentz electron theory of optical refraction and dispersion, the electron is considered as an oscillator with a natural frequency which responds as a sort of forced oscillation to the electromagnetic waves; and the refractive index for electromagnetic waves of a given frequency is worked out in terms of the number of electrons per unit volume and the coupling between the oscillators and the waves. For 'waves' read 'neutrons', of wavelength $\lambda = h/mv$ if you like; and for 'forced oscillation' read 'weak interaction between neutrons and electrons'. The picture is then translated into neutron-optics terms. Neutrons passing from a vacuum to a medium should thus be refracted; the refractive index will depend on the extent of the interaction between the neutrons and the electrons in the medium, and on the number of electrons per unit volume. If we know the latter and can measure the refractive index, then the magnitude of the neutron-electron interaction can be calculated.

Things are not so simple really, because the nuclei of the atoms in the medium have their say in things, and scatter the neutron beam. So the refractive index is, in fact, measured by determining the critical angle at a boundary between two solids which have approximately the same scattering effect but widely different electron densities, such as bismuth ($Z = 83$, density 8·9 gm/cc) and solid oxygen ($Z = 8$, density of the order 1·1 gm/cc). The critical angle then gives the relative refractive index between the two media. The apparatus is shown in Fig. 1. It should be noted that this experiment measures the strength of the action between a neutron and an electron, not that of the action of β-decay.

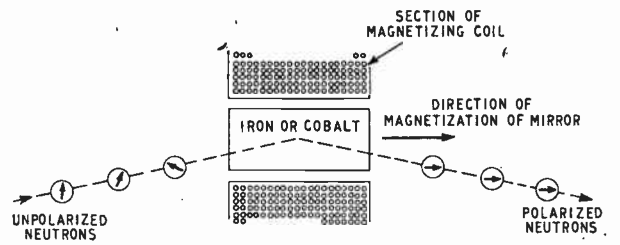


Fig. 2. *Production of polarized neutron beam. The diagram is in a sort of semi-perspective, and the mirror is surrounded by a magnetizing solenoid, and also attached to a yoke (not shown) completing the magnetic circuit. The direction of magnetization is from left to right. Unpolarized neutrons striking the surface at a suitable angle are reflected with their magnetic axes parallel to the direction of magnetization of the mirror*

Polarization of Neutrons

You remember all about Malus and reflection at a dielectric or transparent surface, and the Brewster angle in the production of polarized light. Something rather similar in appearance is done to obtain a polarized beam of neutrons (Fig. 2) by reflection at the surface of a smooth sheet of magnetized iron or cobalt. The magnetic axes of the neutrons are aligned either parallel or antiparallel to the direction of magnetization of the mirror, and we have the same situation as in optics, where we never really get one beam of polarized light, but always two which often conveniently separate themselves. Here it appears that the mirror acts not only like a Malus reflector, but also like a calcite crystal, as the refractive index is different for the two directions of polarization. Total reflection can occur at the surface, but the critical angle is different for the two directions of polarization, and a beam in which one polarization predominates can be obtained by arranging the direction suitably.

With a beam of polarized neutrons undergoing β-decay as they travel, it was possible to see whether this orientation of their axes conferred any preferential direction on their decay products.

Symmetry Properties in the Decay of Polarized Neutrons

This series of experiments was performed by M. T. Burgy and his collaborators at the Argonne National Laboratory, and V. L. Telegdi of the University of Chicago, and published in the *Physical Review*, Vol. 110, p. 1214 (1958). A very narrow vertical-strip beam of slow ('thermal') neutrons with their spins setting horizontally in one direction (or about 87% of them doing so) was obtained by scattering a collimated beam, that had been previously moderated and rendered monochromatic, at a very small grazing angle from a vertical mirror of magnetized cobalt, about 12 cm high by 120 cm long. While the half-life of a neutron is about a quarter of an hour, sufficient individuals decay while traversing a 15-cm length of the evacuated detector chamber (Fig. 3) for the event to be recorded, first by a pulse in the electron detector due to the β-particle, and then after the proper short interval by a pulse in the proton detector. The two together check that this is indeed a genuine β-decay event. With the mirror magnetized one way, the neutron spins were

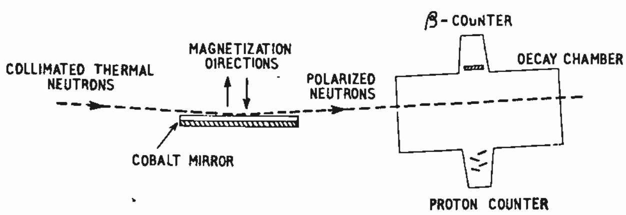


Fig. 3. *Scheme of apparatus for testing symmetry in β-decay, viewed in plan. The cobalt mirror, set vertically, could be magnetized horizontally in either of the directions shown by the arrows, so that the beam of neutrons entering the decay chamber was a thin vertical wafer with the neutron spins setting horizontally in the appropriate arrow direction, pointing either towards or away from the β-counter. The β-counter used a scintillator in conjunction with a photomultiplier, and the proton counter a system of dynodes*

polarized towards the electron detector, while with its magnetization reversed, they were polarized with the spin-axes pointing away from it. It was found that 20% more electrons were emitted in a direction opposite to the spin direction than along the spin direction. In order to check that this was attributable solely to differences in the neutron polarization, each observation was repeated with the neutron beam depolarized by passing it through a very thin steel sheet at the entrance to the chamber.

The foregoing account may be a little misleading, in that it seems to suggest that the electrons had to go one way or the other. The point is, that a symmetrical distribution *might* have been expected, but that there was instead an emission in all directions, but with that against the spin favoured. There is an analogy in the events of the cricket field. You might think that somebody like Lock or Laker would get people dismissed from catches in any part of the field in equal proportions; actually a high proportion of them fall to catches on one particular side due to playing against the spin. Do not think, by the way, that I am implying that cricket is nothing but a form of weak interaction nowadays. It is a noble instrument of instruction, without which no schoolboy would ever believe in Newton's laws of motion, and no true Briton ever be reconciled to the principle of glorious Uncertainty; if it did not exist, it would be necessary to invent it in the interests of physics.

But this analogy runs away with me, and could be pursued to the point of infinite tedium. As compared with football, which is a highly-energetic strong interaction of short half-life (45 min), cricket is indeed a low-energy interaction of long half-life. The various decay modes can usually take anything up to three days, and 'strange' encounters which take an unconscionable long time dying have been observed by many reporters in various Commonwealth centres. Footballers are symmetrical in their play—like Wodehouse's man with two left feet most of the time, and craftily ambidextrous when the referee isn't looking; the cricketer is consistently either left-handed or right-handed. In football, time and space treat both sides more or less impartially; not so in cricket, where one side or the other is usually trying to beat the clock and there is no precedent for any spatial symmetry involving both sides batting at once. And, of course, there is this odd two-component business in cricket; the ball may be accompanied by an anti-particle, the no-ball—which cannot exist until it is detected. The impatient among you may be fidgeting, and murmuring about bats that get stored in belfrys; but I am plodding through the drowsy sun-drenched summer afternoon to the stage at which I intend to declare.

This is the point. Put yourself in the position of an intelligent footballer seeing a cricket match for the first time and trying to interpret it in familiar terms, and you are somewhere near the problem that the theoretical physicist found in weak interactions. The most difficult part is really in absorbing the vast array of apparently unco-ordinated events, and in finding out what the pattern really is. So far as I can understand things, this side is pretty well under control now. Next, to try and find out why it all happens, the sensible footballer would probably seek to isolate the simplest type of interaction, that of a single bowler and batsman at the nets. Once he understood what each was trying to do, he would then have some hope of sorting out the many-body interactions of a full-dress match. And this, of course, is where the neutron experiments come in; they are, to end this analogy for good, a study of weak interactions practising at the nets.

To return to business. In the action $n \rightarrow e + p + \bar{\nu}$, the antineutrino flies off in one direction and the proton recoils in the other. The antineutrino itself cannot be detected, but the recoil proton can and is. Going through the experiment again, but this time noting the relative numbers of protons for the two orientations of the neutron spin, it was found that there is a strong preferential emission of antineutrinos *in* the neutron-spin direction.

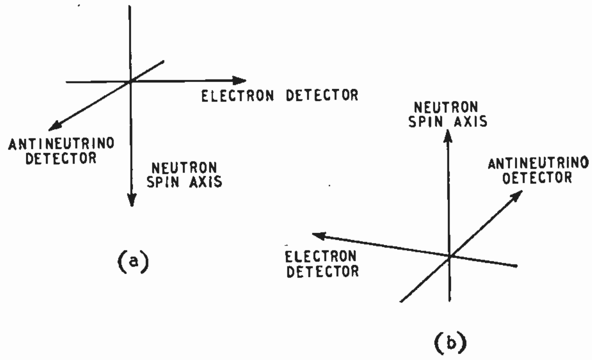


Fig. 4. *Time-reversal simplified*: (a) *the relative directions of antineutrino (or proton) detector and electron detector as we would see them,* (b) *as the same situation would appear to an observer for whom time was running backwards and who sees all the timeable things—the momenta of electron and proton, and the neutron spin, reversed. As can be seen by rotating* (b), *this differs only from* (a) *in that the direction of the neutron spin relative to the other two arrows is reversed. In this experiment, to see whether reversal of the neutron spin affected the counts in the two detectors, they were shifted from the positions of Fig.* 3 *to those shown here*

What symmetry really means in this connection is that a process involving certain spatial directions, and the process obtained by imagining the whole thing reflected in a mirror, should, if symmetry obtained, have the same relations between the relative directions. That is, the same result should be obtained in equations in which x, y, and z are replaced by $-x$, $-y$, and $-z$. The experiments, in showing that symmetry of this kind breaks down in β-decay, help to discriminate between types of equation which might be used to describe the process.

An Experiment with Time

So much for x, y, and z. But what about the fourth co-ordinate, t? Well, there is no question of making time run backwards, but it is possible to forecast the result of putting $-t$ for t in the equations by taking up the view-point of an imaginary observer for whom time was running in reverse. Fig. 4 (a) shows the directions of emission of antineutrino and electron (the proton is omitted) with respect to the neutron spin. A time-inverting observer would meet this as it is, but would *record* this same event with the direction of the spin and of the momenta of the electron and antineutrino reversed. Now, this second point of view is related to the first like the Fleming left-hand motor rule, and the right-hand dynamo rule.

In Fig. 4(a), with your left hand say to yourself, "forefinger electron, second finger neutron-spin, thumb antineutrinos". And apply the same incantation to Fig. 4(b) with your right hand. If you now superpose the forefingers and thumbs of the two hands, you see that this amounts *only to the direction of the neutron spin* being reversed.

Reading, of course, recoil-proton detector for antineutrino detector, it is only necessary to preserve the two directions of these fixed, and to note their respective particle counts for the two opposite orientations of the neutron spin in order to check whether time is operating symmetrically. These experiments showed that it did.

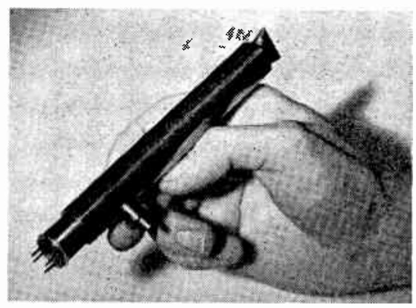
The significance of these results is rather harder to explain. I can only say, as the Burgy-Telegdi paper does, that they help to discriminate between some four possible processes that might account for β-decay. Until the experts can get round to putting things a little more simply, that is about the best that I can do. Meanwhile, it is interesting to reflect that after about twenty years of serving nuclear physics as a piece of furniture rather like your own trusty electron, and after a rather shorter career in nuclear power as (in the words of O. R. Frisch) an industrial commodity to be consumed by the ton, the neutron has been promoted to a post of special responsibility in the attack on the mysteries of weak interactions.

THE OPHITRON

A compact microwave generator embodying a new focusing principle has been developed by the General Electric Co. Ltd.

This valve is an electrostatically focused backward-wave oscillator which has been named the 'Ophitron'. The name is derived from a Greek word meaning a serpent and is suggested by the undulating path of the electron stream flowing along the structure. The main advantages of this oscillator are: small size (6 in. long by $\frac{3}{4}$ in. diameter), low weight (7 oz.) and its simple construction.

A single stamped-out periodic structure and two flat focusing plates form the propagating path for the r.f. wave, and set up the periodic electrostatic field which focuses the electron beam. The system has the fundamental advantage that the crests of the undulating electron beam are brought into the region of the maximum r.f. field. This feature gives good coupling between beam and wave and gives a large bandwidth. The present Ophitron tunes electronically over at least a 40% band in the 10,000-Mc/s region.



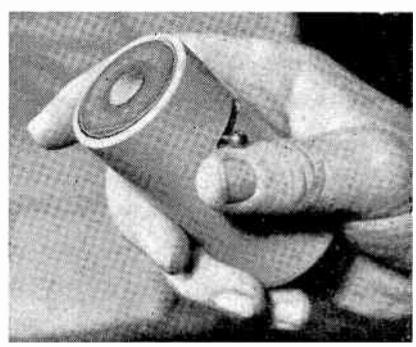
G.E.C. electrostatically-focused backward-wave oscillator

TRANSISTORIZED ARTIFICIAL LARYNX

A new artificial larynx, for persons who have lost their voices through surgical removal (laryngectomy) or paralysis of their vocal cords, has been developed by Bell Telephone of America.

Still in the experimental stage, it is completely self-contained in a unit $3\frac{1}{4}$ in. long by $1\frac{3}{4}$ in. diameter. The underlying principle is a vibrating driver (transducer) which is held against the throat. By means of a finger-operated combination push-to-talk switch and inflection control, the user can control the frequency of the driver and, therefore, the pitch of his artificial voice. Users of this 'larynx' can, with practice, achieve a sentence intelligibility of 97%.

In this unit, two transistors are used in a relaxation oscillator of variable frequency and pulse width. The frequency is variable between 100 to 200 c/s for men and 200 to 400 c/s for women.



The complete artificial larynx showing the combined on/off switch and inflection control

Electromagnetic Wave Problems

A SYNTHETIC APPROACH

By J. D. Lawson*

SUMMARY. *A number of wave problems encountered in physics and electrical engineering are related in ways which may not be immediately apparent. In this article a number of such problems are discussed in such a way as to bring out their common features. First, the plane electromagnetic wave in a loss-free medium is described in some detail; the physical distinction between the normal uniform plane waves and slow or 'inhomogeneous' waves, in which the amplitude varies exponentially in one direction, is emphasized. This is followed by a discussion of some diffraction problems in which the fields may be readily synthesized as a spectrum of plane waves. Cylindrical systems are then introduced by the imaginary operation of 'rolling up' planar systems; thus a corrugated surface guide supporting a slow wave becomes a linear accelerator or a magnetron according to whether it is rolled up in a direction perpendicular or parallel to the corrugations. Radiation from an electron moving in a straight line (Čerenkov radiation) and in a circle (synchrotron radiation) are studied by considering the electron as a δ-function of current which can be resolved by Fourier analysis into a spectrum of sinusoidal currents, each associated with a travelling electromagnetic wave. In this case analogies are drawn with surface waves on wires and with corrugated surfaces rolled up in such a way that the corrugations are on the outside. Also discussed are the properties and limitations of 'super-gain' aerials, and their relation to phenomena associated with the wave-mechanical description of neutron scattering.*

The solution of the time-independent wave equation $\nabla^2 + (2\pi/\lambda)^2 = 0$ has a wide variety of forms, each with its appropriate mathematical description. Sometimes this mathematical description tends to obscure the essential simplicity of the physical situation, and does not reveal features common to a number of systems. A physical description of the field distribution often depends essentially on the topology and scale (the ratio of a characteristic dimension of the system to λ), whereas a mathematical description is very sensitive to the actual geometry. Thus, the difference between the wave propagation in a circular waveguide and a hexagonal waveguide is physically trivial, but a mathematical description of the fields looks very different in the two cases. In this article some common features of topologically similar problems are discussed in terms of physical ideas obtained from the study of the two forms of the simple electromagnetic plane wave in a loss-free medium.

* *Atomic Energy Research Establishment, Harwell.*

The method is descriptive rather than deductive, and the object is merely to show a few underlying physical features common to a number of phenomena which may not appear at first sight to be closely related. Simplifications are made, and intuitive reasoning is sometimes used; it is felt that this is justifiable in an article designed to present familiar ideas in a slightly unorthodox way, rather than to obtain new results. Adequate treatments of the subjects under consideration will be found in the references, which are to articles which are readily available rather than to original sources.

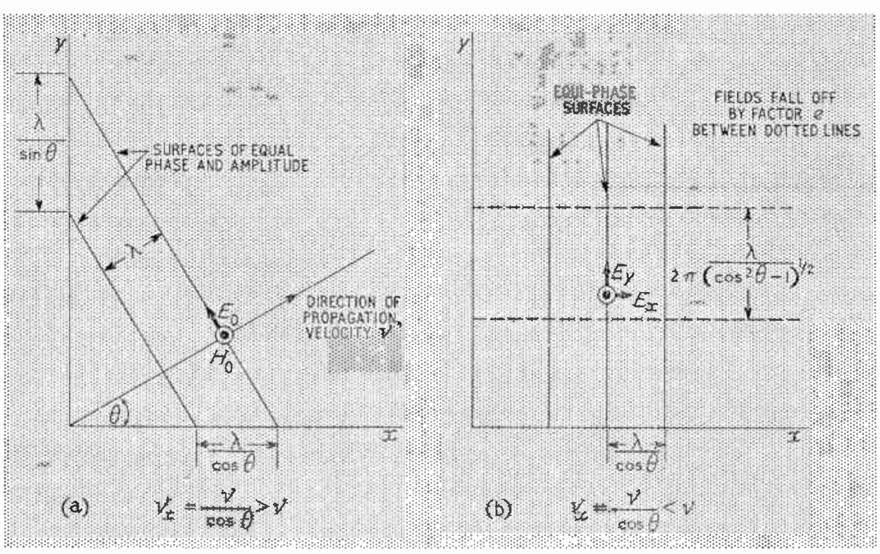


Fig. 1. *Two forms of plane wave in a lossless medium*

Two Forms of Plane-Wave Solution

The plane-wave solution of Maxwell's equations in a lossless medium will now be described. Co-ordinates are chosen such that the magnetic field is in the z direction, then if the direction of propagation of the wave makes an angle θ with the x axis the field components are given by the real part of the expression:

$$\left.\begin{aligned} H_z &= H_0 \exp\{2\pi i(ft - x\cos\theta/\lambda - y\sin\theta/\lambda)\} \\ E_x &= -\ Z_0 H_z \sin\theta \\ E_y &= Z_0 H_z \cos\theta \end{aligned}\right\} \quad .. \quad (1a)$$

Z_0 is the intrinsic impedance of the medium, and the wavelength and frequency are related to the velocity of propagation v by the equation:

$$v = f\lambda \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (2)$$

A diagrammatical representation of such a plane wave is given in Fig. 1(a). It will be seen that the apparent wavelengths measured along the x and y axes are $\lambda/\cos\theta$ and $\lambda/\sin\theta$ respectively. The phase velocity of the disturbance is therefore $v \sec\theta$ along the x axis and $v \operatorname{cosec}\theta$ along the y axis. These velocities vary between v and ∞ as θ varies, so that in such a wave they are always greater than v. This result is quite familiar in the theory of rectangular waveguides in which the simplest mode in a guide of width a consists essentially of two interfering plane waves at angles $\pm \sin^{-1}(\lambda/2a)$ to the direction of propagation.

It is of interest also to consider the impedance of the wave system defined by Equ. (1a). In a wave system referred to cartesian co-ordinates the impedance Z_x measured in the x direction is given by $Z_x = E_y/H_z$, provided that there are no other components of field in the yz plane[1,2]. The significance of this quantity is that it is continuous across boundaries parallel to the yz plane. For the plane wave under consideration, Fig. 1(a), $Z_x = E_y/H_z = Z_0 \cos\theta$. Similarly $Z_y = -E_x/H_z = Z_0 \sin\theta$.

In deriving the solution of the wave equation given in Equ. (1), the only restriction placed on $\cos\theta$ and $\sin\theta$ is that $\cos^2\theta + \sin^2\theta = 1$. It is therefore necessary to investigate solutions in which $\cos\theta$ is greater than unity and $\sin\theta = \pm i(\cos^2\theta - 1)^{\frac{1}{2}}$ is pure imaginary. Writing the solution in terms of $\cos\theta$ and choosing the negative imaginary value of $\sin\theta$ yields

$$\left.\begin{aligned} H_z &= H_0 \exp\{-2\pi y(\cos^2\theta - 1)^{\frac{1}{2}}/\lambda\} \times \\ &\qquad \exp\{2\pi i(ft - x\cos\theta/\lambda)\} \\ E_x &= iZ_0 H_z(\cos^2\theta - 1)^{\frac{1}{2}} \\ E_y &= Z_0 H_z \cos\theta. \end{aligned}\right\} \quad (1b)$$

In such a wave the fields decrease exponentially away from the x axis, and since $\cos\theta > 1$, the phase velocity

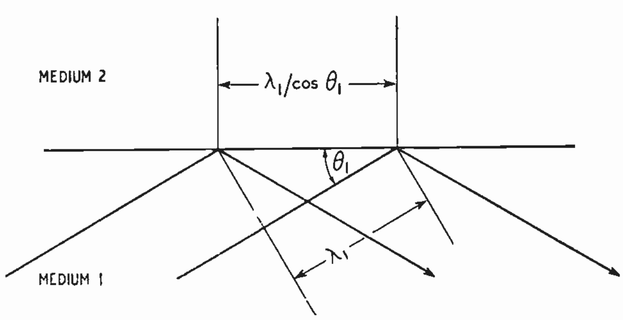


Fig. 2. *Reflection at an interface; the wave in medium 2 is a slow wave if $\lambda_1/\cos\theta_1 < \lambda_2$*

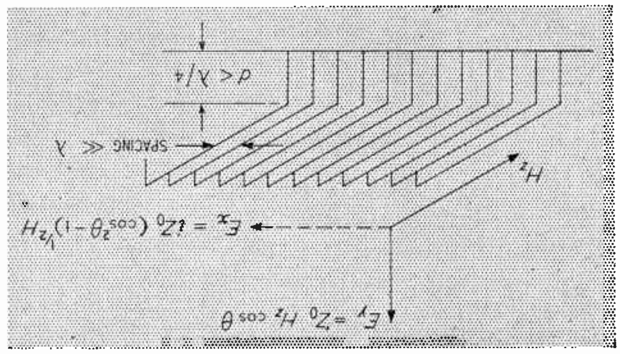


Fig. 3. *Inductive corrugated surface*

along the x axis is less than v. The x component of electric field is pure imaginary, this means that it is $\pi/2$ out-of-phase with the other fields. Consequently the impedance Z_y is also imaginary, $Z_y = -iZ_0(\cos^2\theta - 1)^{\frac{1}{2}}$. A negative imaginary value denotes that the magnetic field 'leads' the electric field, and hence that the impedance is capacitive. Such a wave is shown diagrammatically in Fig. 1(b).

Waves of this type are known as surface waves, or sometimes as slow waves or inhomogeneous plane waves. They occur, for example, at the surface of a slab of optically-dense material at which total internal reflection is occurring; under these circumstances Snell's law gives a value greater than unity for $\cos\theta$, the angle between the 'refracted' ray in the less dense medium and the surface. Evidently the phase velocity along the interface is less than the velocity of light in the less dense medium (Fig. 2).

Such surface waves may also be produced on corrugated surfaces. A surface structure such as that shown in Fig. 3 is purely inductive, since it appears as a system of short-circuited transmission lines of length less than $\lambda/4$. Provided that the fine structure of the surface can be neglected, its impedance may be matched to that of a capacitive surface wave. The impedance $Z_{(-y)}$ looking into the surface is $iZ_0 \tan 2\pi d/\lambda$ where d is the depth of the slot, and the impedance looking away from the surface into the surface wave Z_y is $-iZ_0 (\cos^2\theta - 1)^{\frac{1}{2}}$. Now the condition for a match is that these should be equal numerically but opposite in sign, so that

$$Z_0 \tan 2\pi d/\lambda = Z_0(\cos^2\theta - 1)^{\frac{1}{2}} \quad .. \quad .. \quad (3)$$

whence

$$\cos\theta = v/v_x = \sec 2\pi d/\lambda \quad .. \quad .. \quad .. \quad (4)$$

As d increases from 0 to $\lambda/4$, the phase velocity drops from v to zero.

A Spectrum of Plane Waves

So far, only single waves have been considered; some problems however can be very conveniently treated by considering an angular spectrum of plane waves, in which $\cos\theta$ takes all values between $-\infty$ and $+\infty$. As an example, a somewhat idealized solution of the problem of two-dimensional diffraction through an aperture in a screen will be outlined. A more complete and rigorous treatment of this method may be found elsewhere[3,4].

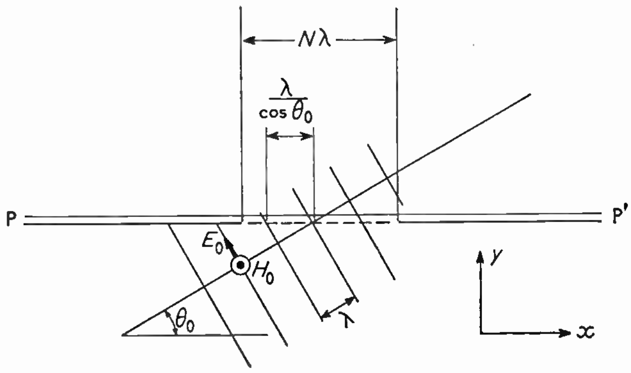


Fig. 4. *Diffraction by aperture*

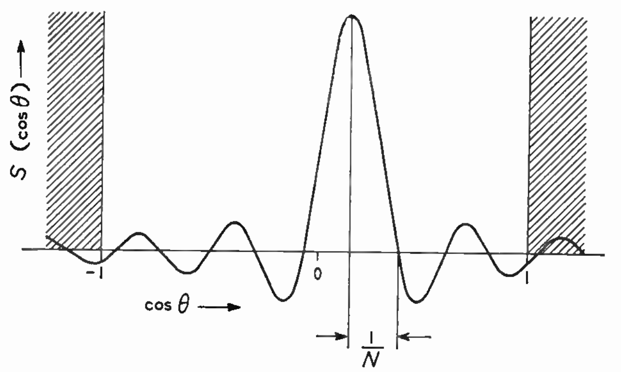


Fig. 5. *Spectrum of plane waves through the aperture plane in Fig. 4. The values of cos θ in the shaded region correspond to slow waves*

The situation to be analysed is shown in Fig. 4. A plane wave in which H is perpendicular to the paper falls on a screen at an angle θ_0; there is an aperture of width $N\lambda$ in the screen, and it is required to find the distribution of fields in the space beyond the screen.

Before doing this, the concept of an aperture plane PP' will be introduced. This plane is just beyond the screen (Fig. 4), and divides the space into two halves, one of which contains the source of radiation and the screen, whereas the other is empty. These will be referred to as the 'source region' and 'free region' respectively. The screen will be assumed to be conducting, and edge effects will be neglected. By this we mean that the distribution of electric field in the aperture plane is assumed to be uniform with a phase gradient of $2\pi \cos\theta_0$ radians/wavelength opposite the aperture ($N\lambda/2 > x > -N\lambda/2$), and zero elsewhere ($x > |N\lambda/2|$).

By means of the Fourier integral this field may be analysed into a spectrum of fields in the aperture plane each extending from $-\infty$ to $+\infty$, each component of the spectrum being characterized by a particular value of $\cos\theta$. This procedure is formally similar to the resolution of a single rectangular pulse into a frequency spectrum. Furthermore each of these component fields may be consistently regarded as belonging to a plane wave travelling into the free half of space at an angle θ from the aperture.

Omitting the term exp. $(-2\pi ift)$ expressing variation with time (since this is a constant factor throughout) the aperture field may be written:

$$E_x = E_0 \sin\theta_0 \exp(-2\pi ix\cos\theta_0/\lambda),$$
$$\text{where } N\lambda/2 > x > -N\lambda/2.$$

Denoting the spectrum of fields by $S(\cos\theta)$

$$E_x = \int_{-\infty}^{\infty} S(\cos\theta)\exp(-2\pi ix\cos\theta/\lambda)\, d(\cos\theta)$$

whence by the Fourier inversion theorem

$$S(\cos\theta) = \int_{-N\lambda/2}^{N\lambda/2} E_x \exp(2\pi ix\cos\theta/\lambda)\, dx/\lambda$$
$$= E_0 \sin\theta_0 \sin\{N\pi(\cos\theta - \cos\theta_0)\} \div \pi(\cos\theta - \cos\theta_0) \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Fig. 5 shows the shape of the spectrum; values of $|\cos\theta|$ greater than unity correspond to slow waves travelling along the aperture plane, with amplitude decreasing in a direction measured perpendicular to the plane. It is interesting to note that changing $\cos\theta_0$ merely changes the origin in the figure. It is possible to show that the angular spectrum of waves is identical to the distant 'polar diagram' of the aperture considered as an aerial[3,4]. This might be expected from the form of Equ. (6), which is that of the well-known polar diagram of a continuous linear array of length $N\lambda$ and phase gradient $2\pi \cos\theta_0$ radians per wavelength[5].

It is possible to set up a field in which $\cos\theta_0$ is greater than unity in the aperture plane by placing a material of high optical density behind the screen, and making the angle of incidence in this medium (measured to the surface) less than the critical angle. If this is done the 'main beam' at $\theta = \theta_0$ disappears, and only radiation corresponding to the secondary maxima occurs. The importance of this apparently trivial example will be apparent later.

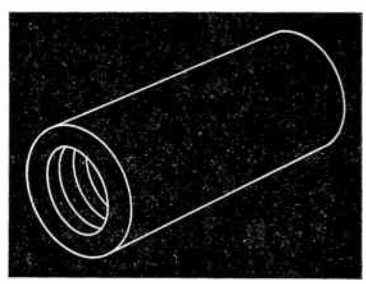
Some Applications to Particle Accelerators

Some characteristics of particle accelerators will now be discussed in the light of concepts so far developed.

Since surface waves have a phase velocity less than that of light, and a field component in the direction of propagation, they are clearly suitable for accelerating particles. For example, the corrugated surface of Fig. 3 could be rolled into a tube about a horizontal line (Fig. 6), and the phase velocity of the wave varied by varying the depth of the corrugations. This is essentially what is done in the travelling-wave electron accelerator[6]. The mathematical representation of the fields looks different, exponentials are replaced by Bessel functions, but the essential physical situation is the same.

Another system worthy of consideration in this

Fig. 6. *Corrugated waveguide formed by rolling up the surface of Fig.* 3



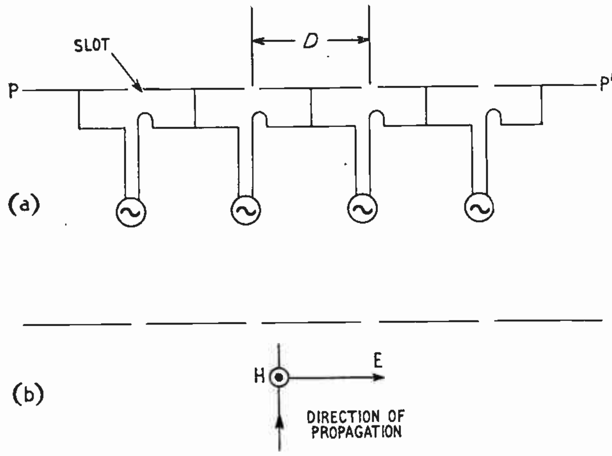


Fig. 7. *Array of slots in a conducting metal sheet fed by (a) resonators; (b) a plane wave*

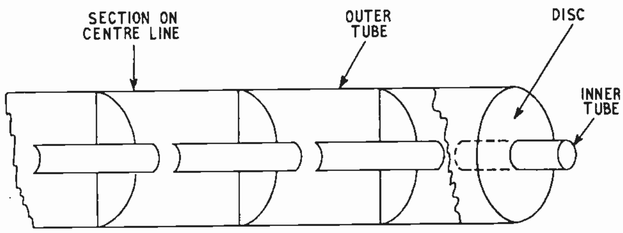


Fig. 8. *The slot system of Fig. 9 (a) rolled up to form a standing-wave linear accelerator*

connection is that of an infinite array of slots in a metal sheet, fed either by resonators which are in turn fed by generators all in phase, Fig. 7(a), or alternatively by an incident plane wave normal to the sheet, Fig. 7(b). The polar diagram of the radiation from the slots can be found in a manner similar to that used to calculate diffraction through a single aperture. Since, however, the function E_x in the aperture plane is periodic and infinite in extent, the form of the function $S(\cos\theta)$ is that of a 'line spectrum'. Lines will occur at values of $\cos\theta$ given by $\cos\theta = n\,\lambda/D$, where D is the slot spacing and n may be any integer positive or negative. The envelope of the lines will depend on the slot width, and will be broad if the slots are narrow. There will only be a finite number of lines for which $n\,\lambda/D$ is less than unity; these will correspond to plane waves travelling away from the aperture at angles $\cos^{-1}(n\lambda/D)$, as in a diffraction grating. For $n\lambda/D$ greater than unity however, there is an infinite set of slow waves travelling in both directions along the aperture plane. (A detailed study of a very similar problem, the reflection of a wave at a grid of wires, has been made by Macfarlane[7]).

If now, as before, the system of Fig. 7(a) is rolled up about a horizontal axis into a small enough tube the radiated waves may be suppressed while the slow waves are retained. The system then becomes virtually a resonant type linear accelerator (Fig. 8). The amplitude of the very slow waves (n large) falls off rapidly with inward radial distance from the walls, so that these waves do not interact strongly with the particles. An alternative way of interpreting this effect is to say that particles moving at these slow speeds ($vD/n\lambda$) spend many cycles in the field of each gap, and thus do not receive a large net acceleration. In the notation of klystron theory this is expressed by saying that the gap factor, β, is small.

If the accelerator of Fig. 8 is split into separate resonator units, and the whole rotated about a vertical axis, the type of accelerating system used in synchrotrons is obtained (Fig. 9).

Cylindrical Waves Moving Axially

In the discussion on accelerators, cylindrical waves were introduced. Another form of cylindrical wave which has been studied both theoretically and experimentally may be obtained by effectively turning the corrugated waveguide inside out, and replacing the corrugations (if desired) by a dielectric, so that the system consists of a metal tube or wire surrounded by a cylindrical shell of dielectric[8]. The radial dependence of the field for such a system can be expressed in terms of the Hankel function[9]. At large distances from the wire however the field is indistinguishable from that of a plane wave if observed over small ranges of r and ϕ where r is the distance from the wire and ϕ the angle measured in a plane perpendicular to the wire with the wire at the origin. Furthermore the value of $\cos\theta_0$ (which is greater than unity) associated with the wave is just that given by the velocity of light divided by the velocity of

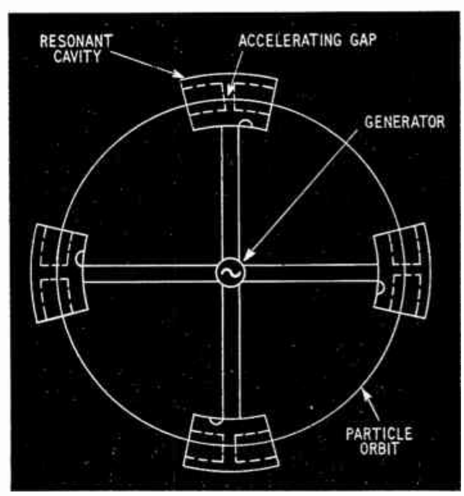


Fig. 9. *R.F. system for synchrotron*

the wave along the wire, as in the case of the plane wave. This can be verified quite simply by writing down the asymptotic expression for the Hankel function solution, as given for example in reference 9.

In such a guided wave the power flux is of course entirely in a direction parallel to the wire. An alternative way of supporting such a wave would be to use an infinite array of Hertzian dipoles placed end to end, each fed in such a way that the phase gradient along the array is $2\pi\cos\theta_0$ per wavelength. If such a system is used there is no reason why $\cos\theta_0$ should not be less than unity. If this is so, the Hankel function changes its character, and the solution remote from the dipoles becomes a travelling wave, moving outwards at an angle θ_0 to the axis.

The radiation from an array of finite length can be found in an analogous way to the radiation through a finite aperture, by Fourier analysis of the current distribution along the array into a spectrum of current waves each extending all the way along the axis. Analogous to Equ. (6), for an array of length $N\lambda$,

$$S(\cos\theta) = I_0 \sin\{N\pi(\cos\theta - \cos\theta_0)\}/\pi(\cos\theta - \cos\theta_0) \quad \ldots \quad \ldots \quad (7)$$

The angular distribution of radiation, $P(\cos\theta)$, is not, however, given by Equ. 7. It is nevertheless related to it by the expression

$$P(\cos\theta) \propto \sin\theta \,.\, S(\cos\theta) \quad \ldots \quad \ldots \quad (8)$$

Even if $|\cos\theta| > 1$ some radiation occurs when the array is of finite length; this may be compared with diffraction through a finite aperture when $|\cos\theta| > 1$ discussed in the section on 'A Spectrum of Plane Waves'. Of particular interest is the case when $\cos\theta = 1 + 1/2N$.[10]

Radiation from an Electron Moving in a Straight Line

The main interest of the previous section is the insight it gives into the problem of radiation from an electron. Fourier analysis has already been used to analyse the current function into components with different spatial periodicities $\cos\theta/\lambda$, but a single temporal periodicity f has always been assumed. In the radiation problem, however, use is made of Fourier analysis in time also.

An electron or assemblage of electrons moving in a straight line with velocity u may be considered as a current, $I = g(ut - x)$. This may now be Fourier analysed into frequency components of the form $\exp.\{2\pi i(ft - fx/u)\}$, so that if $h(f)$ is the distribution of frequencies

$$I(x, t) = \int h(f) \exp.\{2\pi i(ft - x\cos\theta_0/\lambda)\}\, df \quad \ldots \quad (9)$$

$$\text{where} \quad \cos\theta_0 = f\lambda/u = v/u \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

In free space $\cos\theta_0$ is always greater than unity, and no radiation occurs. In a dielectric medium, however, u can exceed v, and in this case radiation occurs at an angle $\cos^{-1} v/u$. This is Čerenkov radiation[11]. If wavelengths large compared with the linear dimensions of the electron bunch only are considered, then $g(ut - \delta)$ is proportional to $\sigma(ut - x)$, $h(f)$ then becomes independent of f, and it is readily seen from Equ. (9) that the spectral distribution varies as $1/f$. It was stated above that in free space $|\cos\theta_0|$ is always greater than unity, and that no radiation occurs. If, however, the track is of finite length, by analogy with the finite aperture in the section on 'A Spectrum of Plane Waves' $\cos\theta_0$ has to be replaced by a spectrum in which all values of $\cos\theta$ are present, and some radiation does therefore take place. This radiation is normally associated with the acceleration of the charge at the beginning and end of the track. The angular distribution of a single frequency component of the radiation from an ideal point electron in free space which moves with uniform velocity over a finite track of length L is given by Equs. (7) and (8), with $N = L/\lambda$ (λ being the free-space wavelength of the frequency component under consideration). If the track of the particle is many wavelengths long, an overall picture of the radiation polar diagram can be obtained by replacing the oscillatory term in the numerator of Equ. (7) by its envelope, Equ. (8) then becomes

$$P(\cos\theta) \propto \sin\theta/\pi(\cos\theta - \cos\theta_0) \quad \ldots \quad \ldots \quad (11)$$

The divergence at $\theta = \theta_0$ is in the region where $\cos\theta > 1$, and is therefore not important.

For a relativistic electron travelling at nearly the speed of light an interesting substitution can be made. If γ is the ratio of the total energy of the electron to its rest energy then for $u \approx c$

$$u/c = (1 - 1/\gamma^2)^{\frac{1}{2}} \approx 1 - 1/2\gamma^2 \quad \ldots \quad \ldots \quad (12)$$

whence for θ small equation (11) becomes

$$P(\cos\theta) = p(\theta) \propto 2\theta/\pi(\theta^2 + 1/\gamma^2) \quad \ldots \quad (13)$$

It is seen that the radiation is directed more strongly forward as the electron energy increases. The angle at which the maximum emission occurs can readily be shown to be $\theta = 1/\gamma$.

This method of calculating the radiation from an accelerated electron is not, in general, the most useful or convenient; it is, however, sometimes useful for discussing the behaviour of low-frequency components[12].

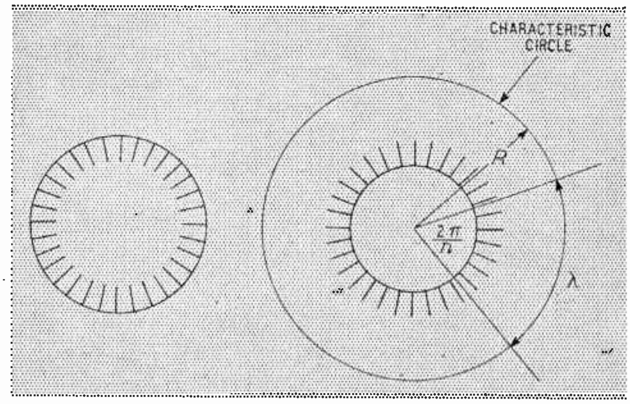


Fig. 10. *The corrugated surface of Fig. 3 rolled up about an axis perpendicular to the paper*

Cylindrical Waves Moving Circumferentially

In Fig. 3 a plane guiding surface is shown. It is os interest to consider what happens when the surface if curved into a cylinder with its axis perpendicular to the paper. If the surface is rolled up with the corrugations on the inside, a magnetron structure is obtained. The magnetron operates when the magnetic field and applied voltage are adjusted so that the electron cloud moves with an angular velocity equal to that of the slow waves, Fig. 10.

When the corrugations are on the outside, the situation is rather more interesting. If the phase velocity of the wave is u at the surface of the corrugations, it will be equal to v the velocity of light at a radius equal to v/u times the radius of the cylinder. This radius and the associated circle will be called the characteristic radius R and the characteristic circle respectively. If the total change of phase round the cylinder is $2n\pi$, then it may easily be verified that $R = n\lambda/2\pi$. The solution of the wave equation for this case can be expressed in terms of a Hankel function of the second kind of order n.[13] Fig. 11 shows the variation of the circumferential component of E for the special case where $n = 4$. An examination of the form of the solution shows that the wave changes character at the characteristic circle; it varies monotonically outwards to the circle, and is oscillatory outside it. Well inside the characteristic circle the components of E and H are nearly $\pi/2$ out-of-phase, at large distances outside they are in phase. The whole solution is rather like that of a plane wave in which $\cos\theta$ varies with radius r according to the relation $\cos\theta = R/r$. Inside the circle the wave is predominantly an evanescent wave, and outside it is a predominantly travelling wave, so that power gradually leaks away from the corrugated surface into the radiation field. For small values of u or of the surface curvature the characteristic circle is a long way from the surface, and the power leaks out very slowly.

Analogy with Wave Mechanics

The region between the circle and the surface is analogous to a potential barrier in wave mechanics. In the scattering of neutrons by a nucleus for example, partial waves associated with an angular momentum $\{l\ (l+1)\}^{\frac{1}{2}}$ only interact weakly with a nucleus of radius less than $l\lambda/2\pi$. The reason for this is that such a nucleus lies inside the characteristic sphere and a potential barrier (the centrifugal barrier) has to be crossed in order to reach it. Under these circumstances, the wave function decreases monotonically inwards from the characteristic sphere.

'Super-Gain' Aerials

If two waves of equal amplitude and rotating in opposite directions are present on a cylindrical guiding surface, the angular dependence of the components of the field becomes proportional to exp. $i\ (2\pi ft - n\phi)$ + exp. $i\ (2\pi ft + n\phi) = 2\cos n\phi$ exp. $(2\pi ift)$. If the system is considered as an aerial, the distant radiation pattern then has the form $p(\phi) \propto \cos n\phi$. A more practical aerial could be made from a slotted cylinder fed by generators; c.f., the system shown in Fig. 7 rolled up about an axis perpendicular to the paper. If the slots are sufficiently close, any arbitrary field distribution round the circumference can ideally be obtained by suitable adjustment of the amplitude and phase of the generators. This field distribution can be written as a Fourier series

$$E_\phi = \Sigma E_n \cos n\phi \quad \ldots \quad (14)$$

The distant radiation field can similarly be written

$$E'_\phi = \Sigma E'_n \cos n\phi \quad \ldots \quad (15)$$

where E_n'/E_n is a function of the radius r of the aerial. From Equ. (15) it is clear that from an aerial of given size, an angular distribution of any arbitrary shape can be obtained by taking enough terms of Equ. (15) and adjusting the values of E_n accordingly. However, as n is increased beyond a value such that the characteristic circle has a larger radius than that of the aerial ($n > 2\pi r/\lambda$) the value of E_n'/E_n drops very rapidly indeed, due to the presence of the 'potential barrier'[14]. In order that an appreciable amount of power can leak out, therefore, the fields E_n (when n is greater than $2\pi r/\lambda$) must be extremely large at the radius r. These fields are predominantly reactive and represent a considerable amount of stored energy in the neighbourhood of the slots. Thus it is difficult to produce a beam narrower (between zeros) than π/n, where $n = 2\pi r/\lambda$; that is, narrower than $\lambda/2r$. This may be compared with the angle between zeros from a uniformly illuminated aperture of width $2r$ of $\sin^{-1}\lambda/2r$, or $\lambda/2r$ when $r >> \lambda$. The difficulty of producing a beam substantially narrower than that from a uniformly illuminated plane aperture is well known[3].

Radiation from Electrons Moving in a Circle

When electrons move in a circle, power is radiated. This fact is well known to designers of particle accelerators, and is important in the design of large electron synchrotrons. That such radiation will occur can easily be seen by Fourier analysis of the current pulse (due to the electron) as a spectrum of sinusoidal current distributions running round the circle with a phase velocity equal to the electron velocity u. Since u is less than v (the velocity of light), the field due to a component with

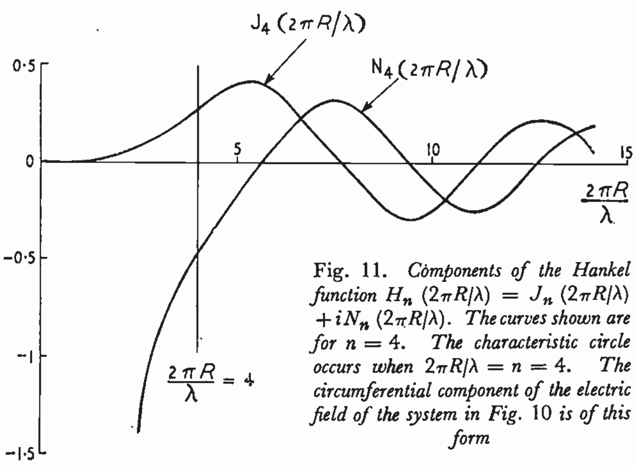


Fig. 11. *Components of the Hankel function $H_n\ (2\pi R/\lambda) = J_n\ (2\pi R/\lambda) + iN_n\ (2\pi R/\lambda)$. The curves shown are for $n = 4$. The characteristic circle occurs when $2\pi R/\lambda = n = 4$. The circumferential component of the electric field of the system in Fig. 10 is of this form*

wavelength λ will fall off in a direction away from the orbit, being substantially reduced in a distance $\lambda/2\pi$ $(\cos^2\theta - 1)^{\frac{1}{2}}$ where $\cos\theta = v/u > 1$; c.f., the plane wave in Fig. 1 (b). If then the characteristic circle is nearer to the circle on which the electron moves than this, radiation will occur freely, if it is further away, little radiation will occur. A 'cut-off' therefore occurs at a wavelength given by

$$\lambda = \Delta R/2\pi(\cos^2\theta - 1)^{\frac{1}{2}} \quad \ldots \quad (16)$$

where ΔR is the radial distance between the two circles; this argument is only valid when the electron velocity is nearly equal to v, so that $\Delta R \ll R$. From geometrical considerations

$$\lambda/2\pi\ (\cos^2\theta - 1)^{\frac{1}{2}} = \Delta R = R\ (1 - u/v) \quad \ldots \quad (17)$$

Now from Equ. (12),

$$u/v = \sec\theta \approx 1 - 1/2\gamma^2$$

whence Equ. (17) becomes

$$\lambda = \pi R/\gamma^3 \quad \ldots \quad (18)$$

This is, therefore, the critical wavelength below which little radiation occurs. A full mathematical treatment of this problem has been given by Schwinger[15]. Because of this cut-off, classical theory is a good approximation unless the circle is so small that its radius is of the same order as the de Broglie wavelength of the electron. Under these conditions, quantum mechanics must be used.

Conclusion

The aim of this article has been to show how a physical understanding of the two forms of plane electromagnetic wave can give insight into a number of wave and radiation phenomena. Although it may appear trivial to some readers, it is hoped that it may be of value to those who think visually rather than in terms of formal relationships.

Acknowledgement

I should like to thank Professor A. L. Cullen for several helpful suggestions and criticisms.

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Super-Gain Aerial Beam

DERIVATION OF A CYLINDRICAL APERTURE DISTRIBUTION

By R. F. Kyle*

SUMMARY. *This article describes a method of deducing the distribution of field on a cylinder of any prescribed radius from a given distribution on a cylinder of infinite radius.*

It has been the dream of designers for some years to produce an aerial with more gain than that obtained from an aperture with uniform illumination and constant phase. It has been demonstrated theoretically that aperture distributions to produce such super-gain aerials exist, but it has also been shown that the difficulties of feeding such an array are great and that the value of Q becomes very large. For apertures which are a fraction of a wavelength long, some degree of super gain is certainly practicable, as shown in the case of certain television aerials; however, this has not been demonstrated in the case where the aperture length is considerably in excess of one wavelength.

This article develops a method by which the amplitude and phase distribution around a cylinder of arbitrarily small diameter can be deduced from a radiation pattern of given shape. It was suggested by the late Dr. O. Bohm that the simplest theoretical approach to the problem of working back from the radiation pattern to the distribution over an aperture, is to consider the conditions around a closed surface. This eliminates the diffraction methods which are necessary when a line source is considered. A circular cylindrical surface is the simplest case to analyse and an expression for the field on any radius can be deduced for the required radiation pattern at infinity.

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Theory

The horizontal radiation pattern of a circular cylinder whose axis coincides with the z-axis of the co-ordinate system is given by an expression of the form $F(\theta)$. The case considered in this note is where $F(\theta) = \cos^{2m}\theta$ and $F(\theta)$ is taken as zero outside the range $\theta = \pm\pi/2m$. This represents a beam with no side-lobes and the voltage beam width is given by $\phi = \pi/2m$. The pattern is assumed to be uniphase.

The above expression can be expanded in the form of a Fourier series.

$$F(\theta) = \Sigma A_n \cos n\,\theta \qquad \ldots \qquad (1)$$

where $A_n = \dfrac{\phi}{\pi}\dfrac{\sin n\,\phi}{n\phi}\dfrac{1}{1-\left(\dfrac{n\,\phi}{\pi}\right)^2}$ and $\phi = \dfrac{\pi}{2m}$

Any electromagnetic wave can be represented in cylindrical co-ordinates by

$$\psi = \Sigma a_n \exp(in\theta)\, H^{(1)}{}_n(r\sqrt{k^2-h^2}) \exp(\pm ihz - i\omega t) \qquad \ldots \qquad (2)$$

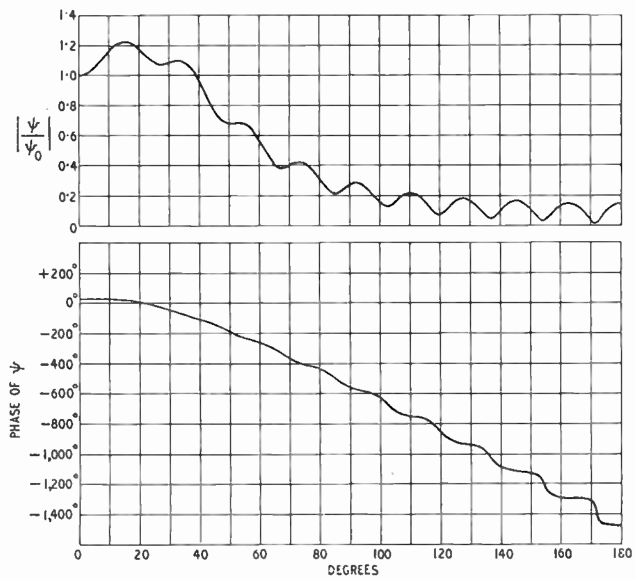


Fig. 1. *Variation of amplitude and phase around cylinder of radius* $\frac{10\lambda}{2\pi}$

This represents a wave travelling outwards[1]. If it is assumed that $h = 0$, then the problem becomes a two-dimensional one and the radiation is purely radial. If it is further assumed that the distribution is symmetrical about $\theta = 0$ and the term $\exp(-i\omega t)$ is neglected then expression (2) reduces to

$$\psi = \Sigma a_n \cos n\theta \, H_n^{(1)}(kr) \quad \ldots \quad (3)$$

where $k = \frac{2\pi}{\lambda}$

It now remains to determine the coefficients a_n by identifying the expression (3) for large values of r with the assumed radiation pattern.

The asymptotic expression for $H_n^{(1)}(kr)$ is

$$H_n^{(1)}(kr) = \sqrt{\frac{2}{\pi kr}} \exp(ikr) \exp\left[-\overline{2n+1}\,\frac{\pi i}{4}\right]$$

As it is only the variation with θ which is considered in the expression for the radiation pattern the terms in r and the constants which do not vary with the terms of the series can be neglected.

$$\therefore H_n^{(1)}(kr) =$$

$$\left[\sqrt{\frac{2}{\pi kr}} \exp(ikr) \exp\left(-\frac{\pi i}{4}\right)\right] \exp\left(-\frac{n\pi i}{2}\right)$$

From this we get $a_n \exp\left(-\frac{n\pi i}{2}\right) = A_n \;\therefore\; a_n = i^n A_n$

Therefore for any value of r, $\psi = \Sigma i^n A_n \cos n\theta \, H_n^{(1)}(kr)$

Particular Case

If the particular case of $m = 5$ is taken in the above expressions the half-voltage beam width is 18°. The Fourier series is an infinite one but if it is terminated at the 11th term it is found that, instead of a main beam with no sidelobes, there are sidelobes approximately 19 dB down from the main beam and that the main beam is widened by about 5°.

It is obvious by considering this Fourier series that, in general, small changes of a few per cent in the amplitude of one mode on the finite cylindrical surface will change the radiation pattern by a negligible amount.

The expression for the field amplitude and phase derived above have been computed around cylinders of circumference 10λ and 5λ, for the particular case $m = 5$ and $n = 0$ to 10; these are shown in Figs. 1 and 2. It is clear from these curves that the variations of amplitude which have to be set up around the smaller cylinder are extremely rapid and violent. The phase variation is steeper on the smaller cylinder.

Impedance Considerations

If the case of a transverse magnetic field is considered and, as before, only the purely two-dimensional problem is taken, then there are two impedances in the directions of the transverse axes which can be defined.

$$Z_r = -\frac{E_z}{H_\theta} \text{ and } Z_\theta = \frac{E_z}{H_r}$$

where $E_z = k^2\psi$; $H_r = -\frac{ik^2}{\omega\mu}\frac{1}{r}\frac{\delta\psi}{\delta\theta}$; and $H_\theta = \frac{ik^2}{\omega\mu}\frac{\delta\psi}{\delta r}$

$$\text{Hence } Z_\theta = \frac{\omega\mu}{n} r, \; Z_r = \frac{i\omega\mu}{k} H_n^{(1)}(\rho) \Big/ \frac{\delta}{\delta\rho} H_n^{(1)}(\rho)$$

$$= iZ_0 H_n^{(1)}(\rho) \Big/ \frac{\delta}{\delta\rho} H_n^{(1)}(\rho)$$

It is the radial impedance Z_r which is of practical significance and when

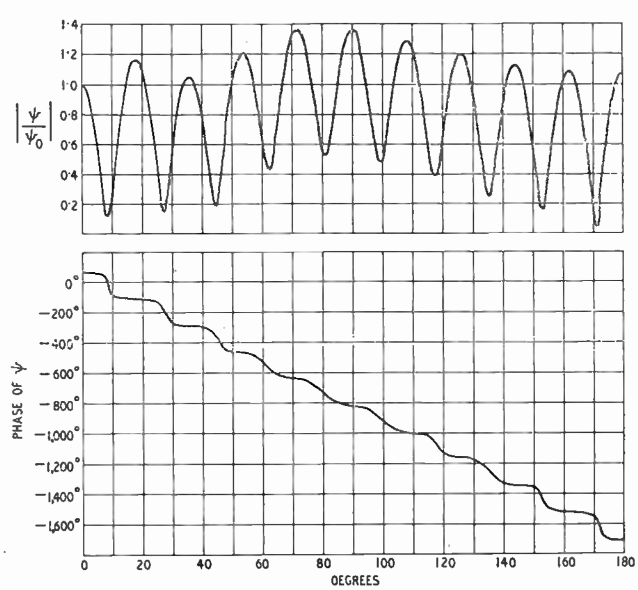
$$r \to \infty, H_n^{(1)}(\rho) \Big/ \frac{\delta}{\delta\rho} H_n^{(1)}(\rho) \to \frac{1}{i}$$

Hence $Z_r \to Z_0$

The values of Z_r for the separate modes on cylinders of circumference 10λ and 5λ are shown in Fig. 3. The most significant aspect of these graphs is that the resistive component drops to very low values for the higher modes on the smaller cylinder.

An estimate of the frequency sensitivity of the

Fig. 2. *Variation of amplitude and phase around cylinder of radius* $\frac{5\lambda}{2\pi}$



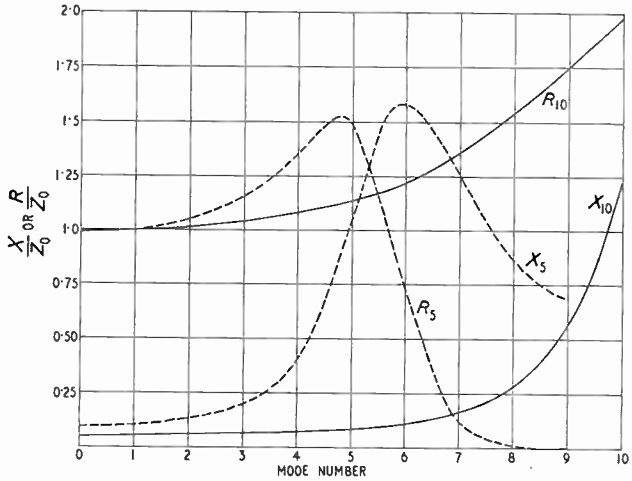


Fig. 3. *Resistance and reactance of cylindrical modes*

impedance has been calculated as being an alternative to the calculation of the Q and, as is to be expected, the variation is most for the higher modes. The percentage changes of resistance and reactance for a 1% change of frequency are given in Table 1.

TABLE 1

Percentage Change of Resistance and Reactance of the Individual Modes for a 1% Frequency Variation.

(A) Cylinder of Radius $\frac{10\lambda}{2\pi}$

	$\frac{\Delta R}{R} \times \frac{100}{\%}$	$\frac{\Delta X}{X} \times \frac{100}{\%}$
Z_0	Zero	− 1·0
Z_1	− 0·0003	− 1·01
Z_2	− 0·03	− 1·12
Z_3	− 0·083	− 1·33
Z_4	− 0·16	− 1·65
Z_5	− 0·28	− 2·12
Z_6	− 0·46	− 2·82
Z_7	− 0·70	− 3·80
Z_8	− 1·02	− 5·17
Z_9	− 1·13	− 6·78
Z_{10}	+ 0·77	− 7·01

(B) Cylinder of Radius $\frac{5\lambda}{2\pi}$

	$\frac{\Delta R}{R} \times \frac{100}{\%}$	$\frac{\Delta X}{X} \times \frac{100}{\%}$
Z_0	Zero	− 0·9
Z_1	− 0·008	− 1·3
Z_2	− 0·1	− 1·5
Z_3	− 0·29	− 2·4
Z_4	− 0·45	− 3·6
Z_5	− 0·9	− 4·0
Z_6	8·0	0·44
Z_7	13·2	2·5
Z_8	15·5	2
Z_9	17·9	1·6
Z_{10}	20·3	1·4

Conclusions—Further Problems

The problem of relating the properties of the individual dipoles or sources to the overall field round the cylinder has not been resolved. It is considered that any system of sources will be backed by a metal cylinder and the modifications which this produces in the field remain to be calculated, as does also the effect of considering a finite source system in place of the field independent of the z direction.

Acknowledgement

The article is published by kind permission of the Admiralty.

REFERENCE

[1] "Electromagnetic Theory" by J. A. Stratton. (McGraw-Hill Book Co.)

STEPPING TRANSISTOR

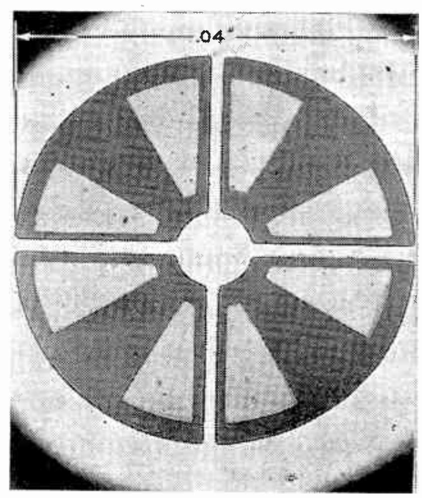
The development of a p-n-p-n semiconductor element that can serve as the basic building block of a silicon stepping transistor was recently announced by Bell Telephone Laboratories, U.S.A.

The four-terminal device acts as a pulse-controlled on/off switch and may be used as a basic stage in building certain logic circuits in digital computers. By using one element to drive two others, versatile decoders can be made.

A more complex device, which is fabricated from a single piece of silicon, can also perform the logic functions. An experimental prototype stepping transistor with four stages has been made.

The original object of the development was to produce a semiconductor device that would function in a similar way to a gas stepping tube (such as a Dekatron). The gas stepping tube utilizes the bistable voltage–current characteristic of a gas discharge for its operation. Unidirectional transfer of voltage between one anode and several cathodes is obtained by the non-symmetrical geometry of its construction.

The stepping transistor uses a p-n-p-n transistor as the bistable element. The design of the structure results in a bistable voltage–current characteristic between a single common electrode and a set of multiple electrodes. Non-symmetrical geometry is employed to obtain a uni-directional transfer of voltage. Also, unlike the gas stepping tube, close proximity is not basically required in the stepping transistor.



A four-stage stepping transistor fabricated on a single piece of silicon.

The current level at which these devices are operated can be designed within the range 1 to 100 mA with supply voltages of 10 to 100 V.

Experimental models have been operated at speeds up to 10^6 pulses per second and it is expected that, with improved designs, they will operate even faster.

Transistor High-Frequency Parameter f_1

ITS MEASUREMENT AND IMPLICATIONS

By L. G. Cripps, B.A.*

SUMMARY. *The frequency at which the earthed-emitter short-circuit current gain has fallen to unity is a parameter of use in defining high-frequency characteristics of transistors. In this article the idea is discussed and the significance of the parameter explained. A method of measurement of use up to frequencies of the order of 200 Mc/s is also given. It is concluded that the parameter is sufficiently important for it to replace, at least partially, the alpha cut-off frequency, as a means of specifying the frequency performance of a transistor.*

A parameter which gives a qualitative idea of the high-frequency performance of a junction transistor (Fig. 1) is the frequency at which $|\alpha'| = 1$. It has not been widely used in the past since its connection with equivalent circuit parameters and other characteristics has not been well understood. The purpose of the present article is to discuss its more precise use as a means for obtaining quantitative results, in the way that the alpha cut-off frequency has been used in the past. The relations between the new parameter and quantities such as the alpha cut-off frequency are first considered, and a brief explanation is given of the effects of emitter depletion-layer capacitance. A method of measurement, alternative to one discussed by Pritchard[1] is also described. Certain of the results are shown to be virtually independent of any (constant) drift field which may be present in the base region of the transistor. Two papers have appeared recently which are related to the present article. Thomas and Moll[2] have given a general discussion of transistor current gain, and certain of their results are in accord with the ideas presented below. Appendix II of the paper by Thornton and Angell[3] compares a quantity f_T (almost identical with f_1) with the alpha cut-off frequency.

Before proceeding with the main discussion it is convenient to prove a basic theorem, remarkable for its simplicity and for the fact that it does not seem to be very widely known. If we assume the internal alpha of a transistor to be represented by

$$\alpha = a - jb, \qquad \ldots \quad (1)$$

where a and b are both real, then the quantity $\alpha' \ (= \alpha/(1-\alpha))$ will be given by

$$\alpha' = \frac{a - ib}{(1-a) + jb}$$

If we then consider the particular condition

$$a = 1/2 \qquad \ldots \quad (2)$$

we see that

$$\alpha' = \frac{1/2 - jb}{1/2 + jb} \text{ so that } |\alpha'| = 1. \qquad \ldots \quad (3)$$

Thus (2) and (3) are equivalent conditions, and we may assert the theorem: the frequency at which $|\alpha'| = 1$ is identical with the frequency at which $\text{Re}(\alpha) = 1/2$.

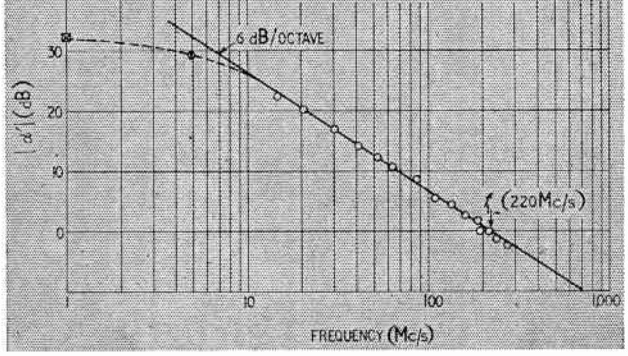
It should be noted that this result is quite general, and will apply to any device for which the quantities α and α' may be defined. It is independent of the form of the functions representing the behaviour of a and b with frequency, and is also independent of the low-frequency value of alpha (α_0). It will thus hold for the alpha of a transistor with a 'built-in' drift field, whatever the characteristics of that field.

The Parameter f_1

We define f_1 ($= \omega_1/2\pi$) to be the frequency at which the real part of the internal alpha of the transistor has fallen to 6 dB below its low-frequency value: $\text{Re}(\alpha)/\alpha_0 = 1/2$. By the theorem just proved, f_1 is almost, but not quite, the frequency at which $|\alpha'| = 1$ (since α_0 is normally close to unity) and, for many practical purposes, the two frequencies may be taken to be the same; a discussion of the relation between them is given in the section describing the measurement of f_1.

It should be noted that by 'internal alpha' in the above definition is meant the alpha for the base trans-

Fig. 1. *Measured curve of $|\alpha'|$ against frequency for an experimental transistor*



* *Mullard Research Laboratories.*

mission process, after the effects of parasitic elements such as collector capacitance and series resistance, base resistance, etc., have been removed.

In the following, we shall consider the relation between f_1 and the earthed-base and earthed-emitter cut-off frequencies, and the capacitance $C_{b'e}$ in

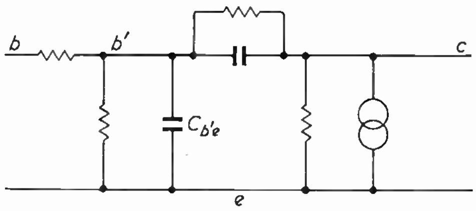


Fig. 2. *Earthed-emitter hybrid-π equivalent circuit for alloy junction transistors*

the earthed-emitter hybrid-π equivalent circuit circuit (Fig. 2). Stephenson[4] has related f_1 to physical rather than electrical quantities in a paper concerned with the effect of d.c. collector voltage. te Winkel[5] has given a more complete discussion of the equivalent circuit of a drift transistor using f_1.

It has been shown[6] that the following expression is a good approximation for the alpha of a transistor with no drift field:

$$\alpha = \frac{\alpha_0 \exp(-j\,\Phi f/f_c)}{1 + jf/f_c} \quad \ldots \quad (4)$$

Here Φ is the phase angle (in radians) at the cut-off frequency $f = f_c$, referred to the radius $\theta = -\pi/4$ (Fig. 3). It has a value $\Phi = 0{\cdot}22$.

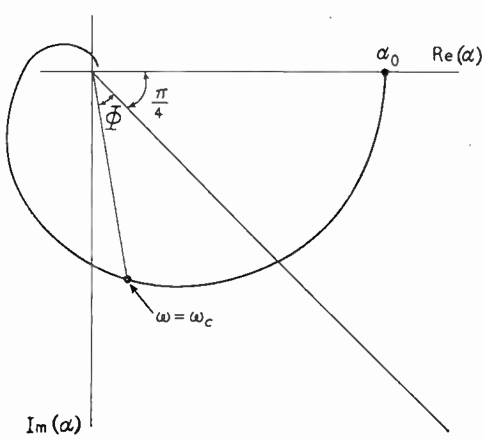
te Winkel[5] has shown that Equ. (4) is also a good approximation if a uniform drift field is present, provided an appropriate value of Φ is employed [see his equation (25) loc. cit.]. The range of validity of the equation is approximately $0 \leqslant f \leqslant 2f_1$, and Φ takes values $0{\cdot}22 \leqslant \Phi \leqslant 1$.

From Equ. (4) it is possible to obtain the relation between f_1 and f_c, for various values of Φ. If this is done it is found that, to a good approximation,

$$f_1 = f_c\,(1 + \Phi) \quad \ldots \quad (5)$$

Equation (5) can also be inferred from te Winkel's[5]

Fig. 3. *The angle Φ*



analysis, and the degree of approximation estimated.

Calculation of the behaviour of α' from expression (4) for alpha gives

$$\alpha' = \frac{\alpha_0'}{1 + j\dfrac{f}{f_c}\cdot(1+\Phi)\,(1+\alpha_0')} \quad \ldots \quad (6)$$

where

$$\alpha_0' = \frac{\alpha_0}{1 - \alpha_0}$$

The derivation of this equation has been given by te Winkel, together with an indication of its range of validity. Crudely, it breaks down at frequencies of the order of f_1.

Two important results emerge. First, α' follows the simple law, implying that $|\alpha'|$ falls with increasing frequency at a rate asymptotically approaching 6 dB per octave, whatever the value of drift field. Experimental confirmation of this fact is given in Fig. 1. Secondly, the 3-dB down point is seen from Equ. (6) to occur when $f/f_c\,(1+\Phi)\,(1+\alpha_0') = 1$, so that, with $f = f_c'$ at this point, we have, firstly

$$f_c' = \frac{f_c}{1+\alpha_0'}\cdot\frac{1}{1+\Phi} \quad \ldots \quad (7)$$

and secondly, using (5),

$$f_c' = \frac{f_1}{1+\alpha_0'} \quad \ldots \quad (8)$$

in which the unpleasant quantity $(1 + \Phi)$ has been removed. The value of f_c' calculated according to Equ. (8) is shown on the experimental curve of Fig. 1.

For alloy transistors it is well known that neglecting emitter depletion-layer capacitance, the capacitance $C_{b'e}$ (see Fig. 2) is given by

$$C_{b'e} = 1{\cdot}21/\omega_c r_e \quad \ldots \quad (9)$$

If a uniform drift field is present, this expression becomes

$$C_{b'e} = (1+\Phi)/\omega_c r_e \quad \ldots \quad (10)$$

so that, using (5) we may write

$$C_{b'e} = 1/\omega_1 r_e \quad \ldots \quad (11)$$

and again the quantity $(1 + \Phi)$ has been removed. If there is appreciable emitter depletion-layer capacitance, this expression must be modified to

$$C_{b'e} = C_{ed} + 1/\omega_1 r_e \quad \ldots \quad (12)$$

where ω_1 is an 'internal' quantity which differs from the measured value due to the presence of C_{ed}. An indication of the effect of C_{ed} on the measured f_1 may be obtained by the following heuristic argument. We may equate the actual $C_{b'e}$ to that which would be calculated from a measurement:

$$1/\omega_{1m} r_e = C_{ed} + 1/\omega_1 r_e \quad \ldots \quad (13)$$

Writing $r_e = kT/qI_e$

we have

$$1/\omega_{1m} = 1/\omega_1 + (C_{ed}\,kT/q)\,(1/I_e) \quad \ldots \quad (14)$$

Thus a graph of $1/\omega_{1m}$ against $1/I_e$ should be a straight line of intercept $1/\omega_1$ and slope $C_{ed}\,kT/q$. An experimental curve is shown in Fig. 4, which indicates that Equ. (14) is at least of the correct form. From the curve, values of f_1 and C_{ed} were deduced.

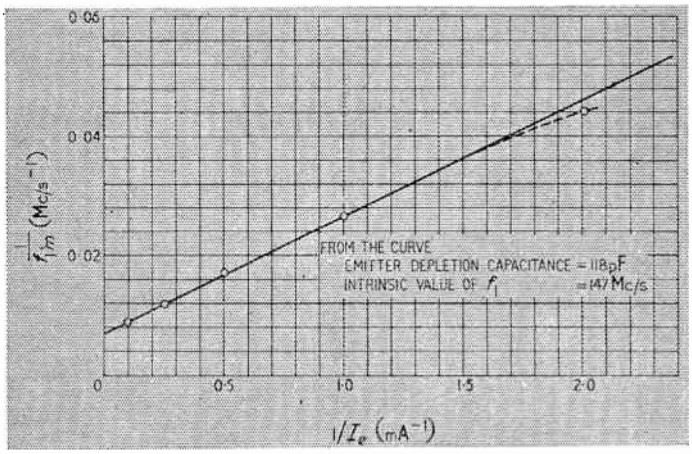
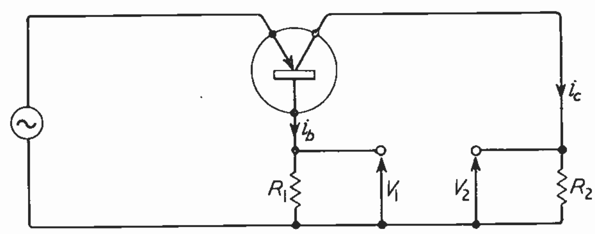


Fig. 4. *Measured curve of* $1/f_{1m}$ *against* $1/I_e$ *for an experimental transistor*

Fig. 5. *Basic method of measuring* f_1



Measurement of f_1

The quantity actually measured by the apparatus to be described is the frequency at which the modulus of the earthed-emitter current gain falls to unity. Correction for the effects of collector capacitance, base resistance and the external measuring circuit must be applied to the result to obtain the corresponding quantity for the 'intrinsic' transistor; that is, for the base transmission process. The corrected quantity then corresponds to the true value for $|\alpha'| = 1$, and therefore, for $\text{Re}(\alpha) = 1/2$, by the basic theorem proved earlier. To obtain f_1, for which by definition $\text{Re}(\alpha) = \alpha_0/2$, a second correction is necessary. The two corrections are discussed in detail in the Appendix. They correspond to similar corrections when measuring f_c by methods which yield the frequency at which $|\alpha| = 1/\sqrt{2}$ rather than $|\alpha| = \alpha_0/\sqrt{2}$.

The basis of the method is shown in Fig. 5. A signal is fed to the emitter, and the voltages V_1 and V_2 developed across two small and equal resistors R_1 and R_2 included in series with the base and collector are observed by a single voltmeter which is connected alternately across the two resistors. The frequency of the generator is adjusted until the voltages V_1 and V_2 are equal in magnitude. Since $R_1 = R_2$, the generator setting corresponds to the frequency at which $|i_c| = |i_b|$. This measured frequency will be called f_{1m}.

The method has the advantage of being independent of the calibration accuracy of the voltmeter and is, in principle, capable of operation up to very high frequencies, provided the reactive parts of the impedance of R_1 and R_2 are balanced and are not too large. An amplitude-modulated signal generator may be employed, so that a wide-band voltmeter can be obtained by using a diode detector followed by amplification at the modulation frequency. Non-linearity of the detector at low levels is unimportant.

It should be noted that the equipment easily lends itself to the measurement of $|\alpha'|$ at frequencies other than f_1, so that a curve of $|\alpha'|$ against frequency may be obtained. The procedure is as follows. The detector is connected across R_1 and the voltage V_1 observed. The detector is then transferred to R_2 and the input signal attenuated until the observed voltage V_2 is the same as the voltage V_1 observed in the first position. The change of attenuator reading is then $|\alpha'|$. The curve of Fig. 1 was obtained by this technique.

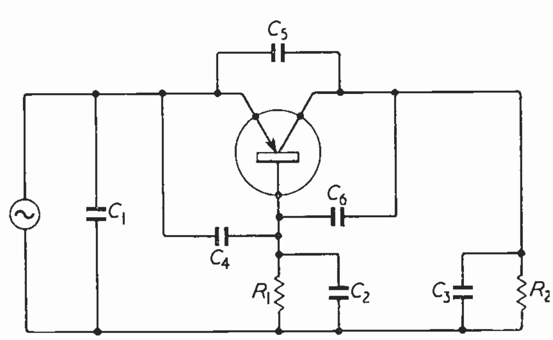
Before considering the detailed circuit, a number of factors affecting accuracy will be considered.

The requirements for the generator are twofold. First, its frequency calibration must clearly be accurate or should be checked against a standard. Secondly, the output waveform should be pure. This factor may be easily overlooked in this type of measurement, but results can be nullified if harmonics or audio frequency are presented, since the transistor will behave differently for these frequencies and for the fundamental.

As in all measurements of this type, the signal level employed must be small enough for transistor non-linear effects to be negligible. This condition can be achieved by reducing the signal level until no change of answer is obtained.

Ultimate accuracy depends upon the ease with which a small difference between the two signals V_1 and V_2 (Fig. 5) can be detected. Thus the detector used for these voltages must have good noise performance or the difference will be lost. Since the resistors R_1 and R_2 are only of the order of 10 Ω and therefore develop only small voltages, high sensitivity is also important. A receiver would be an obvious choice for the detector, but has the severe disadvantage of requiring retuning each time the generator frequency is adjusted. However, sufficiently good performance can normally be combined with the advantage of wide-band detection, by using

Fig. 6. *Stray capacitances*



a modulated signal, as described above, provided the amplifier following the detector is narrow-band.

The behaviour of the two measuring resistors R_1 and R_2 is of importance. It is easy to satisfy the condition $R_1 = R_2$ at low frequencies (to an accuracy of 1 part in 1000, say), and the use of high-stability resistors ensures a reasonable permanence of the equality (occasional checking of the resistors is, of course, desirable). However, stray components become important at high frequencies and, since the resistances are low, series inductance becomes important at a much lower frequency than shunt capacitance. By using similar and similarly-arranged resistors the inductive effects of the loops associated with the resistors may be approximately balanced. Minor adjustment at high frequencies to the loops then allows a more accurate balance to be obtained. This may be done, with no transistor in circuit, by connecting a suitable impedance alternately between emitter and base terminals, and then emitter and collector terminals, and adjusting for equality of V_1 and V_2.

The stray capacitances in the circuit are shown in Fig. 6. C_1 may be neglected completely since it will not normally be high enough to limit the generator output. As explained above, C_2 and C_3 only become important at frequencies outside the range of the apparatus since the series inductance of R_1 and R_2 predominates. C_4, C_5 and C_6 must be made small by screening the circuits associated with the three transistor terminals from each other.

Finally, there are the corrections which must be applied to the measured frequency to allow for the effects of resistors, and for the fact that $\alpha_0 \neq 1$. The derivation of the correction formula is given in the Appendix, the result being

$$f_1 = f_{1m}\left[1 + \omega C_c(r_{bb'} + R_1 + R_2) + \frac{2}{\alpha_0'}\right] \quad .. \quad (15)$$

This correction formula is based on a simple equivalent circuit and the assumption that the correction is small. It may be necessary under some circumstances to use a more exact expression.

Complete Measuring Circuit

The complete circuit is shown in Fig. 7 and will operate over the range 5–200 Mc/s. The signal is fed to the emitter via a d.c. blocking capacitor (1000 pF) and the emitter supply is connected via a decoupling circuit (1·5 kΩ, 1000 pF, 1·5 kΩ). A path for the base direct current is provided by a 1·5-kΩ resistor, across which the 10 Ω measuring resistor is connected by a 1000-pF capacitor; a.c. coupling is used to avoid applying d.c. to the detector. A similar arrangement is used for the measuring circuit (1000 pF and 10 Ω) at the collector, and the collector d.c. supply is connected through a decoupling network (1·5 kΩ, 1000 pF, 1·5 kΩ) similar to that at the emitter. The 1·5-kΩ resistor in the base, and the 1·5-kΩ resistor in the collector decoupling network shunt the measuring resistors, but the shunting is small (less than 1%) and in any case the two effects almost cancel. The coupling capacities (1000 pF) to the 10 Ω measuring resistors are almost certainly inductive at the high-frequency end of the range, but their impedance will still be low and the effect small. Accuracy of measurement is probably better than 2% over most of the range [provided the correction formula (15) is applied] but the errors may rise slightly above, say, 180 Mc/s. The inductances associated with the two measuring resistors are balanced at 220 Mc/s and the balance then holds over the entire range of the apparatus. The curve of Fig. 1 was obtained using the apparatus described. It should be noted that the application of the correction formula (15) changed the observed value of f_1 for the particular transistor used by about 10%, and altered the slope of the curve from 6·4 dB/octave to 6·0 dB/octave.

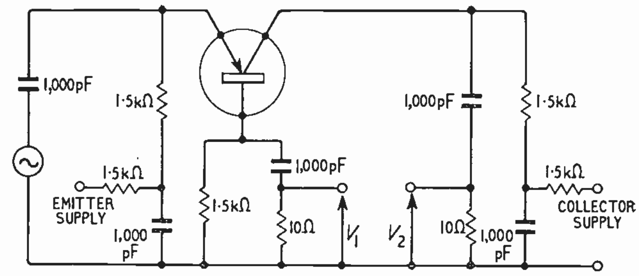


Fig. 7. *Complete circuit of apparatus for measuring f_1 over the range 5–200 Mc/s*

Conclusions

The two conditions $|\alpha'| = 1$ and $\text{Re}(\alpha) = 1/2$ are equivalent, and the equivalence is independent of the behaviour of alpha. The result is thus independent of any drift field which may be present. The frequency at which these conditions are satisfied may be called f_{1m}.

A more convenient parameter for analysis is f_1, which is the frequency for $\text{Re}(\alpha) = \alpha_0/2$. It may easily be obtained from f_{1m} [for which $\text{Re}(\alpha) = 1/2$] by applying a small correction. f_1 is related to well-known parameters by the expressions

$$f_1 = f_c/(1 + \Phi)$$
$$f_1 = f_c'(1 + \alpha_0')$$
$$C_{b'e} = 1/\omega_1 r_e$$

Emitter depletion capacitance may be related to $C_{b'e}$ and ω_1 by the expression

$$C_{b'e} = C_{ed} + 1/\omega_1 r_e,$$

which leads to a simple means of measuring C_{ed}.

Measurement of f_1 may be easily carried out, to an accuracy of about 2%, up to frequencies of the order of 200 Mc/s.

The conclusion from the work described here is that f_1 is a more attractive parameter than f_c for many purposes, in that it is convenient to measure, and has more direct application to equivalent circuits. It is therefore desirable that f_1 should replace, or at least supplement, f_c wherever possible.

Acknowledgements

The author is indebted to several of his colleagues for suggestions and assistance. In particular, Mr.

L. P. Morgan first suggested the basic method of measuring f_1; Mr. J. B. Rodgers designed, constructed and checked the measuring equipment; Mr. M. J. Gay carried out the original calculations of errors introduced by C_c, $r_{bb'}$, and external resistors; and Mr. W. L. Stephenson pointed out the method of estimating ω_1 and C_{ed} from measurements at various currents. The author also wishes to thank the Directors of Mullard Ltd., and the Director of the Mullard Research Laboratories for permission to publish this paper.

APPENDIX

Calculation of a Correction Formula for the Effects of C_c, r_{bb}', Measuring Resistors, and α_0.

The analysis will be carried out in two parts, the effect of α_0 being treated separately from the remaining effects.

Assuming the equivalent circuit of Fig. 8, in which the section enclosed by a dotted line represents the transistor and writing $1/j\omega C_c = -jX_c$, then we have

$$I_b\,[r_{bb}' + R_1] = [I_c\,(1-\alpha) - \alpha\, I_b]\,[-jX_c] + I_c R_2$$

If suffix m is used to denote a measured quantity we thus have, after rearrangement,

$$|\alpha'|_m = \left|\frac{I_c}{I_b}\right| = \frac{|r_{bb}' + R_1 - j\,\alpha\, X_c|}{|R_2 - j\,X_c\,(1-\alpha)|} \qquad (16)$$

With $\alpha = a - jb$ this becomes

$$|\alpha'|_m = \frac{|\omega\, C_c\,(r_{bb} + R_1) - ja - b|}{|\omega\, C_c\, R_2 - j\,(1-a) + b|}$$

$$= \sqrt{\frac{\omega^2 C_c^2\,(r_{bb}' + R_1)^2 + b^2 - 2b\,\omega\, C_c\,(r_{bb}' + R_1) + a^2}{\omega^2\, C_c^2\, R_2^2 + b^2 + 2\,b\,\omega\, C_c\, R_2 + (1-a)^2}}$$

The true value is given by

$$|\alpha'| = \left|\frac{\alpha}{1-\alpha}\right| = \left|\frac{a-jb}{1-a+jb}\right| = \sqrt{\frac{a^2+b^2}{(1-a)^2+b^2}}$$

Hence

$$\frac{|\alpha'|_m}{|\alpha'|} = \sqrt{\frac{1 - \dfrac{2b}{a^2+b^2}\cdot\omega\, C_c\,(r_{bb}'+R_1) + \dfrac{\omega^2\, C_c\,(r_{bb}'+R_1)^2}{a^2+b^2}}{1 + \dfrac{2b}{(1-a)^2+b^2}\cdot\omega\, C_c\, R_2 + \dfrac{\omega^2\, C_c^2\, R_2^2}{(1-a)^2+b^2}}}$$

We now assume that the effect of C_c etc. is small so that

$$\omega\, C_c\,(r_{bb}' + R_1) \ll 1$$
$$\omega\, C_c\, R_2 \ll 1$$

Expanding by the binominal theorem and neglecting second-order terms we have

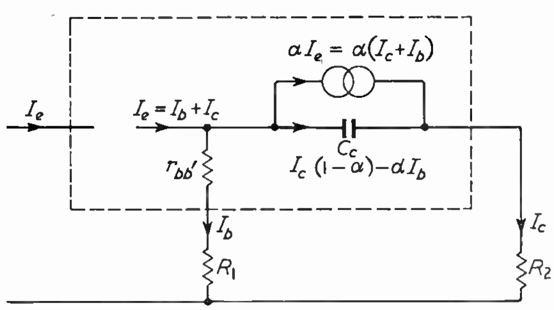
$$\frac{|\alpha'|_m}{|\alpha'|} \simeq \left[1 - \frac{b}{a^2+b^2}\cdot\omega\, C_c\,(r_{bb}'+R_1)\right]\left[1 - \frac{b}{(1-a)^2+b^2}\omega C_c R_2\right]$$

$$\simeq 1 - b\,\omega\, C_c\left[\frac{r_{bb}' + R_1}{a^2+b^2} + \frac{R_2}{(1-a)^2+b^2}\right]$$

To obtain a true correction factor it is necessary to know the values of both a and b. We know a is of the order of $0{\cdot}5$ and it is a reasonable approximation to take the same value for b. Thus we assume

$$a = b = 0{\cdot}5$$

Fig. 8. *Circuit for analysis of effect of C_c, r_{bb}' and external resistors*



so that

$$\frac{|\alpha'|_m}{|\alpha'|} \simeq 1 - \omega\, C_c\,(r_{bb}' + R_1 + R_2)$$

or $\quad |\alpha'| \simeq |\alpha'|_m\,[1 + \omega\, C_c\,(r_{bb}' + R_1 + R_2)]$

$$= 1 + \omega\, C_c\,(r_{bb}' + R_1 + R_2) \qquad (17)$$

if $\quad |\alpha'|_m = 1$

Taking the approximation

$$\alpha' = \frac{\alpha_0'}{1 + j\, f/f_c'}$$

then $|\alpha'| = \dfrac{\alpha_0'}{\sqrt{1 + (f/f_c')^2}}$

At frequencies of the order of f_1, we have $f/f_c' \gg 1$. Hence,

$$|\alpha'| \simeq \alpha_0' f_c'/f$$

so that

$$\frac{d|\alpha'|}{df} = -\,\alpha_0' f_c'/f^2 = -\,|\alpha'|/f.$$

Thus, since

$$\Delta\,|\alpha'| = \frac{d\,|\alpha'|}{df}\,\Delta f$$

we have

$$\frac{\Delta\,|\alpha'|}{|\alpha'|} = -\,\frac{\Delta f}{f}$$

Thus if $|\alpha'|$ is measured to be $x\%$ too high, the frequency is $x\%$ too low. Hence, using Equ. (17), the correction formula is

$$f_1 = f_{1m}\,[1 + \omega C_c\,(r_{bb}' + R_1 + R_2)] \qquad (18)$$

A more accurate result requires a knowledge of a and b so that a bridge or other method of measurement is necessary enabling the real and imaginary parts of α to be found.

The effect of α_0 may be calculated as follows. Provided α_0 is not too different from unity, only a small correction is necessary to obtain the true value of f_1. Thus, an approximate expression for α is justified:

$$\alpha = \frac{\alpha_0}{1 + j\, f/f_c} \qquad (19)$$

Then $\mathrm{Re}(\alpha) = \dfrac{\alpha_0}{1 + (f/f_c)^2}$

Hence

$$\frac{d\,\mathrm{Re}(\alpha)}{df} = -\,\frac{\alpha_0}{[1 + (f/f_c)^2]^2}\cdot\frac{2f}{f_c^2}$$

$$= -\,\frac{\mathrm{Re}(\alpha)}{1 + (f/f_c)^2}\cdot\frac{2f}{f_c^2}$$

Now

$$\Delta\mathrm{Re}(\alpha) = \frac{d\,\mathrm{Re}(\alpha)}{df}\cdot\Delta f$$

Thus

$$\frac{\Delta\,\mathrm{Re}(\alpha)}{\mathrm{Re}(\alpha)} = -\,\frac{\Delta f}{f}\cdot\frac{2(f/f_c)^2}{1 + (f/f_c)^2}$$

$$= -\,\frac{\Delta f}{f}\cdot\frac{2\left[\dfrac{f}{f_1(1+\Phi)}\right]^2}{1 + \left[\dfrac{f}{f_1(1+\Phi)}\right]^2}$$

Thus, at $f = f_1$

$$\frac{\Delta\,\mathrm{Re}(\alpha)}{\mathrm{Re}(\alpha)} = -\,\frac{\Delta f}{f}\cdot\frac{2\left[\dfrac{1}{1+\Phi}\right]^2}{1 + \left[\dfrac{1}{1+\Phi}\right]^2}$$

If $\Phi = 0{\cdot}2$,

$$\frac{\Delta\,\mathrm{Re}\,(\alpha)}{\mathrm{Re}\,(\alpha)} = -\,\frac{\Delta f}{f}\cdot 0{\cdot}82$$

If $\Delta = 1{\cdot}0$

$$\frac{\Delta\,\mathrm{Re}\,(\alpha)}{\mathrm{Re}\,(\alpha)} = -\,\frac{\Delta f}{f}\cdot 0{\cdot}40$$

Thus a reasonable compromise, approximately valid for all values of Φ, would appear to be

$$\frac{\Delta\,\mathrm{Re}\,(\alpha)}{\mathrm{Re}\,(\alpha)} = -\,\frac{\Delta f}{f}\cdot\frac{1}{2} \qquad (20)$$

[Of course, if the value of Φ is known, a more accurate figure can be taken, but there would be little point in doing this since the initial equation (19) is not accurate in any case.]

Equ. (20) means that a small change x% in Re(α) corresponds to a change $(-2x)$% in frequency. The percentage change in Re(α) in passing from the measured point Re(α) = 1/2 to the required point Re(α) = $\alpha_0/2$ is a decrease of $(1 - \alpha_0) \times 100\%$. Thus the change in frequency, by Equ. (20), is an increase of $2(1 - \alpha_0) \times 100\%$. Thus the correction formula is

$$f_1 = f_{1m}\ [1 + 2(1 - \alpha_0)]$$

$$\simeq f_{1m}\left[1 + \frac{2}{\alpha_0'}\right] \qquad \ldots \qquad (21)$$

The approximation breaks down at high values of Φ since Equ. (19) is then no longer valid. However, since the correction is small, Equ. (21) may be sufficiently accurate for most purposes.

Combining Equs (18) and (21), neglecting second-order corrections, gives

$$f_1 = f_{1m}\left[1 + \omega C_c(r_{bb}' + R_1 + R_2) + \frac{2}{\alpha_0'}\right] \qquad \ldots \qquad (22)$$

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Hydrogen-Oxygen Fuel Cell

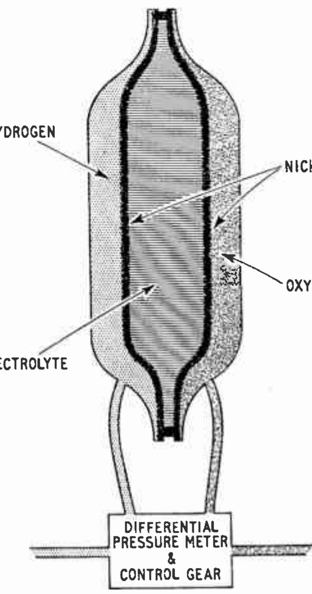
For over one hundred years, engineers and scientists have been endeavouring to produce a practical fuel cell. First envisaged in the early part of the nineteenth century by Sir William Grove, a form of fuel cell was produced by the end of that century, but lack of materials and technology prevented its further development.

Now, a team working in Cambridge under the sponsorship of the National Research and Development Corporation and led by F. T. Bacon, M.A., A.M.I.Mech.E., has produced a cell capable of delivering an output of 5 kW at 24 V.

A 'Fuel Cell' is an electro-chemical device in which the free energy of combustion of a fuel is converted directly into electrical energy. It operates by a simple reversal of the process of electrolysis of water.

The one now produced consists of 40 cells, 10 in. diameter and approximately 30 in. long; each cell consists of two porous sintered-nickel electrodes, one for hydrogen and the other for oxygen, separated by an electrolyte. The oxygen electrode is treated with lithium and pre-oxidized to prevent corrosion. The electrolyte is a strong caustic potash and working conditions are around 200° C and 400 p.s.i. The electrolyte soaks into the porous electrodes but, on the application of gas under pressure from the back of the plate, is expelled from the larger pores; the gas cannot bubble through the smaller-pored surface due to the surface tension of the liquid. Thus, there is a very large surface of wetted metal in contact with gas in each electrode (about forty square metres).

Oxygen molecules on the oxygen electrode combine with water to form negatively charged hydroxyl ions, each of which removes an electron from the oxygen electrode. The hydroxyl ions migrate through the electrolyte to the hydrogen electrode where they combine with the hydrogen to form water, depositing an electron in the process. Thus the hydrogen electrode becomes negative with respect to the oxygen electrode and, if a load is connected, current flows in the external circuit.



Simplified schematic diagram of fuel cell

In order to remove the water formed, the hydrogen is circulated past the back of the hydrogen electrodes and the mixture of hydrogen and steam is cooled externally, so that the condensate can be released as required.

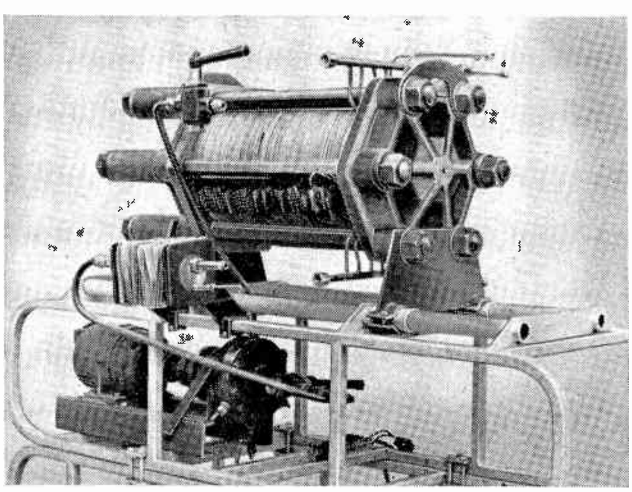
The pressure of the two gases in the cell must be very evenly balanced; to ensure this, a control system is incorporated to keep the oxygen pressure constant and to control the hydrogen pressure against it by a very accurate differential pressure meter which actuates a power-operated inlet valve controlled by a servo-mechanism.

In its present form, the hydrogen-oxygen fuel cell has reached the second stage of development and is now approaching the commercial proposition of a completely automatic source of power. Before this can be accomplished there are several problems to be solved, including the reduction in size of the control gear and the pre-heating of the cell.

When operating, the cell generates heat that can be used to keep the cell at its optimum operating temperature but, for starting, it is necessary to supply heat from an external source.

In its commercial form the cell will have to be provided with some means of pre-heating. This could be supplied by a secondary source of power, such as an accumulator or, alternatively, on off-load condition the cell could be made to 'tick over' by supplying current to a pre-heating element. Up to the present time this problem has not been solved.

A forty-cell battery with the hydrogen circulator and condenser for water removal mounted underneath



Cancel with Care

Fig. 1 shows an equivalent circuit for a transformer which has unity ratio, at frequencies sufficiently high for the shunting effect of the primary and secondary inductances to be negligible. Leakage inductance is represented by L and the primary and secondary capacitances by C_1 and C_2; these represent internal as well as external capacitances. The resistances R_1 and R_2 are mainly the source and load resistances, but can be taken to include also shunt losses in the transformer.

A constant current I is supplied, and the resulting secondary voltage V_0 is easily obtained in the form

$$\frac{IR}{V_0} = 1 - \omega^2 T_1^2 (1+b)\, d + j\omega T_1 \left(\frac{1+ab}{1+a} + d - \omega^2 T_1^2 bd\right) \quad \ldots \quad (1)$$

where

$$\left.\begin{aligned} R &= \frac{R_1 R_2}{R_1 + R_2},\; T_1 = C_1 R_1,\; a = R_1/R_2 \\ b &= C_2 R_2 / C_1 R_1,\; d = L / C_1 R_1 (R_1 + R_2) \end{aligned}\right| \quad \ldots \quad (2)$$

The magnitude of IR/V_0, say $1/G$, is therefore given by

$$\frac{1}{G^2} = 1 + \omega^2 T_1^2 \{(x+d)^2 - 2d\,(1+b)\} + \omega^4 T_1^4 \{d^2(1+b)^2 - 2bd\,(x+d)\} + \omega^6 T_1^6 b^2 d^2 \quad \ldots \quad (3)$$

where $x = \dfrac{1+ab}{1+a}$ .. .. (4)

For maximal flatness we require the coefficients of $\omega^2 T_1^2$ and $\omega^4 T_1^4$ to be zero, so that

$$(x+d)^2 = 2d\,(1+b) \quad \ldots \quad (5)$$

$$d^2(1+b)^2 = 2bd\,(x+d) \quad \ldots \quad (6)$$

Now if $b = d = x = 1$ it is easily verified that Equs. (5) and (6) are both true, but when $b = 1$, Equ. (4) tells

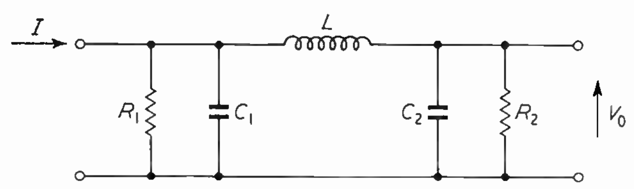


Fig. 1. *An equivalent circuit for a unity-ratio transformer at high frequencies*

us that x must be 1 whatever the value of a may be. Physically, $b = 1$ means that the time constants C_1R_1 and C_2R_2 are equal. In a practical case we might have $R_1 = 20$ kΩ, $R_2 = 5$ kΩ, $C_1 = 100$ pF, $C_2 = 400$ pF and $L = 50$ mH; a then has the value 4 and $b = d = 1$, the time constants $C_1 R_1$ and C_2R_2 being 2 μsec.

Now let us consider the general case. In Equs. (5) and (6) the quantities b, d and x are all real, positive and finite. The obvious way to proceed is to eliminate x [or rather $(x+d)$] by squaring both sides of Equ. (6) and substituting from Equ. (5); this gives

$$(1+b)^4 d^4 = 4b^2 d^2 \cdot 2d(1+b) \quad \ldots \quad (7)$$

At this point we must note carefully that Equ. (7) could not only be obtained from Equs. (5) and (6) as they stand, but would also be obtained if Equ. (6) had been

$$d^2(1+b)^2 = -2bd\,(x+d) \quad \ldots \quad (8)$$

Equ. (8) is fortunately irrelevant to our present investigation, because b, d and x are positive, but when squaring has to be done in order to solve equations, it is most important that all solutions obtained are checked in the original equations, because a solution of Equ. (7) could have been a solution of Equs. (5) and (8) instead of a wanted solution of Equs. (5) and (6).

Returning to Equ. (7), we can be quite sure that $(1+b)$ and d^3 are different from zero, and therefore may be cancelled to give

$$d = \frac{8b^2}{(1+b)^3} \quad \ldots \quad (9)$$

Substituting from Equ. (8) to Equ. (5), we may also safely cancel a d and divide through by b to obtain

$$x = \frac{(1+b)^2 d}{2b} - d = \frac{4b\,(1+b^2)}{(1+b)^3} \quad \ldots \quad (10)$$

and we can easily verify that these values of x and d satisfy the original Equs. (5) and (6), whatever the value of b may be. We have, however, already seen that although Equ. (4) is apparently a relation between x and a, it reduces to $x = 1$ (which is independent of a) when $b = 1$. Let us therefore try and express a in terms of x from Equ. (4) and see how the result is affected by putting $b = 1$.

Multiplying through Equ. (4) by the safely positive quantity $(1 + a)$, we have

$$(1+a)x = 1 + ab$$

$$\therefore a(x-b) = 1 - x \quad \ldots \quad (11)$$

Now provided that x is not equal to b, we can deduce from Equ. (11)

$$a = \frac{1-x}{x-b} \quad \ldots \quad (12)$$

Substituting from Equ. (10) for x, we can safely multiply numerator and denominator by $(1+b)^3$ to clear cumbersome fractions, and we thus obtain

$$a = \frac{(1+b)^3 - 4b(1+b^2)}{4b(1+b^2) - b(1+b)^3} = \frac{1 - b + 3b^2 - 3b^3}{b\{3 - 3b + b^2 - b^3\}} = \frac{(1-b)(1+3b^2)}{b(1-b)(3+b^2)} \quad (13)$$

Provided that b is not equal to 1, Equ. (13) yields

$$a = \frac{1 + 3b^2}{b(3 + b^2)} \qquad \ldots \ldots \ldots \ldots \ldots (14)$$

by cancelling the factor $(1 - b)$. If, however, b is equal to 1, we have already seen that x has the required value 1 whatever the value of a may be.

We have also noted that Equ. (12) is not valid when $x = b$; Equ. (11) in this special case tells us that $x = 1$. There is thus only one special case, when both x and b are equal to 1.

In order to understand the peculiarities of the special case, let us consider first what happens for a general value of b if we are content to allow a small tolerance in the value of x, so that we accept x_1 as sufficiently near the required value of x given by Equ. (10), where

$$x_1 = \frac{4b(1 + b^2)}{(1 + b)^3}(1 + \lambda) \qquad \ldots \ldots \ldots (15)$$

If we think of λ as 0·01, this means that we are prepared to tolerate a 1% excess in x; if λ is $-0{\cdot}01$, we are prepared to tolerate a 1% deficiency. When we allow x to be replaced by x_1, we must correspondingly replace a by a_1 where

$$x_1 = \frac{1 + a_1 b}{1 + a_1} \qquad \ldots \ldots \ldots \ldots \ldots (16)$$

Multiplying through Equ. (16) by $(1 + a_1)$ [which is positive in cases of practical interest] and rearranging, we have

$$a_1 (x_1 - b) = 1 - x_1 \qquad \ldots \ldots \ldots \ldots (17)$$

In order to obtain a usable value of a_1 from Equ. (17), we must adjust λ so that x_1 is between b and 1 [if $b = 1$, Equ. (17) simply tells us that $x_1 = 1$ since a_1 cannot usefully be -1, and Equ. (15) then tells us that λ is necessarily zero. No tolerance is thus required, and a_1 reduces to a, which, as we have already seen, can have any value in this case]. If b exceeds 1, $(1 - x_1)$ and $(x_1 - b)$ will both be negative, so that a useful, positive value of a_1 is obtained; if b is less than 1, $x_1 - b$ and $(1 - x_1)$ will both be positive, so that again a useful value of a_1 is obtained. In either case we can find an explicit formula for a_1 from Equ. (17) by dividing through by $(x_1 - b)$. If we then substitute for x_1 from Equ. (15), we have

$$a_1 = \frac{1 - x_1}{x_1 - b} = \frac{(1-b)(1+3b^2) - 4\lambda b(1+b^2)}{b(1-b)(3+b^2) + 4\lambda b(1+b^2)} \qquad \ldots (18)$$

The position we have now reached is that if we require exact maximal flatness in the general case $(b \neq 1)$ we must make R_1/R_2 have the value a given by Equ. (14). Nevertheless, if we are prepared to tolerate a slight departure from maximal flatness (measured by the quantity λ defined in Equ. (15)) we can allow R_1/R_2 to have instead the value a_1 given by Equ. (18). λ must necessarily be small, or the variation of G with frequency [Equ. (3)] will be excessive. If therefore $(1 - b)$ is not small, whether it is positive or negative, a_1 will not be very different from a. On the other hand, if $(1 - b)$ is comparable with λ, a_1 can be very different from a. Suppose, for example, that $b = 0{\cdot}99$. Then Equ. (18) reduces to

$$a_1 = \frac{0{\cdot}0394 - 7{\cdot}8412\lambda}{0{\cdot}0394 + 7{\cdot}8412\lambda} \qquad \ldots \ldots \ldots (19)$$

and therefore if λ is just below $+0{\cdot}005$, a_1 is small and positive, while if λ is just above (i.e. nearer zero than) $-0{\cdot}005$, a_1 is very large. Hence although the value of a for maximal flatness is in this case very close to unity [from Equ. (14) with $b = 0{\cdot}99$ or Equ. (19) with $\lambda=0$] λ will not numerically exceed 0·005 for *any* value of R_1/R_2, so that the error in x will not exceed ½% and there will be very little change of G_1 with frequency whatever the value of R_1/R_2 may be. Correspondingly, if we put $(1 - \epsilon)$ for b in Equ. (18) and neglect ϵ^2 and $\epsilon\lambda$, Equ. (18) reduces to

$$a_1 = \frac{\epsilon - 2\lambda}{\epsilon + 2\lambda} \qquad \ldots \ldots \ldots \ldots \ldots (20)$$

and, therefore, although the correct value for maximal flatness is found from Equ. (14) to be unity, λ will only lie between $+\frac{1}{2}\epsilon$ [$R_1 \ll R_2$, a_1 small] and $-\frac{1}{2}\epsilon$ [$R_1 \gg R_2$, a_1 large] whatever the value of a_1 may be.

If $\frac{1}{2}\epsilon$ numerically exceeds the greatest value of $|\lambda|$ that can be tolerated, say λ_0, then Equ. (20) shows that a_1 can only be varied between finite limits which include the value given by Equ. (14); in fact

$$\frac{|\epsilon| - 2\lambda_0}{|\epsilon| + 2\lambda_0} < a_1 < \frac{|\epsilon| + 2\lambda_0}{|\epsilon| - 2\lambda_0} \qquad \ldots \ldots \ldots (21)$$

and, as we have already noted, if $|\epsilon|$ is large compared to λ_0 [though still sufficiently small to justify the neglect of ϵ^2 and $\epsilon\lambda$ in deriving Equ. (20)] a_1 differs little from the value unity obtained for a in Equ. (14) neglecting ϵ^2. If ϵ^2 cannot be neglected, we must, of course, use Equ. (18) instead of Equ. (20), but the result is still essentially the same—a_1 does not differ appreciably from a if the error in x is to be kept within the prescribed tolerance.

Thus the apparently anomalous case when $b=1$ is now seen in its proper perspective as a limiting case. The value a_0 of a obtained from Equ. (14) after the factor $(1 - b)$ is cancelled always gives maximal flatness, and if $(1 - b)$ is not small (whether positive or negative) we cannot vary a appreciably from a_0 without seriously disturbing the constancy of G_1 with respect to frequency. If $(1 - b)$ is small, but of the same order of magnitude as the maximum relative discrepancy in x that can be tolerated, a_0 is still the correct value of a for maximal flatness, but considerable variation of a can be permitted without seriously disturbing the constancy of G. When $(1 - b)$ is very small, even the variation of a from 0 to ∞ will have so little effect on the value of x, that the maximal flatness is virtually independent of a. When b is actually 1, we simply proceed to the limit so that the maximal flatness is completely independent of the value of a, and no tolerance in the value of x is required.

U.S. ELECTRONICS

The 6th National Symposium on Reliability and Quality Control in Electronics will be held at the Statler Hilton Hotel, Washington, D.C. from 11th to 13th January 1960. Information regarding the submission of papers and attendance at the Symposium may be obtained from Mr. R. Brewer of the Research Laboratories, The General Electric Co. Ltd., Wembley, Middlesex. (Arnold 1262).

Coaxial-Cable Performance

DETERMINATION OF SINE-SQUARED PULSE RESPONSE

By W. A. Cameron, B.Sc., A.M.I.E.E.*

The British Post Office has recently included in its specification for repeater sections of 0·375-in. coaxial cable, pulse measurements of impedance regularity, and has followed the C.C.I.T.T.† recommendations[1] governing the overall testing of television links, that the test pulse should be sine squared in shape. This specification is for a three-mile and six-mile repeater spacing and requires a test pulse of width at half height of 0·1 μsec.

The transmission of a transient waveform through a cable causes a decrease in amplitude of the waveform and an increase in its effective width. Thus the measurement of impedance regularity of a cable by pulse reflection requires a knowledge of the response of the cable to the impulse used. This can be measured experimentally using multiple reflections in a short length of cable, or calculated from a knowledge of the pulse shape.

Measurement of the Pulse Response of Coaxial Cable

Equipment essential for the pulse measurement of cable impedance regularity consists of a pulse generator and a high-speed oscilloscope with a fairly high sensitivity[2].

In order to measure the pulse response of the cable, the pulse generator, which is normally of low output impedance, is connected to a short length l of the cable under test through a series resistor of value R, and the output from the cable is connected to the oscilloscope input (which is of impedance R_0) through a similar resistor (as shown in Fig. 1). Due to the presence of the second resistor, a discontinuity will exist and, at this point, the input pulse will be reflected and an echo pulse will travel along the cable towards the pulse generator where it will again be reflected. At each point of discontinuity there will be a reflection factor of

$$\rho = \frac{R - R_0}{R + R_0} \quad \ldots \quad (1)$$

and a voltage transmission factor of

$$k = \frac{2\,R_0}{R + R_0} \quad \ldots \quad (2)$$

where R_0 is the characteristic impedance of the cable. Thus, if R is chosen to be much larger than R_0 and the oscilloscope is of a sufficiently high gain to compensate for the factor k then, for each input pulse, a train of impulses will be displayed on the oscilloscope and the nth impulse of the train will be distorted due to transmission along a length $(2\,n - 1)\,l$ of cable. Since the maximum value of R will be limited by the available gain of the oscilloscope amplifier, a correction to each pulse height will have to be made for the additional attenuation due to the factor $\rho^{2(n-1)}$. Fig. 2 shows a typical echo train and Fig. 3 the decrease of the pulse height with the length of cable traversed, as measured in the laboratory on 750 yards drum length of 0·375 in. coaxial cable using this technique. These results have been corrected for the additional attenuation due to the factor $\rho^{2(n-1)}$.

Calculation of the Response of 0·375 in. Trunk Coaxial Cable to a Sine-Squared Pulse

If a linear system is driven by a transient signal and if the transient is of sufficiently short duration then the output waveform from the system may be approximated by the impulse response of the system. The pulse response of a system is its response to a Dirac impulse $\delta(t)$ which has a Laplace Transform given by

$$\int_0^{\infty} e^{-st}\,\delta(t)\,dt = 1 \quad \ldots \quad (5)$$

As is well known[3], if $i(t)$ is the system impulse response and $f(t)$ the input waveform then, assuming zero initial values, the output will be given by the convolution integral

$$V_0\,(t) = \int_0^t i(\tau)\,f\,(t - \tau)\,d\tau \quad \ldots \quad (6)$$

and by use of this integral one may compute the response

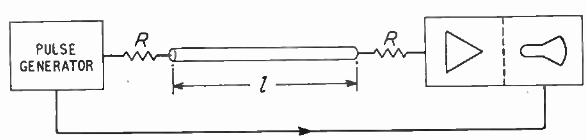
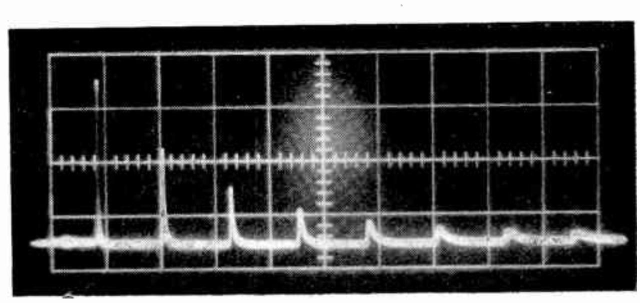


Fig. 1. *Measurement of cable pulse response by multiple reflections*

Fig. 2. *Typical echo train*



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† International Telegraph and Telephone Consultative Committee.

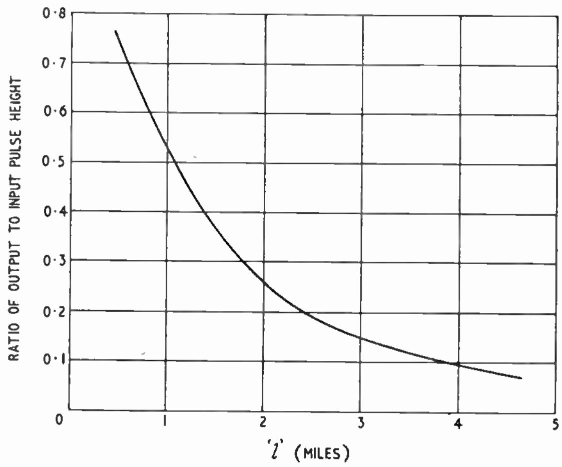


Fig. 3. *Measured decrement in pulse height v. length of cable*

of a linear system to any waveform from a knowledge of the system impulse response.

The transmission of a voltage wave along a correctly terminated transmission line is given by

$$V(x) = V(0)\, e^{-Px} \qquad \ldots \quad (7)$$

where P is the propagation constant for the line and x is the distance along the direction of propagation. For a coaxial cable with low dielectric loss

$$P = jHf + (1 + j)\, K \sqrt{f}$$

where H and K are constants depending on the cable dimensions. Putting $s = j\omega = 2\pi jf$

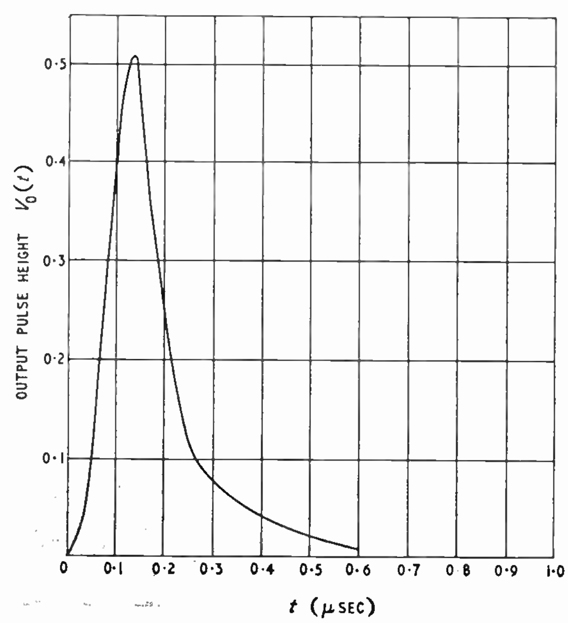
$$Px = \frac{HXs}{2\pi} + \frac{Kx}{\sqrt{\pi}}\sqrt{s} \qquad \ldots \quad (8)$$

where, for 0·375-in. trunk coaxial cable,

$$K = 4{\cdot}375 \times 10^{-4}.$$

In a transient analysis we may neglect the basic time delay due to exp $-(HX\,s/2\pi)$ and consider the response

Fig. 4. *Sine-squared pulse response of one mile of cable*



of a network having the transfer characteristic

$$V_0(s,x) = V_i(S,O)\exp\left(\frac{-Kx}{\sqrt{\pi}}\sqrt{s}\right) \qquad \ldots \quad (9)$$

The impulse response of the cable is given by the inverse transform of

$$\exp\left(\frac{-Kx}{\sqrt{\pi}}\sqrt{s}\right)$$

which is given by Carslaw and Jaeger[3] as

$$i(t) = \frac{Kx}{2\pi t}\,3/2\,\exp\left(\frac{-K^2x^2}{4\pi t}\right) \qquad \ldots \quad \ldots \quad (10)$$

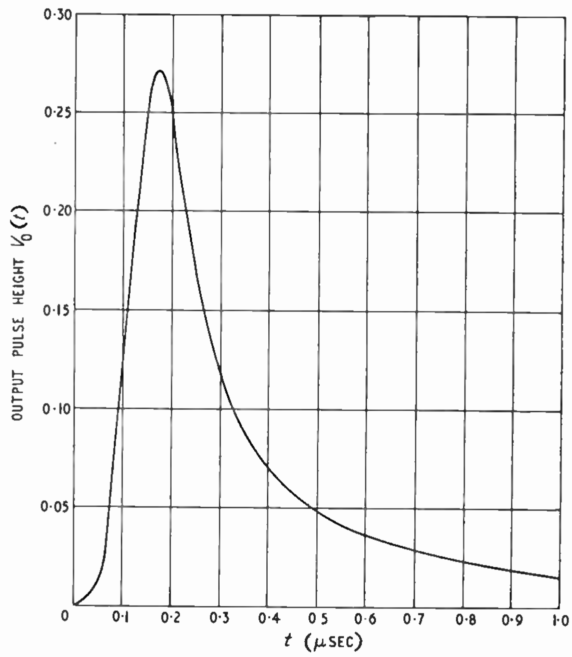


Fig. 5. *Sine-squared pulse response of two miles of cable*

Substituting Equ. (10) into the integral (6) and taking

$$f(t)\begin{cases} = \sin^2(\pi t/2T),\ 0 \leqslant t \leqslant 2T \\ = 0,\ t < 0 \text{ and } t > 2T \end{cases} \qquad \ldots \quad (11)$$

we see that the output waveform from the cable is given by

$$V_0(t) = \frac{Kx}{2\pi}\int_0^t \frac{1}{\tau}\,3/2\,\exp\left(\frac{-K^2x^2}{4\pi\tau}\right)\sin^2\frac{\pi}{2T}(t-\tau)\,d\tau \qquad \ldots \quad \ldots \quad (12)$$

This integral has been evaluated over the relevant range of t for x = 1, 2, 3, and 4 miles using a Hollerith HEC 2M digital computer. Graphs of the output waveform for these lengths of cable are given in Figs. 4–7. Fig. 8 shows how the calculated height of the output pulse varies with cable length, and is in good agreement with the measured curve given in Fig. 3. Fig. 9 gives the pulse height attenuation in dB plotted against the cable length in yards. This is the curve which would normally be used in correcting a cable echo response to allow for pulse-height attenuation.

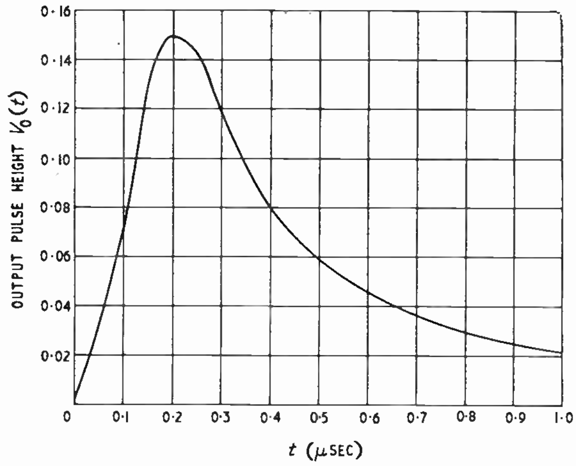


Fig. 6. *Sine-squared pulse response of three miles of cable*

Validity of the Impulse Approximation

It is of interest to know the minimum length of cable for which it is valid to consider the pulse as an impulse in computing the attenuation of the pulse amplitude and this question will now be considered.

The Laplace Transform of the sine-squared pulse is given by

$$V_i(s) = \int_0^\infty e^{-st} \sin^2 \frac{\pi t}{2T}\, dt$$

$$= \left\{\frac{1 - e^{-2sT}}{2}\right\} \left\{\frac{1}{s} - \frac{sT^2}{s^2T^2 + \pi^2}\right\} \quad .. \quad (13)$$

We may expand this in ascending powers of T as

$$V_i(s) = T - sT^2 + s^2T^3 \left\{\frac{2}{3} - \frac{1}{\pi^2}\right\} - s^3T^4 \left\{\frac{1}{3} - \frac{1}{\pi^2}\right\} \quad .. \quad .. \quad (14)$$

Now, $V_0(s) = V_i(s)\, Z(s)$, where $Z(s)$ is the system function.

Thus from Equ. (14) we see that since, assuming zero initial conditions, multiplication of the system function by s^n implies the nth differentiation of the system impulse response we may, by performing the requisite differentiations, expand $V_0(t)$ in ascending powers of T as

$$V_0(t) = T\, i(t) - T^2 \frac{di(t)}{d(t)} + T^3 \left\{\frac{2}{3} - \frac{1}{\pi^2}\right\} \frac{d^2i(t)}{dt^2} - T^4 \left\{\frac{1}{3} - \frac{1}{\pi^2}\right\} \frac{d^3i(t)}{dt^3} \quad .. \quad (15)$$

where $i(t) = \dfrac{Kx}{2\pi t}\, 3/2 \exp\left\{-\dfrac{K^2x^2}{4\,\pi t}\right\}$

$$= \frac{b}{t}\, 3/2 \exp\left(-\frac{a}{t}\right)$$

$$\frac{di(t)}{dt} = \left\{\frac{a}{t^2} - \frac{3}{2t}\right\} i\,(t)$$

$$\frac{d^2i(t)}{dt^3} = \left\{\frac{a}{t^2} - \frac{3}{2t}\right\} \frac{di(t)}{dt} + \left\{\frac{3}{2t^2} - \frac{2a}{t^3}\right\} i\,(t)$$

Since we are interested in the peak response we shall consider the validity of the approximation at the time when $di(t)/dt = 0$, that is when

$$t = \frac{2a}{3} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (16)$$

Thus neglecting powers of T greater than the third we require that

$$\left| T^3 \left\{\frac{2}{3} - \frac{1}{\pi^2}\right\} \frac{d^2i}{dt^2} \right| \ll \left| T\, i(t) \right|$$

$$\text{or} \left| T^2 \left\{\frac{2}{3} - \frac{1}{\pi^2}\right\} \left\{\frac{3}{2t^2} - \frac{2a}{t^3}\right\} \right| \ll 1$$

or substituting from Equ. (16) $1{\cdot}89/a^2 \ll 1$. For an 0·1-μsec pulse on 0·375-in. trunk coaxial cable

$$a = 0{\cdot}153 \times 10^{-7}\, x^2$$
$$T = 10^{-7} \text{ sec}$$

and our requirement becomes

$$x^4 \gg 80{\cdot}7$$

$$\text{or } x > 3 \text{ miles} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (17)$$

Substituting Equ. (16) into Equ. (12) we obtain

$$i(x)_{\text{peak}} = \frac{T\, 3\sqrt{6\pi}\, \exp}{K^2\, x^2} (-1{\cdot}5) = \frac{1{\cdot}518}{x^2} \quad .. \quad (18)$$

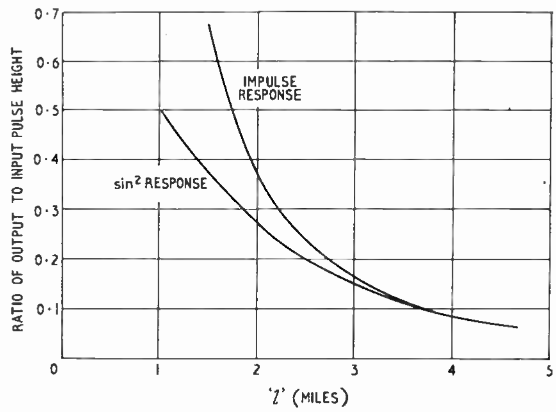
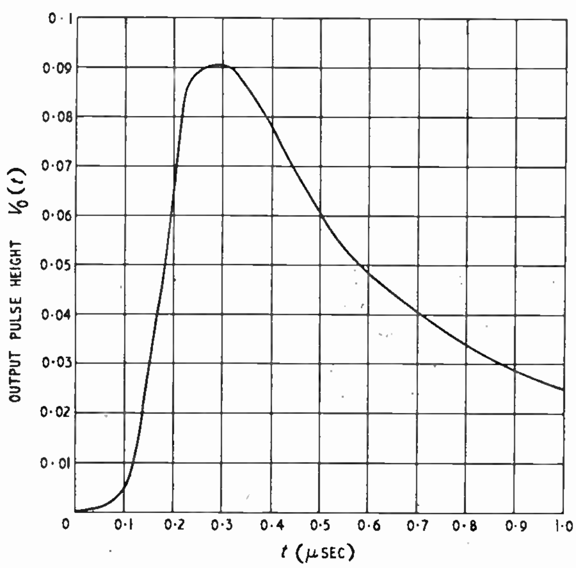


Fig. 8. *Peak height of output wave*

Fig. 7. *Sine-squared pulse response of four miles of cable*



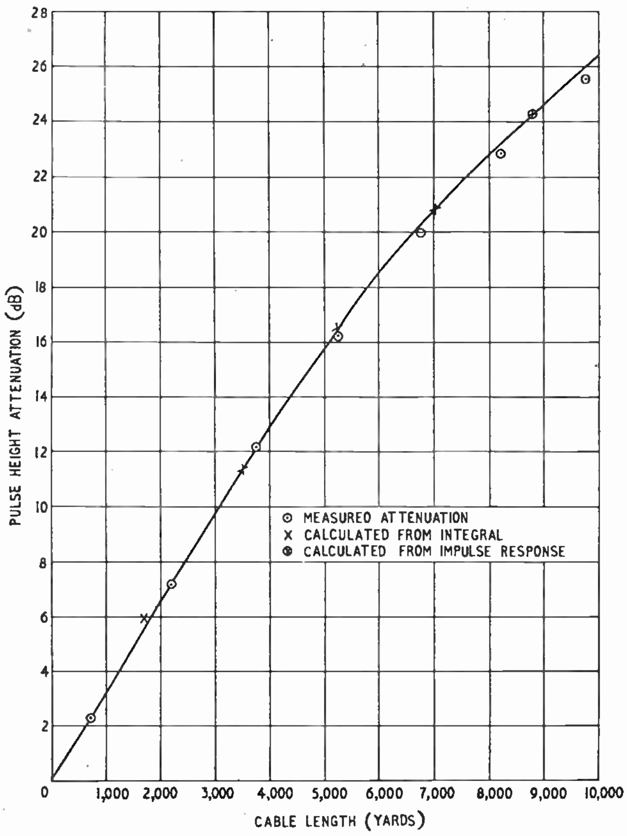


Fig. 9. *Height attenuation of* 0·1 *μsec sine-squared pulse*

where x is in miles and for 0·375-in. trunk coaxial cable $K = 4{\cdot}375 \times 10^{-4}$ and $T = 10^{-7}$.

Thus we see that for cable lengths of greater than three miles the pulse height is decaying according to the inverse square of the cable length. That is, doubling the length of cable traversed will produce an additional attenuation of 12 dB.

This function is shown in Fig. 8 where it is compared with the peak height of the response of the cable to an 0·1-μsec sine-squared pulse.

Conclusion

Methods have been described for the calculation and measurement of the response of a length of cable to a transient waveform of given shape. In particular, a curve has been derived for the attenuation of the peak amplitude of an 0·1-μsec sine-squared pulse propagating through 0·375 in. diameter coaxial cable of the type used for trunk telephony.

REFERENCES

[1] Volume I of the Red Book of the C.C.I.T.T., Geneva, 1956, p. 229.

[2] F. F. Roberts, "A Pulse Test Set for the Measurement of Small Impedance Irregularities in High Frequency Cables", *Proc. Instn elect. Engrs*, Part III, January 1949, Vol. 96, p. 17.

[3] H. S. Carslaw and J. C. Jaegar, "Operational Methods in Applied Mathematics" Oxford University Press, 1948.

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.

Comparison of Four Television Standards

SIR,—Dr. Haantjes and Mr. Breimer of Philips' Research Laboratories, have pointed out the existence of an error in the Appendix of my article, "Comparison of Four Television Standards", which appeared in *Electronic & Radio Engineer*, November 1957. The formula for the group delay, $\tau(x)$, given in the caption of Fig. 6, is too small by a factor n and this means that the scale of group-delay ordinates in Fig. 6 requires multiplication by 40 for the U.K., U.S. and West European television systems, whilst the French system requires a multiplication by 15. The same remarks apply to the ordinate scale of Fig. 7, whilst in Fig. 8 each ordinate corresponding to a given abscissa, n, must be multiplied by that value of n. Also, the formula for $\phi(x)$ must be multiplied by n.

The result of this correction is to make the group-delay errors caused by the Nyquist slope in the receiver no longer negligible, as was suggested in the original article.

The last column of the attached table gives a measure of the group-delay error as a proportion of the duration of a picture element. It will be seen from this that the U.K. system suffers very little degradation, but that the West European 625-line system, employing negative modulation, gives rise to an error across the video band of nearly three picture elements. It is, of course, true

Television system	Parameter, n determining steepness of Nyquist slope in receiver	Picture Element duration τ_0 (μsec)	Group delay at vision carrier .f., $\tau(\omega_0)$ (μsec)	Group delay at cut-off frequency of main sideband $\tau(\omega_0+\omega_c)$ (μsec)	Difference: $\tau(\omega_0)-\tau(\omega_0+\omega_c)$ (μsec)	$\frac{\tau(\omega_0)-\tau(\omega_0+\omega_c)}{\tau_0}$
U.K.	40	0·167	0·52	0·36	0·16	0·96
U.S.	40	0·125	0·52	0·30	0·22	1·76
West European neg. mod. 5-Mc/s video	40	0·100	0·52	0·24	0·28	2·80
French	15	0·048	0·142	0·073	0·069	1·44

that much greater errors than these may arise in practice and, furthermore, the modulation depth has an effect upon the way in which these group-delay errors are translated into distortion of the response of a receiver to transient excitations.

D. Maurice.

B.B.C. Research Department,
Kingswood Warren,
Surrey.
9th September 1959.

Echo-Distortion in Frequency Modulation

Sir,—Mr. Medhurst's article in the July issue, p. 253, is a valuable contribution to the study of multichannel radio systems, and has been read with interest. Some of the results given have been compared with measurements made in this Laboratory, and good agreement has been found.

It may be of interest to mention a further approximate result when θ_0 is large, derived from a consideration of the f.m. noise-power spectrum. This approximation neglects the effect of the carrier phase and therefore gives only the mean distortion power ratio; it is,

$$\frac{1}{r^2}\frac{D}{S} = \frac{1}{2\sqrt{\pi A^3}\left(1 - \frac{\sin\theta_0}{\theta_0}\right)^{\frac{1}{2}}} \exp - \frac{1}{4A^2\left(1 - \frac{\sin\theta_0}{\theta_0}\right)}$$

where Mr. Medhurst's symbols are used. The result is valid only for large values of A; it closely follows the mean-power curves derived from Figs. 1 and 2 for $A\,\theta_0 > 2$ and $A > 1$.

It may also be noted that the mean-power curves lie 3 dB below the corresponding curves in Fig. 1 over the region where Equation (7) is valid (approximately $A\,\theta_0 < \frac{1}{2}$).

Post Office Engineering Dept., R. Hamer
Cardiff.
18th September 1959.

New Books

Synthesis of Linear Communication Networks

By Wilhelm Cauer. Pp. 866 + xxxvi. McGraw-Hill Publishing Co. Ltd., 95 Farringdon Street, London, E.C.4. Price £7.17s.

This is not a 'new' book. The first edition of this classic of German and international circuit theory was completed in 1940 and published in Germany in 1941 (under the title "Die Theorie der linearen Wechselstromschaltungen"). A new, much enlarged, edition was originally planned and prepared by Cauer himself. After his tragic and early death in 1945 a second edition was prepared by Klein and Pelz and published (again in German) in 1954. This edition contains some additions based on various Cauer manuscripts and a number of explanatory comments and notes by the editors. Now an English (or rather American) translation, based on the second German edition, has been prepared by Knausenberger and Warfield. Some of the material has been re-arranged, and some notes and comments by the translators and "a commentary of latest developments in network theory together with a bibliography of pertinent English-American literature" have been added.

Cauer is one of the pioneers and architects of modern network theory. One of his first important contributions was the generalization of Foster's reactance theorem, on the one hand by means of continued fraction expansions leading to ladder structures, and on the other hand by extending it to *RC* and *RL* two-terminal networks. This was followed by the application of elliptic function theory to approximation ('interpolation') problems in network design (combined with a modern treatment of lattice filters). He continued to contribute to all problems of modern network synthesis, always with originality and mathematical rigour, his fundamental aim being the creation of 'exact mathematical' synthesis methods.

Modern synthesis methods are characterized by three stages.

1. General types and structures of 'physically possible' networks are studied and corresponding classes of network performance characteristics are determined.
2. The performance characteristics required in a particular design or synthesis problem (which originally do not exactly correspond to those of a physically possible network) are *approximated* by suitably chosen characteristics which do correspond to such a network.
3. A network is *realized* which corresponds to the chosen approximating characteristics.

Until less than two years ago there were no text books in English dealing in a comprehensive way with such modern synthesis methods. Today the situation is different, and this is chiefly due to the publication of Guillemin's latest book "Synthesis of Passive Networks" (which has to be considered together with his well-known previous books).

Thus the question arises:—What purpose is served by the publication of another book which deals basically with the same subject and which in its essential parts is now nearly 19 years old? To this reviewer the answer seems clear:—Quite apart from the historical interest with which many research workers in this field will greet the publication of this translation, there are at least three eminently practical aspects which ought to be stated. First, this book is widely quoted in publications, but access to it was difficult until now. Secondly, even after nearly two decades this is an invaluable reference book for the serious research worker in this field; as an example it may be mentioned that some derivations of important formulae, given without proof in Darlington's famous publication on insertion-parameter filters, will be found in Cauer's book. Thirdly, the treatment and style in Cauer's book are quite different from those in Guillemin's book. Where Guillemin always seems to remain the teacher, passionately interested in making matters easy for the reader—without in any way lowering the standard—Cauer's main interest seems to lie in mathematical rigour and in the generality of results. This difference in the two authors' styles and methods of approach increases by their very contrast the attraction and value of the appearance of Cauer's book in an English edition.

The book begins with four prefaces of various kinds, a short biographical note by his widow and an extract from an obituary, written by K. W. Wagner. After a list of Cauer's publications and patents and a detailed list of contents there is an Introductory Chapter which has been added in the second edition and is based on an original monograph by Cauer. Its value appears doubtful, as it is in many parts difficult to understand unless the reader is already familiar with the book or at least with the subject matter. On page 28 the characteristics function ψ (where ψ is defined by the expression $A = \log_e \sqrt{1 + |\psi|^2}$ for the 'operating loss' A) is discussed. Here the statement ". . ., if the operating loss is prescribed, ψ can be found except for its sign" is wrong (the corresponding statement on p. 27 in the second German edition "if the operating loss is prescribed, ψ can generally be chosen *in various different ways*, even apart from its sign" is correct). The following chapters are: 1. Statement of the Problems and Examples; 2. Circuit Analysis; 3. Two-Terminal-pair Networks; 4. Positive-real Functions and Positive Matrices; 5. Reactance Theorems; 6. Image Parameter Theory of the Low-pass Reactance Filter; 7. Generalized Image-parameter Theory. Then there are two appendices (1. Two-terminal-pair-network Formula Collection, and 2. Practical Filter-design Techniques Based on the Image-parameter Theory) which complete the first part of this book. In the English edition there are two parts (designated as 'volumes 1 and 2'), though the book is published like its two German predecessors in one single volume, and though the German editions do not show any division into two parts. This sub-division of the English edition, involving a re-arrangement of appendices, is regrettable as it may cause confusion, particularly as Dr. Glowatzki, a pupil of Cauer, is preparing a 'second volume' for the German edition, containing so far unpublished Cauer manuscripts (announced in the second German, but not in the English edition).

The chapter headings of part II of the English edition are: 8. Reactance Two-terminal-pair Networks with Prescribed Operating Conditions; 9. Frequency Band-separating Networks; 10. Equivalence of Reactance Networks. They are followed by five appendices (1. Aids in Linear Algebra; 2. Elements of the Theory of Analytic Functions; 3. Solution of Some Chebyshev Extremal Problems; 4. Practical Filter Design Techniques Based on the Operating-parameter Theory; 5. Recent Advances; Supplementary References) and by an Index. Appendix 5 represents an attempt to bring the book up to date.

Summarizing, it may be said that the editors and translators of this book had a very difficult task and the result can be criticized, and could probably be improved, in many details. However, this is rather unimportant. It should also be said that this is emphatically not a book for a first study of the subject, and even for a specialist it would not serve as the only book on synthesis. However, "Cauer" should be studied and consulted by, and be accessible to, everybody working in the field of modern network synthesis and design. The publication of this translation will make the attainment of this aim very much easier. W.S.

Noise in Electron Devices

Edited by LOUIS D. SMULLIN and HERMANN A. HAUS. Pp. 413 + xvi. Chapman & Hall Ltd. (for John Wiley), 37 Essex Street, London, W.C.2. Price 96s.

The 'electron devices' with which this book is concerned might be summarized as active network devices, since they are grid-controlled thermionic valves, electron-beam tubes and transistors. This is further emphasized by decorating the cover with a pattern of "$2eI_0\Delta f$", and the impression on the reader is almost that pains have been taken to seclude mention of $4RkT\Delta f$ from the book as far as possible. This is unfortunate, because the minimum noise of most thermionic devices is proportional to cathode temperature.

Of the authors contributing to this book, Haus, Quate and Peter are known to all who are interested in electron-beam tubes, and Van der Ziel is known as an authority on flicker noise and semi-conductors. Noise in multi-electrode valves is covered by Talpey (who has published work on elastically-reflected electrons in relation to induced grid noise), and noise in practical transistors and transistor amplifiers by Fonger of R.C.A. Laboratories, Princeton. The book contains a great deal of information which hitherto has been scattered in the literature and thus will be a valuable introduction for anyone intending to specialize in one of the three fields which it covers. It claims to its credit thorough mathematical analyses, but at times one feels a lack of that physical interpretation which would assist in transferring the theory to new applications.

The book is based on a vacation course given at M.I.T. in 1955, and unfortunately for the authors the intervening years have been exceptionally fruitful in the development of amplifying devices. The maser and the (variable-capacitance) parametric amplifier appear only by way of apology in the preface, and the book includes neither the most recent work on low-noise guns for conventional travelling-wave tubes nor the recent work on 'fast-wave' low-noise beam amplifiers.

The reader who has followed this book will have no difficulty in following the subsequent literature on electron-beam amplifiers, but he may feel the lack of guidance in approaching the noise properties of the maser. D.A.B.

Television Servicing

By ALEX LEVY and MURRAY FRANKEL. Pp. 534 + vii. McGraw-Hill Publishing Co. Ltd., 95 Farringdon Street, London, E.C.4. Price 43s.

This should be a useful book to anyone concerned with American television receivers. Its application to British receivers, however, is limited by the difference between the two television systems, for these have led to big differences in receiver circuitry. W.T.C.

Basic Electricity

By VAN VALKENBURGH, NOOGER & NEVILLE Inc. Pp. 596 in 5 parts. The Technical Press Ltd., 1 Justice Walk, Chelsea, London, S.W.3. Price 55s.

These books form a course of training developed for the U.S. Navy and adapted to British and Commonwealth usage by a special electronics training investigation team of R.E.M.E. They are of a very elementary nature, starting with the electron and frictional electricity and ending with circuit breakers.

Anyone examining these books is apt to be misled by the form of the illustrations. Many are of a pictorial character, which will undoubtedly help the real beginner, but most are far too big, creating an impression almost of a child's picture book. The text, however, is clearly written and the material is, in the main, well presented.

The books form a first course of an unusual character and one which is worth studying by anyone interested in elementary training. W.T.C.

Radio Circuits (4th Edition)

By W. E. MILLER, M.A.(Cantab.), M.Brit.I.R.E. Revised by E. A. W. SPREADBURY, M.Brit.I.R.E. Pp. 172 + ix. Published for *Wireless & Electrical Trader* by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 15s.

BRITISH STANDARDS

Fixed Electrolytic Capacitors (Aluminium Electrodes)

Pp. 10. B.S. 2134, Part 2: 1959. Price 5s.

Year Book 1959

Pp. 543. Contains information about the Institution and the services it offers. It lists the British Standards current at 1st January 1959. Price 15s.

These publications can be obtained from British Standards Institution, 2 Park Street, London, W.1.

NATIONAL BUREAU OF STANDARDS

On the Theory of Fading Properties of a Fluctuating Signal imposed on a Constant Signal

By H. BREMMER. Pp. 32. Price 32 cents.

Standards Materials issued by the National Bureau of Standards

Pp. 27. Price 44 cents.

Tables of Osculatory Interpolation Coefficients

By H. E. SALZER. Price 38 cents.

Tables of the Exponential Integral for Complex Arguments

Applied Mathematics Series 51. Price $5·65.

Fractional Factorial Experiment Designs for Factors at Three Levels

Pp. 37. Price 38 cents.

Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure

Pp. 95. N.B.S. Handbook 69. Price 44 cents.

These publications can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.

MANUFACTURERS' LITERATURE

Brimar Valve and Teletube Manual No. 8. A 374-page catalogue including details of recent additions to the ranges of products available, as well as comprehensive information on many current equipment valves. The catalogue also includes: new rating charts for rectifiers, data on "Replacement and Obsolete" types and a revised circuits section. Price 6s.
Standard Telephones & Cables Ltd., Valve Division, Footscray, Sidcup, Kent.

Advance Components Catalogue. This revised edition includes comprehensive details of all current products: a.f. and r.f. generators, v.h.f. and f.m./a.m. generators, 'Q' meters, standard inductors, crystal calibrator, a.c. valve voltmeter, attenuator casting and switch, attenuators and coaxial switches.
Advance Components Ltd., Roebuck Road, Hainault, Ilford, Essex.

How to use Araldite Epoxy Resin Adhesives. A booklet produced as a guide to the materials which can be successfully bonded by Araldite.
CIBA (A.R.L.) Ltd., Duxford, Cambridge.

Electrical Insulation. A 24-page booklet describing electrical insulating materials produced by Langley London Ltd. Includes

information on mica and mica products and the range of Lantex laminates of paper-fabric and glass with bonds of phenolic, polyester, ethoxylene, silicone and other resins.
Langley London Ltd., Kelvin Way, Crawley, Sussex.

Permanent Magnets Summarized. This 48-page booklet was written by F. G. Tyack, A.M.I.E.E., of James Neill & Co. (Sheffield) Ltd., and gives practical information on design and application of permanent magnets.
James Neill & Co. (Sheffield) Ltd., Magnet Department, Napier Street, Sheffield 11, Yorks.

Regalox Alumina Ceramics. Booklet containing information on high-grade sintered alumina ceramic materials produced by *Royal Worcester Ceramics Ltd., Tonyrefail, Glamorgan.*

Beryllium Products. Illustrated technical brochures available on beryllium copper wrought alloys and beryllium metal.
Beryllium Smelting Co. Ltd.,
36-38 *Southampton Street, London, W.C.2.*

Mullard Photomultiplier Tubes. A 6-page folder giving characteristics, constructional details, etc., of photomultiplier tubes for scintillation counting.
Mullard Ltd., Torrington Place, London, W.C.1.

Copper Cables. Pp. 62. Contains chapters on the properties of copper and some of its alloys, the manufacturers of copper wire, power, transmission and other types of insulated cables. An appendix, bibliography and list of applicable British Standards, together with numerous diagrams and illustrations, are also included.
Copper Development Association, 55 South Audley Street, London, W.1.

MEETINGS

I.E.E.

27th October. "Future Trends in Memory Stores for High-Speed Digital Computers", discussion to be opened by W. Renwick, M.A., B.Sc.

28th October. "Development of Eurovision", by M. J. L. Pulling, C.B.E., M.A.

2nd November. "Some Comments on the Classification of Waveguide Modes", by A. E. Karbowiak, B.Sc.(Eng.), Ph.D., and "Some Comments on Quasi-Optical Methods at Millimetre Wavelengths", by L. Lewin.

3rd November. "An Analogue Electronic Multiplier using Transistors as Square-Wave Modulators", by P. Gleghorn, B.Sc.(Eng.).

6th November. Medical Electronics Discussion Group. Subject not announced, to commence at 6 o'clock.

9th November. "Theory of the Travelling-Wave Parametric Amplifier", by Prof. A. L. Cullen, Ph.D., B.Sc.(Eng.); "The Gain of Travelling-Wave Ferromagnetic Amplifiers", by P. J. B. Clarricoats, B.Sc.(Eng.),Ph.D.; "Some Properties of Travelling-Wave Resonance", by J. R. G. Twisleton, B.Sc., and "Saturation Effects in a Travelling-Wave Parametric Amplifier", by A. Jurkus, B.Sc., and P. N. Robson, B.A.

These meetings will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2, and will commence at 5.30, except where otherwise stated.

The Television Society

22nd October. "New Television Standards: Their Effect on British Television". Discussion.

6th November. "Deflection Techniques for 110° Picture Tubes", by B. Eastwood, B.Sc.

These meetings will commence at 7 p.m. at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2.

The Society of Instrument Technology

14th October. "An Automatic Analogue Computer for Missile Homing Investigations", by J. G. Thomason, B.Sc., to be held at Manson House, 26 Portland Place, London, W.1, at 7 o'clock.

Brit. I.R.E.

28th October. "Radio—Its Impact on Shipping", by Captain J. D. F. Elvish, C.B.E., and "A Historical Survey of Radar and Radio Aids to Aircraft Navigation", by Air Marshal Sir Raymund G. Hart, K.B.E., C.B., M.C.

4th November. "Input/Output Devices", half-day symposium; meetings commencing at 3 and 6 p.m.

11th November. "Physiological and Acoustical Aspects of Hearing" by R. P. Gannon, B.Sc., M.B., Ch.B.

These meetings will be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, and will commence at 6.30, except where otherwise stated.

NEW DIRECTOR FOR S.I.M.A.

The Scientific Instrument Manufacturers' Association of Great Britain have recently announced the inauguration of S.I.M.A.'s new Director—Captain Robert Alexander Villiers, C.B.E., A.M.I.E.E., R.N. (Retired).

OBITUARY

It is with regret that we learn of the sudden death of a well-known personality in the radio industry, Thomas Edward Goldup, C.B.E., M.I.E.E., aged 65.

Mr. Goldup joined Mullard Valve Co. in 1923, and in 1928 was responsible for the formation of their Technical Service Department. In 1938 he was made a director of Radio Transmission Equipment Ltd., now Mullard Equipment Ltd. and, in 1951, he was appointed a director on the main Mullard board.

In addition to his work for Mullard Ltd., Mr. Goldup was known throughout the industry for his active participation in matters relating to technical education. He was a member of many committees, including the British Standards Institution and Radio Industry Council, and he was Chairman of the Ministry of Supply at Malvern. ....

Mr. Goldup was appointed C.B.E. in 1954 and elected President of the Institution of Electrical Engineers for the year 1957/58.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Deviations from nominal frequency for July* 1959

Date 1959 July	MSF 60 kc/s 1500 G.M.T. Parts in 10^9	Droitwich 200 kc/s 1030 G.M.T. Parts in 10^9
1	NM	− 7
2	− 18·3	− 7
3	− 18·4	− 8
4	− 18·3	NM
5	− 18·0	NM
6	NM	− 10
7	− 18·0	− 11
8	− 18·5	− 12
9	− 18·5	− 12
10	− 18·2	− 13
11	− 18·1	NM
12	− 18·3	NM
13	− 18·1	− 11
14	− 18·0	− 9
15	− 18·2	− 9
16	− 18·4	− 9
17	− 18·6	− 9
18	NM	NM
19	− 18·7	NM
20	− 18·3	− 9
21	− 18·3	− 10
22	− 18·1	− 11
23	− 17·6	− 12
24	− 16·8	− 12
25	− 16·8	NM
26	− 16·4	NM
27	− 16·3	NM
28	− 16·0	NM
29	NM	NM
30	− 16·1	− 13
†31	NM	− 13

* *Nominal frequency is defined to be that frequency corresponding to a value of* 9 192 631 770 *c/s for the N.P.L. caesium resonator.*

† *At* 2400 *G.M.T. on this day the phase of the seconds pulses was advanced by* 20 *milliseconds. NM = Not Measured.*

New Products

Transistor Beta Tester

Siemens Edison Swan have announced a new low-priced battery-operated transistor tester.

Its purpose is to provide a quick run-of-the-mill test on all p-n-p transistors; current gain and collector leakage being measured under common-emitter conditions.

Current gain (β or α') within a range 10–150 can be read directly on a dial by adjusting the control until an audible note just ceases. This measurement can be

carried out at a collector current of 0·5–4 mA, the set collector current being read on a meter.

Leakage current is measured on the meter at a fixed voltage of 9 V. Accuracy of measurement $\pm$ 5% or $\pm$ 5, whichever is the greater.

Siemens Edison Swan Ltd.,
155 *Charing Cross Road, London, W.C.*2.

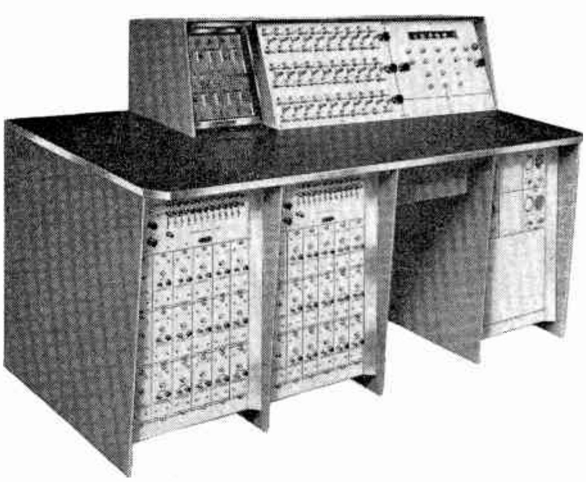
Space '30' Analogue Computer

Solartron Electronic Group have announced the introduction of a new general-purpose analogue computer designed for the solution of linear and non-linear simultaneous or single differential equations.

It includes 30 operational amplifiers (with computing components), 60 co-efficient potentiometers, 4 diode bridges, 4 relay amplifiers, 2 diode function generators, 4 servo multipliers, $\pm$ 100-V 200-mA reference supply, a digital voltmeter (5 digit), 816-way detachable patch panel, control and monitoring panel with automatic timer, a.c. mains stabilizer and all the necessary power supplies.

All the computing passive elements incorporated are of 0·1% accuracy.

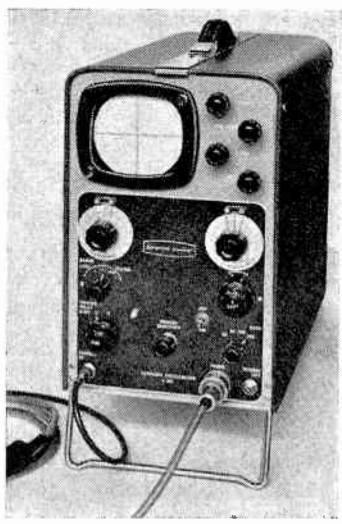
Solartron Electronic Group Ltd.,
Thames Ditton, Surrey.



Pulse Monitoring Oscilloscope

Mullard Equipment Ltd. have introduced a new pulse monitoring oscilloscope with the exceptionally fast rise-time of 2 mμsec, equivalent to a bandwidth of d.c. to 220 Mc/s.

The Instrument, type L362, has been designed for the display or measurement of



pulses between 3-mμsec and 3-μsec duration.

It has been developed from a design of the Atomic Energy Research Establishment, Harwell, and makes use of the sampling principle; the complete c.r.t. trace is built-up, as a low-frequency replica of the input, from a series of dots, each of which corresponds to a sample taken from successive repetitions of the input. A charge storage circuit maintains the position of a dot until the succeeding sample is taken.

Details from the makers' specification include:

Y System	
Sensitivity	150 mV/cm.
Voltage measurement range	1·5–0–1·5 V.
Input impedance	1 kΩ, 2 pF approx.
Noise level	10 mV peak-to-peak at probe input.
X *System*	
Time-base ranges	0·03, 0·1, 0·3, 1 and 3 μsec.
Calibration	By calibrated potentiometer scaled 0–1 and 0–3.
Trigger pulse delay	0·02–0·3 μsec and 0·3–2 sec.
Number of samples	25, 50, 100 or 200 approx.
P.r.f. limits	Approx. 50 c/s–10 kc/s.

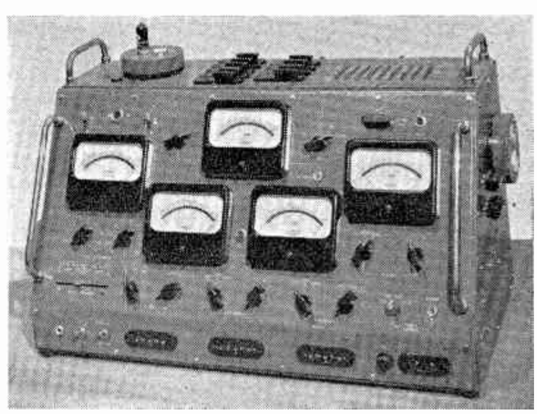
The L362 is distributed in the U.K. by

Research & Control Instruments Ltd.,
207 *King's Cross Road, London, W.C.*1.

Valve Analyser and Bridge

The Metrix valve analyser type U-61B is designed for the accurate and detailed analysis of static characteristics of receiving and low-power transmitting valves. In addition, it can be used to obtain neon-tube regulation curves and thyratron control characteristics. Positive-grid characteristics may also be obtained.

Five meters indicate simultaneously: heater voltage, anode voltage, screen voltage, grid voltage and anode or screen current. Four separate stabilized voltage sources provide the necessary electrode voltages, all of which are variable and available for external use by means of sockets on the front panel. A series of adaptors each carrying one or two valve bases is supplied, these adaptors fit into nine jacks on the valve panel and are available fitted with any valve base. Between the voltage and pin selectors and the adaptor jacks, there are sockets and jumpers which



allow circuit elements to be interposed in the electrode circuits.

The instrument is fitted with a system of overload cut-outs which protect the d.c. sources of h.t. and the milliammeters in the event of an overload caused by faulty setting-up or a defective valve.

The valve bridge type 661 is designed for the measurement of the dynamic characteristics of valves; amplification factor, internal resistance and slope.

It is almost identical in appearance to the analyser U-61B, and the two instruments can be connected together by means of a cable provided to form a completely self-contained assembly for the measurement of all static and dynamic characteristics. With this arrangement, the d.c. supplies from the U-61B are used to obtain the accurate static operating conditions when taking dynamic measurements on the bridge.

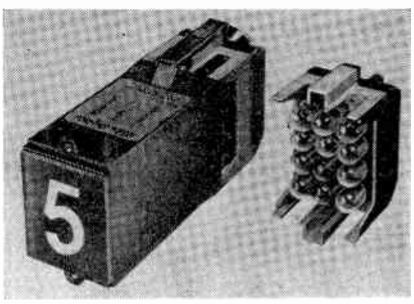
Possible measurements include: amplification factor ranging from 0·01 to 1,000, internal resistance from 100 Ω to 10 MΩ and slope from 0·001 to 100 mA/V. The minimum accuracy is 5% for the resistance range and 2·5% for other characteristics.

Manufactured by Compagnie Générale de Métrologie, France, these intruments are distributed in the U.K. by

Metrix Instruments Ltd.,
54 Victoria Road, Surbiton, Surrey.

Projection Type Indicator

Known as the Aldis Digilite Type A100, this new unit provides display facilities for



figures 0 to 9 plus two decimal points, one left, one right.

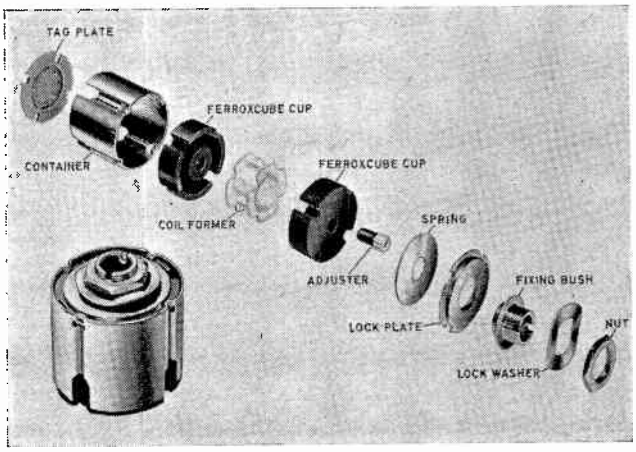
It comprises 12 lamps in a quick-release lamp housing and an optical lens system for projecting illuminated figures on to the front-viewing screen. Flush panel mounting gives an angle of view of 75° off axis in all directions. The height of the figures is 1·2 in.

R. B. Pullin & Co. Ltd.,
Phoenix Works, Great West Road,
Brentford, Middx.

Adjustable Ferrite Pot-Core Assemblies

Mullard has introduced a new range of adjustable ferrite pot-core assemblies known as 'Vinkors'.

They are made from a new grade of Ferroxcube material and incorporate an adjustable magnetic shunt which can vary



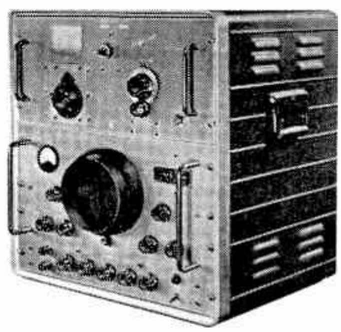
the inductance of an assembled coil ±7% with an accuracy of better than 2%.

The present range of 'Vinkors' comprises five types for use at frequencies up to 200 kc/s, with outside core diameters of 18, 21, 25, 30 and 35 mm respectively. Each size of core is available with an effective permeability of 160, 100 or 63.

Mullard Ltd.,
Torrington Place, London, W.C.1.

Spectrum Analysers

The new Polytechnic Series 860 spectrum analysers have been designed for precise spectrum measurements—evaluation of high v.s.w.r., leakage and loss; and analysis of radar, radio relay and other signals. Four



models are available, each with an accuracy of ± 0·8% or ± 1 Mc/s, to cover the frequency ranges 2,400 to 3,400 Mc/s, 3,000 to 3,700 Mc/s, 5,100 to 5,900 Mc/s and 8,500 to 9,600 Mc/s.

The Polytechnic analyser is essentially a sensitive, continuously-scanning microwave receiver which resolves the spectrum of an r.f. signal and presents it on a 5-in. c.r.t. screen. A complete analyser consists of one or more r.f. heads, with an indicator unit which contains a narrow-band i.f. amplifier, video amplifier, sweep circuits, cathode-ray tube, metering circuits and power supplies.

The radio-frequency range is determined by the r.f. head, each of which contains a calibrated input attenuator with 100-dB range, a swept microwave local oscillator, a calibrated frequency meter and a crystal mixer. The local oscillator is swept in synchronism with the horizontal trace of the c.r.t. so that the spectrum amplitude is displayed as a function of frequency; the sweep speed is variable from 5 to 30 c/s. The sensitivity of each r.f. head is better than −80 dBm and the maximum resolution between two adjacent signals is 40 kc/s.

These instruments are manufactured by Polytechnic Research & Development Co., Inc., U.S.A. and are distributed in the U.K. through

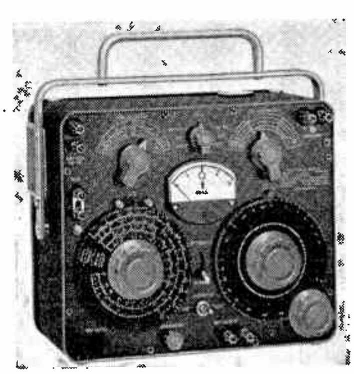
Leland Instruments Ltd.,
Abbey House, Victoria Street, London, S.W.1.

Impedance Bridge

Claude Lyons Ltd., U.K. distributors for General Radio Company, U.S.A., have announced the introduction of a new impedance bridge type 1650-A.

It is a general-purpose instrument designed for *R*, *C*, *L* and *Q* or *D* measurements. The bridge is complete with built-in transistorized 1-kc/s oscillator and selective detector and it incorporates the 'Orthonull' mechanism, which is a device to speed bridge-balance convergence when high-loss components are measured. The basic 'Orthonull' mechanism is a friction clutch that drives exponential variable-resistance arms making the normally electrically-interdependent *RCL* and *QD* adjustments independent by non-reciprocally ganging them.

When used with an external d.c. supply, the resistance range will measure a.c. and d.c. resistance values from 0·001 Ω to 10 MΩ with an accuracy of ± 1% ± 0·001 Ω. The capacitance range covers 1 pF to 1,000 μF (± 1% ±1 pF) and the inductance range 1 μH to 1,000 H (± 1%



± 1μH). The Q and D ranges measure a maximum of 1,000 and 50 respectively.

The carrying handle and protective face-plate cover combine to provide an adjustable-angle prop-stand for the bridge.

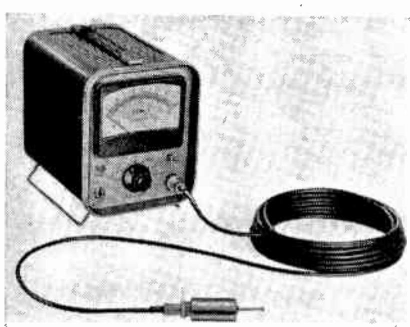
Distributed in U.K. by
Claude Lyons Ltd.,
Valley Works,
4-10 *Ware Road, Hoddesdon, Herts.*

Capacitance-Sensing Tachometer

Designed for the measurement of speed of rotating objects, this instrument can also be used for such applications as proximity measurement, timing and control of automatic processes and synchonization of fast-moving machinery.

Known as type CTM-1, it utilizes a capacitance probe which can be supplied with detachable end-pieces of various shapes, lengths and diameters.

In operation, the end-piece of the probe



is mounted near to, but not in contact with, any irregularity on the rotating part moving at the speed to be measured. The irregularity may be an indentation or a projection but must not be less than $\frac{1}{16}$ in. diameter × $\frac{1}{16}$ in. deep. Each time the irregularity passes the end-piece of the probe, a capacitance change is produced. This develops a voltage pulse which is fed via a cable to the counting instrument, which may be as much as several hundred yards away from the probe.

Details from the makers' specification include:

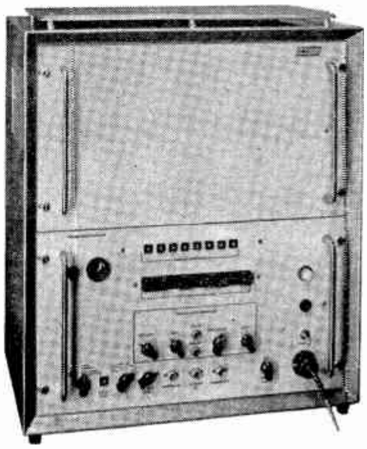
Range	..	0 to 200,000 r.p.m. (6 ranges)
Accuracy		better than 2%.
Drift	..	less than 1% in any hour.
Stability	..	better than ± 0·5% for ± 10 V mains fluctuation.
Power supply		200/250 V, 50 c/s.

Grunther Instruments Ltd.,
14 *Oriental Street, London, E.*14.

Time Calibrator Unit

A new version of their time calibrator unit has been announced by Cawkell Research & Electronics Ltd.

Known as type CU3A, it provides eight basic time-interval pulses which range from 0·5 μsec to 1 msec. Selection of the output is made by press-button switches and arrangements are made so that one, or any combination of the eight time intervals is available, in positive- or negative-going form, at one of the common output sockets.



The eight basic time interval pulses are also available from individual sockets mounted on the front panel of the instrument.

The markers are calibrated against an internal 2-Mc/s crystal-controlled oscillator and may be free-running or keyed from an external source.

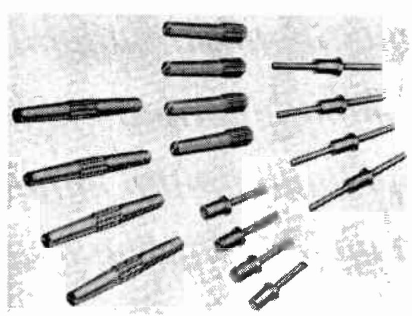
Details from the makers' data includes:

Accuracy	± 0·05% (when set against internal crystal)
Amplitude	± 50 V
Pulse width	0·5 and 1 μsec
Rise time	0·1 μsec.
Output loading	100 pF max.
Internal gate amplitude	− 50 V peak max.
Synchronizing signal	1 V peak min.

Cawkell Research & Electronics Ltd.,
Scotts Road, Southall, Middx.

Solder Pins

Two new ranges of solder pins have been introduced by Harwin Engineers Ltd. to meet the 0·052-in. hole recommended in B.S.S. 3081/1959 and Defence Guide 5007. They are available for rivet or force-fit



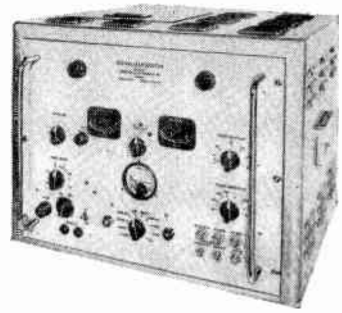
assembly for either single- or double-ended connections.

The pins are turned from solid brass and are flow-tinned.

Harwin Engineers Ltd.,
Rodney Road, Portsmouth, Hants.

'L'-Band Signal Generator

Winston Electronics has recently announced a new generator which provides a source of c.w. or pulse-amplitude-



modulated power over the frequency range 800–2,100 Mc/s.

Known as type 957, it utilizes a single continuously-variable control which is directly calibrated to an accuracy of ±1%. Frequency drift is less than 0·2% during the 'warm-up' period, after which it is approximately 0·003%/°C. The output power can be varied over the range 0 to −100 dB (relative to 1mW), by a directly-calibrated control. The output is taken via an 'N'-type connector which has an output impedance of 50 Ω at a v.s.w.r. not worse than 0·5. Modulation may be provided by: external pulses, the internal pulse generator or the internal generator synchronized by an external pulse or sine-wave generator at a rate of 40 to 4,000 c/s.

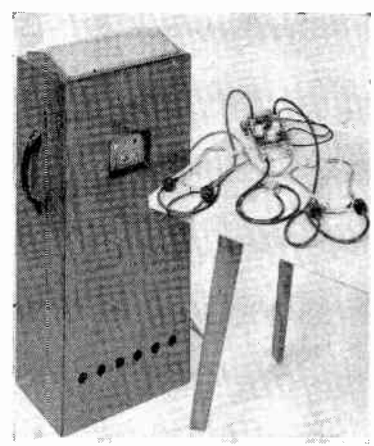
Other facilities include three calibrated controls for pulse width, pulse delay, pulse rate and two outputs for synchronization, one undelayed and the other delayed.

Winston Electronics Ltd.,
Govett Avenue, Shepperton, Middx.

Electronic Stethoscope

The Soniscope is an electronic stethoscope giving high gain in the audio range. It incorporates treble- and bass-frequency attenuators for the selection of required groups of frequencies in the sonic range.

The stethoscope consists of a miniature battery-operated valve amplifier, crystal



contact microphone and two sets of conventional earpieces. A special extension speaker is also available for use with the Soniscope.

Faraday Electronic Instruments Ltd.,
65 *Fairview Road, London, S.W.*16.

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

534.001.5(51) **2808**

Acoustics in China.—Ma Da-Yu. (*Akust. Zh.*, Oct./Dec. 1958, Vol. 4, No. 4, pp. 373–375.) Outline of the development of research in China since 1949, in the fields of ultrasonics, architectural acoustics, electro-acoustics, speech, musical acoustics and hearing.

534.213.4 **2809**

Attenuation of Plane Sound Waves of Finite Amplitude in Gases.—B. F. Podoshevnikov & B. D. Tartakovskiĭ. (*Akust. Zh.*, Oct./Dec. 1958, Vol. 4, No. 4, pp. 369–371.) Investigation of the dependence of attenuation on sound intensity. A graph shows the distribution of sound pressure in a resonant aluminium tube at a frequency of 13 kc/s.

534.22-8-14 **2810**

The Propagation of Sound in Sea-water.—A. V. J. Martin. (*Ann. Géophys.*, Oct.–Dec. 1957, Vol. 13, No. 4, pp. 307–309.) A brief description of laboratory experiments using an ultrasonic pulse technique to determine the velocity of sound in pure and salt water. See 1 of January.

534.22-8-14 **2811**

The Velocity of Ultrasound in Water near the Freezing Point.—N. F. Otpushchennikov. (*Akust. Zh.*, Oct./Dec. 1958, Vol. 4, No. 4, pp. 367–369.) Brief description of measurements made in distilled water at a frequency of 0·7 Mc/s in the temperature range + 20° to 0°C. Results indicate a velocity minimum at 0·7°C and a maximum adiabatic compression at + 2°C.

534.232-8-14 : 537.228.2 **2812**

Electrostrictive Generation of Ultrasonics in Liquids.—E. Gerdes. (*Naturwissenschaften*, June 1958, Vol. 45, No. 12, pp. 280–281.) Preliminary report on measurements to determine the magnitude of electrode deformation due to Coulomb attraction. See e.g. 310 of 1956 (Goetz).

534.26 **2813**

Diffraction of Sound Waves in Converging Beams.—B. D. Tartakovskiĭ. (*Akust. Zh.*, Oct./Dec. 1958, Vol. 4, No. 4, pp. 355–360.) Approximate formulae are derived for the sound field near the focal point of a converging beam, characterized by a nonuniform amplitude distribution over the wave front and spherical aberration.

534.522.1 **2814**

Measurements of Finite Amplitude Distortion of Progressive Ultrasonic Waves at Moderate Intensities.—K. L. Zankel & E. A. Hiedemann. (*Naturwissenschaften*, July 1958, Vol. 45, No. 14, pp. 329–330. In English.) Low-amplitude waves were investigated by measurements in water at 2 and 4 Mc/s, and in carbon tetrachloride at 2 and 3 Mc/s over a range of pressures and at various distances from the transducer.

534.614-8 **2815**

Measurement of Ultrasonic Wave Velocities and Elastic Moduli for Small Solid Specimens at High Temperatures.—H. J. McSkimin. (*J. acoust. Soc. Amer.*, March 1959, Vol. 31, No. 3, pp. 287–295.) Data for fused silica and single-crystal Ge are listed for temperatures up to 300°C in illustration of the measurement methods described.

534.614-8-14 **2816**

Modification of Ultrasonic Interferometer Design.—A. A. Isaev, I. G. Mikhaĭlov & A. S. Khimunin. (*Akust. Zh.*, Oct./Dec. 1958, Vol. 4, No. 4, pp. 363–364.) Note on the design of an improved quartz oscillator for use in interferometric measurements of sound velocity in liquids.

534.75 **2817**

Unpleasantness of Distorted Sounds: a Criterion derived from the Distortion Spectrum.—E. R. Wigan. (*Nature, Lond.*, 9th May, 1959, Vol. 183, No. 4671, p. 1320.) An objective criterion of 'unpleasantness' has been computed. Methods for checking it's validity are briefly discussed.

534.76 : 534.85 **2818**

Moving-Magnetic Stereo.—H. Horowitz. (*Audio*, May 1959, Vol. 43, No. 5, pp. 19–21..47.) A description of a pickup in which the stylus lever is attached to a magnet pivoted between the pole faces of two pairs of pickup coils. Characteristics are discussed.

534.78 : 621.39 **2819**

Intelligibility Evaluation of Voice Communications.—H. Schwarzlander.

(*Electronics*, 29th May 1959, Vol. 32, No. 22, pp. 88–91.) The integral of a difference voltage due to the pure speech signal and that passed through the system under test is used as a measure of intelligibility.

534.781 : 621.374.33 **2820**

An Electronic Speech Sampler for Studying the Effect of Sample Duration on Articulation.—R. Fatehchand & R. Ahmed. (*J. Instn Telecommun. Engrs, India*, March 1959, Vol. 5, No. 2, pp. 86–88.) The start of any word is signalled by a pulse which itself operates the subsequent electronic delay and gate.

534.845 **2821**

Panel Absorbents for Low-Frequency Sound Absorption.—N. K. D. Choudhury & M. V. S. S. K. Rao. (*J. Instn Telecommun. Engrs, India*, March 1959, Vol. 5, No. 2, pp. 103–108.) Resonant plywood panels show effective absorption in the range 75–300 c/s.

534.861 : 534.84 **2822**

The Acoustic Design of Talks Studios and Listening Rooms.—C. L. S. Gilford. (*Proc. Instn elect. Engrs*, Part B, May 1959, Vol. 106, No. 27, pp. 245–256. Discussion, pp. 256–258.)

621.395.623.7.001.4 **2823**

The Impedance and Phase Angle of Loudspeaker Loads.—R. E. Cooke. (*Muirhead Technique*, April 1959, Vol. 13, No. 2, pp. 11–16.) A description of the basic measurement circuit and a discussion of the impedance and phase-angle characteristics obtained for moving-coil and e.s. loudspeaker systems.

621.395.623.8 **2824**

Column Loudspeakers for Public-Address Systems.—M. L. Gayford. (*Electronics*, 12th June 1959, Vol. 32, No. 24, pp. 64–65.) The principles of design are briefly described, with particular reference to polar response.

621.395.625.3 **2825**

A Regulator of Speed and Pitch for Sound Recordings.—A. M. Springer. (*Elektronische Rundschau*, Aug. 1958, Vol. 12, No. 8, pp. 275–276.) An adaptor unit for magnetic-tape recorders is described. This has a rotating assembly of four magnetic heads to provide independent changes of speed and pitch in recordings.

AERIALS AND TRANSMISSION LINES

621.372.8 **2826**

The Design and Testing of Integrally Constructed Waveguide Assemblies.—G. Craven & V. H. Knight. (*Proc. Instn elect. Engrs*, Part B, Vol. 106, No. 27, pp. 321–334.) A microwave-link repeater is described as an example of an assembly. Testing facilities include a plug-in reflectometer and a frequency-sweep reflection display.

621.372.8 : 537.226 **2827**

Dielectric Image Lines.—S. P. Schlesinger & D. D. King. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 291–299. Abstract, *Proc. Inst. Radio Engrs*, Oct. 1958, Vol. 46, No. 10, p. 1777.)

621.372.821 **2828**

Measurement of the Properties of a Strip Line and its Transition Junction.—F. Norman. (*Proc. Instn Radio Engrs, Aust.*, Dec. 1958, Vol. 19, No. 12, pp. 788–795.) Measurements made in the range 8–11 cmλ indicate that a single modified TEM mode could be excited efficiently by means of a simple transition junction.

621.372.823 **2829**

The Waveguide for Low-Loss Transmission.—K. Noda, A. Konose, T. Fujii & K. Miyauchi. (*Rep. elect. Commun. Lab., Japan*, Oct. 1958, Vol. 6, No. 10, pp. 394–400.) A report of measurements of attenuation in straight circular waveguides, and in serpentine and uniform bends propagating the H_{01} mode in circular and elliptic waveguides.

621.372.826 **2830**

Launching Efficiency of Wires and Slots for a Dielectric Rod Waveguide.—R. H. DuHamel & J. W. Duncan. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 277–284. Abstract, *Proc. Inst. Radio Engrs*, Oct. 1958, Vol. 46, No. 10, p. 1777.)

621.372.832.43 **2831**

Centre-Excited TE°_{10}-TE°_{01} Mode Transducer.—B. Oguchi & K. Yamaguchi. (*Rep. elect. Commun. Lab., Japan*, Oct. 1958, Vol. 6, No. 10, pp. 389–393.) Experimental data are given on the design and performance of a new type of mode transducer for use in the 24-kMc/s band.

621.372.832.8 **2832**

X Circulator.—S. Yoshida. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, p. 1150.) A new four-port waveguide circulator; experimental results are given.

621.372.837.2 **2833**

A New Form of High-Power Microwave Duplexer.—P. D. Lomer & R. M. O'Brien. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 264–267. Abstract, *Proc. Inst. Radio Engrs*, Oct. 1958, Vol. 46, No. 10, p. 1776.)

621.372.837.3 : 621.318.134 **2834**

A Fast Ferrite Switch for Use at 70 kMc/s.—E. H. Turner. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 300–303. Abstract, *Proc. Inst. Radio Engrs*, Oct. 1958, Vol. 46, No. 10, p. 1777.)

621.372.837.3 : 621.396.65 **2835**

A Faraday-Rotation Switch for the TH System.—J. A. Weiss. (*Bell Lab. Rec.*, April 1959, Vol. 37, No. 4, pp. 139–143.) Description of a rapid-acting microwave switch based on the Faraday effect, designed for switching stand-by oscillators into service.

621.372.852.22 **2836**

A Perturbation Method for Circular Waveguides containing Ferrites.—P. J. B. Clarricoats. (*Proc. Instn elect. Engrs*, Part B, May 1959, Vol. 106, No. 27, pp. 335–340.) The propagation coefficient of a guide containing a longitudinally magnetized ferrite is derived. Good agreement is obtained with experimental data.

621.372.852.22 **2837**

A Phenomenological Theory of the Reggia-Spencer Phase Shifter.—J. A. Weiss. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1130–1137.) Explains the essential properties of the device by means of a simplified model. See 387 of 1958 (Reggia & Spencer).

621.372.852.22 **2838**

Theory of the Mode Spectra of Cylindrical Waveguides containing Gyromagnetic Media.—R. A. Waldron. (*J. Brit. Instn Radio Engrs*, June 1959, Vol. 19, No. 6, pp. 347–356.) The cut-off equations are derived and solved for the dielectric-centred case and the normal modes are studied. The relations between this case and that of the ferrite-centred case studied previously (341 of February) are pointed out.

621.372.852.323 : 621.318.134 **2839**

Theoretical Analysis of the Operation of the Field-Displacement Ferrite Isolator.—K. J. Button. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 303–308. Abstract, *Proc. Inst. Radio Engrs*, Oct. 1958, Vol. 46, No. 10, p. 1777.)

621.396.67.095 **2840**

Four-Dimensional Electromagnetic Radiators.—H. E. Shanks & R. W. Bickmore. (*Canad. J. Phys.*, March 1959, Vol. 37, No. 3, pp. 263–275.) The effect of modulating one or more parameters of an aerial or aerial array, such as aperture dimensions, frequency or phase distribution, is discussed, and applications to multi-pattern operation, simultaneous scanning and sidelobe suppression are considered.

621.396.67.095 : 537.311.5 **2841**

Determination of a Current Distribution over a Cone Surface which will Produce a Prescribed Radiation Pattern.—H. Unz. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 182–186. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

621.396.674.31 **2842**

The Effects of the Physical Parameters on the Bandwidth of a Folded Dipole.—J. F. German & F. E. Brooks, Jr. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 186–190. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

621.396.674.33 **2843**

The Characteristic Impedance of Two Infinite Cones of Arbitrary Cross-Section.—R. L. Carrel. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 197–201. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

621.396.677 : 523.164 : 621.318.57 **2844**

A Compact Antenna Switch for Scintillation Measurements.—W. D. Ryan. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, p. 1159.) This switch introduces a phase shift of 90° successively into the lines from each of two aerials.

621.396.677.029.63 **2845**

The Performance of Directive Aerials in Complex U.H.F. Fields.—J. A. Saxton & B. N. Harden. (*Proc. Instn elect. Engrs*, Part B, May 1959, Vol. 106, No. 27, pp. 315–317.) Apparent gains of directive aerials, relative to a half-wave dipole, were measured at 580 and 904 Mc/s on a number of urban and rural sites. The median gains were similar to the calculated plane-wave gains, but the apparent gain was low, owing to the complexity of the field, on a significant number of sites.

621.396.677.3 : 523.164.32 **2846**

A New High-Resolution Interferometer for Solar Studies.—Kundu. (See 2936.)

621.396.677.3 : 621.396.965 **2847**

A Note on the Effective Aperture of Electrically Scanned Arrays.—R. W. Bickmore. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 194–196. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

621.396.677.32 **2848**

The Radiation Characteristics of a Zig-Zag Antenna.—D. L. Sengupta. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 191–194. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

621.396.677.71 **2849**

Design Data for Small Annular Slot Antennas.—W. A. Cumming & M. Cormier. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 210–211. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

621.396.677.75 **2850**

Hemi-isotropic Radiators for the S or X Band.—E. G. A. Goodall. (*Proc. Instn elect. Engrs*, Part B, May 1959, Vol. 106, No. 27, pp. 318–320.) "An aerial having approximate hemi-isotropic properties has been constructed on the principle that a dielectric rod will act as a guiding medium for electromagnetic energy. Using this principle, a broad-band, shaped dielectric element has been developed, which, when placed at the aperture of an open-ended circular waveguide, radiates with hemi-isotropic cover over a 20% frequency band."

621.396.677.81 : 621.397.7 **2851**

The Passive TV Relay and its Practical Possibilities.—R. Aschen. (*TSF et TV*, Nov. 1957, Vol. 33, No. 349, pp. 329–330.) Field strength and aerial gain calculations for typical passive relay systems comprising a coupled receiving and transmitting aerial are given. See also 2852 below.

621.396.677.83 **2852**

Passive Relay by Microwave Mirror.—R. Aschen. (*TSF et TV*, Jan. 1958, Vol. 33, No. 351, pp. 5–7.) Formulae are given for calculating the mirror area and reflection losses for a typical relay circuit based on a received field strength of 2 mV/m at a frequency of 200 Mc/s.

621.396.677.83 **2853**

A Log-Periodic Reflector Feed.—D. E. Isbell. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1152–1153.) An aerial of the log-periodic reflector type has been constructed which has been used over the range 105–430 Mc/s. Its effective aperture is fairly constant below 325 Mc/s.

621.396.677.85 **2854**

Microwave Stepped-Index Luneberg Lenses.—G. D. M. Peeler & H. P. Coleman. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 202–297. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

AUTOMATIC COMPUTERS

681.142 **2855**

The Design of a Standard Block for a Digital Computing System.—R. J. Miles. (*Mullard tech. Commun.*, April 1959, Vol. 4, No. 38, pp. 222–248.) Logical theory, design considerations and practical circuit of a block based on alloy-junction transistors operating at frequencies up to 1 Mc/s.

681.142 **2856**

Binary Multiplication in Digital Computers.—A. Green. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1159–1160.) Shows how many steps can be eliminated from the usual process of multiplication by computer.

681.142 **2857**

Computation of Sin N, Cos N and $m\sqrt{N}$ using an Electronic Computer.—E. G. Kogbetliantz. (*IBM J. Res. Developm.*, April 1959, Vol. 3, No. 2, pp. 147–152.)

681.142 **2858**

Rotating-Disk Function Generator for Analogue Computers.—M. E. Young, W. M. Alexander & H. D. Schwetman. (*Rev. sci. Instrum.*, May 1959, Vol. 30, No. 5, pp. 318–322.) A variable-radius revolving lamina modulates the light incident upon the cathode of a photomultiplier tube to produce a required voltage/time function.

681.142 : 518.4 **2859**

A Design for an Automatic Graph Plotter.—M. P. Atkinson, W. T. Bane & D. L. A. Barber. (*Proc. Instn elect. Engrs*, Part B, May 1959, Vol. 106, No. 27, pp. 299–306.) Transistors and printed circuits are used in equipment based on digital techniques. Points may be plotted at a rate of three per second, with an accuracy within 0·01 in.

681.142 : 621.318.042 **2860**

Magnetic-Core Matrices for Logical Functions.—A. L. Freedman. (*Electronic Engng*, June 1959, Vol. 31, No. 376, pp. 358–361.) Some applications of cores having a square hysteresis loop.

681.142 : 621.318.57 **2861**

The Design of Biased-Diode Function Generators.—C. C. Ritchie & R. W. Young. (*Electronic Engng*, June 1959, Vol. 31, No. 376, pp. 347–351.) Relations between the number and spacing of diode sections to give minimum error are derived.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.049.7 **2862**

Recent Advances in Potted and Printed Circuits.—H. G. Manfield (*J. Brit. Instn Radio Engrs*, May 1959, Vol. 19, No. 5, pp. 289–302.) "The various potting resins are described in relation to the variation of properties with different proportions of hardener and the effects on the parameters of the potted components. The causes of failure of potted circuits are discussed. Design problems in the use of printed circuits are examined with particular reference to questions of conductor thickness and spacing. A method of sealing printed circuits by a thin polysulphide rubber layer which is sprayed or brushed on is described."

621.3.049.7 : 621.385.1 **2863**

Thermionic Integrated-Micromodules.—J. E. Beggs, W. Grattidge, P. J. Molenda, A. P. Haase & A. F. Dickerson. (*Electronics*, 15th May 1959, Vol. 32, No. 20, pp. 80..83.) The construction and application of microminiature heaterless valves, resistors and capacitors using titanium and ceramic materials are described.

621.318.57 : 537.227 **2864**

The Transpolarizer: an Electrostatically Controlled Circuit Impedance with Stored Setting.—C. F. Pulvari. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1117–1123.) The device operates by the controlled transfer of polarization through two or more ferroelectric dielectric sections in series.

621.318.57 : 621-52 **2865**

An Electronic Timer with Voltage Control of Setting.—R. Gladstone. (*Electronic Engng*, June 1959, Vol. 31, No. 376, pp. 362–363.) A new grid-controlled 'bootstrap' circuit with common-cathode trigger provides accurately controlled time delays up to about 100 seconds.

621.318.57 : 621.314.63 **2866**

Microwave Switching by Crystal Diodes.—M. R. Millet. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 284–290. Abstract, *Proc. Inst. Radio Engrs*, Oct. 1958, Vol. 46, No. 10, p. 1777.)

621.319.4 : 621.3.049.75 **2867**

Tantalum Printed Capacitors.—R. W. Berry & D. J. Sloan. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1070–1075.) Description of the structural features and characteristics of capacitors using sputtered Ta films as the base for the anodized oxide film, with evaporated metal counter-electrodes.

621.319.45 : 669.718.5 **2868**

The Surface Enlargement of Aluminium for Electrolytic Capacitors.—P. Werner. (*NachrTech.*, June 1958, Vol. 8, No. 6, pp. 269–277.) Various chemical and electrochemical methods are described and compared, and details are given of a method of measuring the increase in surface area achieved.

621.372.5 **2869**

General Solution of the Symmetric Iterative Analysis of Asymmetric Passive Linear Quadripoles.—S. Mayr. (*Arch. Elektrotech.*, 8th Dec. 1958, Vol. 44, No. 2, pp. 120–129.) The asymmetric quadripole is divided into two symmetric quadripole sections which can be treated by iterative matrix methods.

621.372.57 : 621.3.087.4 : 551.594.6 **2870**

Investigation of an Apparatus for Recording Atmospherics.—R. Benoit & J. Kernevez. (*Ann. Géophys.*, Oct./Dec. 1957, Vol. 13, No. 4, pp. 321–324.) An analysis of an integrating circuit with a long time-constant and its response to a series of pulses.

621.372.6 **2871**

A Topological Nonreciprocal Network Element.—A. W. Keen. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1148–1150.) The element is a three-terminal device which may be used with physical elements (immittances) to model the more complex nonreciprocal devices.

621.372.6 **2872**

Traditors, a New Class of Non-energic Nonlinear Network Elements.—S. Duinker. (*Philips Res. Rep.*, Feb. 1959, Vol. 14, No. 1, pp. 29–51.) From an analysis based on the Lagrangian dynamical equations a class of nonlinear multiport elements is defined, which are characterized by the property of neither dissipating nor storing but only transferring energy.

621.372.632 : 621.314.63 **2873**

Transmitting Frequency Converter in which Gold- or Silver-Bonded Diode is Used.—Kita, Sanpei & Okajima. (See 3145.)

621.372.632.029.6 **2874**

One Aspect of Minimum-Noise-Figure Microwave Mixer Design.—S. M. Bergmann. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 324–326. Abstract, *Proc. Inst. Radio Engrs*, Oct. 1958, Vol. 46, No. 10, p. 1777.)

621.373 : 537.312.62 **2875**

A Cryogenic Oscillator.—G. B. Rosenberger. (*IBM J. Res. Developm.*, April 1959, Vol. 3, No. 2, pp. 189–190.) A relaxation process based on the transition between the superconducting and conducting phases of a Pb film is described. Oscillations at frequencies around 100 kc/s have been obtained.

621.373.42.029.422 **2876**

A Sine-Wave Generator with Periods of Hours.—G. Klein & J. M. den Hertog. (*Electronic Engng*, June 1959, Vol. 31, No. 376, pp. 320–325.) An 'inverse function generator' based on the difference amplifier [see e.g. 362 of 1956 (Klein)] is examined and examples of its use are considered, (*a*) in a logarithmic voltmeter, and (*b*) for sine-triangle waveform transformation. Triangle-sine transformation can be achieved by negative feed-back; a v.l.f. triangular waveform obtained from a *CR* circuit and relay is thus converted to an accurate sine wave without transients.

621.373.43 : 621.314.7 : 621.385.1 **2877**

Tube-Transistor Hybrids Provide Design Economy.—G. A. Dunn & N. C. Hekimian. (*Electronics*, 5th June 1959, Vol. 32, No. 23, pp. 68–70.) A bistable cathode follower and four-stage ring counter are described. The transistors appear in the cathode circuits of the valves.

621.373.52 **2878**

Physical Principles of Avalanche-Transistor Pulse Circuits.—D. J. Hamilton, J. F. Gibbons & W. Shockley. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1102–1108.) "A model for the transistor is defined in terms of charge variables and the physical parameters of the device. The transient performance of the model is calculated by focusing attention on the minority-carrier charge stored in the base region and the influence of base-width modulation upon this stored charge. In the charge formulation of the problem, the physical details of the avalanche multiplication process need not be considered; multiplication is accounted for by the boundary conditions which it imposes upon the stored charge. Good agreement has been obtained between calculated and experimentally observed data for a simple avalanche-transistor relaxation oscillator."

621.374.3 : 621.387.4 **2879**

Time to Pulse-Height Converter.—J. V. Kane. (*Rev. sci. Instrum.*, May 1959, Vol. 30, No. 5, pp. 374–375.) A circuit is described for deriving pulses the amplitudes of which decrease linearly with time.

621.374.3 : 621.387.4 **2880**

Linear Gate of 20-mμs Duration.—E. L. Garwin. (*Rev. sci. Instrum.*, May 1959, Vol. 30, No. 5, pp. 373–374.) Diodes with a 6 mμs recovery time are used in a coincidence circuit.

621.374.5 : 538.652 **2881**

A Torsional Magnetostrictive Delay Line.—A. Rothbart. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1153–1154.) An application of the Wiedemann effect, using toroidal coil transducers.

621.375.018.75 : 537.311.33 **2882**

Pulse Amplification using Impact Ionization in Germanium.—M. C. Steele, L. Pensak & R. D. Gold. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1109–1117.) Some aspects of the phenomena of impact ionization in an impurity-doped semiconductor at 4·2 °K are described. Control of the breakdown process is used to obtain pulse amplification in the millimicrosecond range, using two- and three-terminal devices.

621.375.2.029.3 **2883**

Reducing Distortion in Class-B Amplifiers.—B. Sklar. (*Electronics*, 22nd May 1959, Vol. 32, No. 21, pp. 54–56.) Linearization is accomplished by a non-linear compensation network containing diodes. The calculations for an a.f. amplifier with 2·6% distortion are described.

621.375.232.4 **2884**

Grounded-Grid Power Amplifier Design.—J. L. Dautremont, Jr. (*Electronic Equipm. Engng*, Dec. 1958, Vol. 6, No. 12, pp. 33–36.) A graphical design procedure is described, using a disk-seal valve Type 2C39-A as an example.

621.375.4.029.3 **2885**

Single-Ended Amplifiers for Class-B Operation.—H. C. Lin & B. H. White. (*Electronics*, 29th May 1959, Vol. 32, No. 22, pp. 86–87.) A transistorized 10-W high-fidelity push-pull amplifier is described in detail.

621.375.4.029.3 **2886**

Designing High-Quality A.F. Transistor Amplifiers.—R. Minton. (*Electronics*, 12th June 1959, Vol. 32, No. 24, pp. 60–61.) A seven-stage 25-W amplifier is described.

621.375.4.029.3 **2887**

One-Transistor 'Push-Pull'.—J. A. Worcester. (*Electronics*, 12th June 1959, Vol. 32, No. 24, p. 74.) An a.f. output stage in which the biasing condition is controlled by the rectified output.

621.375.9 : 538.569.4 **2888**

Molecular Oscillators and Amplifiers.—N. G. Basov & A. M. Prokhorov. (*Priroda, Mosk.*, July 1958, No. 7, pp. 24–32.) The principle and operation of molecular-beam oscillators and amplifiers are described with reference to the ammonia-beam maser. Molecular amplifiers based on paramagnetic crystals give a wider pass-band and a higher output power than the molecular-beam type. The frequency stability achieved is within one part in 10^9.

621.375.9 : 538.569.4 **2889**

Zero-Field Masers.—G. S. Bogle & H. F. Symmons. (*Aust. J. Phys.*, March 1959, Vol. 12, No. 1, pp. 1–20.) "Solid state three-level masers operating with zero magnetic field are shown to be feasible and to have advantages over magnetic-field masers in many applications. The requirements of the working substance are discussed and it is found that compounds of Cr^{2+}, Fe^{3+}, Ni^{2+}, and Gd^{3+} should be suitable. Diagrams and tables of maser properties of selected compounds are given; on the basis of present knowledge a number of amplifying frequencies between 120 and 75 000 Mc/s should be available. The range of suitable compounds which has been studied is very small, and should be extended."

621.375.9 : 538.569.4 **2890**

Role of Double-Quantum Transitions in Masers.—S. Yatsiv. (*Phys. Rev.*, 15th March 1959, Vol. 113, No. 6, pp. 1538–1544.) Conditions are found in which the operation of a three-level maser is governed by the double-quantum process and does nor require a true 'pumping' stage. Such a case, although realizable in practice, may be of doubtful technical applicability.

621.375.9 : 538.569.4 **2891**

Travelling-Wave Solid-State Masers.—A. E. Siegman, P. N. Butcher, J. C. Cromack & W. S. C. Chang. (*Proc. Instn elect. Engrs*, Part B, 1958, Vol. 105, Supplement No. 11, pp. 711–712. Discussion.)

621.375.9 : 538.569.4 : 523.164 **2892**

A Maser Amplifier for Radio Astronomy at X Band.—J. A. Giordmaine, L. E. Alsop, C. H. Mayer & C. H. Townes. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1062–1069.) "The design and operating characteristics of a maser radiometer for use in radio astronomy at 3-cm wavelength are discussed. The operating system which is described has a bandwidth of 5·5 Mc/s and an input noise temperature, including background radiation into the antenna, of about 85° K. An r.m.s. fluctuation level of about 0·04° K is attained using an averaging time of 5 seconds. A discussion of the factors determining the sensitivity of such devices is presented."

621.375.9 : 538.22 : 538.569.4 **2893**

Two-Level Maser Materials—Hoskins. (See 3037.)

621.375.9 : 538.569.4 : 538.222 **2894**

Theory of Three-Level Paramagnetic Masers.—P. N. Butcher. (*Proc. Instn elect. Engrs*, Part B, 1958, Vol. 105, Supplement No. 11, pp. 684–711.)

Part 1—Quantum Theory (pp. 684–690).
Part 2—Amplification and Oscillation (pp. 691–698).
Part 3—Output Noise Power Spectrum (pp. 699–704).
Part 4—Noise Figure (pp. 705–709).
Discussion (pp. 709–711).

621.375.9 : 550.389.2 : 629.19 **2895**

Parametric Amplifier Receives Space Signals.—(*Electronics*, 5th June 1959, Vol. 32, No. 23, pp. 80–81.) Signal amplification was in L band and pump frequency in X band giving a noise factor of 1 dB and bandwidth 100 kc/s. Using a 32-dB paraboloid (diameter 18 feet) the fraction of a watt radiated by Pioneer IV was received at 410 000 miles.

621.375.9 : 621.3.011.23 **2896**

Microwave Parametric Amplifiers and Convertors.—G. Wade & H. Heffner. (*Proc. Instn elect. Engrs*, Part B, 1958, Vol. 105, Supplement No. 11, pp. 677–679.) The inherent gain, noise and bandwidth characteristics of basic circuits are discussed and a brief description is given of a ladder-network converter in which the output frequency is higher than the pumping frequency.

621.375.9 : 621.3.011.23 **2897**

Circuit Conditions for Parametric Amplification.—J. E. Pallett. (*J. Electronics Control*, March 1959, Vol. 6, No. 3, pp. 261–262.) Correction of an error in Valdes' paper (75 of January).

621.376.23 **2898**

Simplified Product Detector Design.—J. L. Ekstrom. (*QST*, May 1959, Vol. 43, No. 5, p. 43.) A circuit is described for a pentagrid converter which may be self-excited or separately excited and which has an inter-modulation balance adjustment to reduce rectification effects.

621.376.4 **2899**

The Modulator as a Phase Detector.—W. Frazer & R. E. Schemel. (*Electronic Engng*, June 1959, Vol. 31, No. 376, pp. 345–346.) A note on the error due to a finite switching voltage applied to a shunt modulator.

GENERAL PHYSICS

535.13 **2900**

Solution of Maxwell's Equations in Terms of a Spinor Notation: the Direct and Inverse Problem.—H. E. Moses. (*Phys. Rev.*, 15th March 1959, Vol. 113, No. 6, pp. 1670–1679.) The use of spinor notation enables the solution to be obtained in more compact form than does vector notation.

537.226 **2901**

The Quantum Mechanical Theory of the Dielectric Orientation Polarization of Gases: Part 1—The Static Orientation Polarization of a Dipole Gas consisting of Symmetric Spin Molecules.—W. Maier & H. K. Wimmel. (*Z. Phys.*, 5th Dec. 1958, Vol. 153, No. 3, pp. 297–313.)

537.311.1 : 621.396.822 **2902**

Noise Theory for Hot Electrons.—P. J. Price. (*IBM, J. Res. Developm.*, April 1959, Vol. 3, No. 2, pp. 191–193.) Nyquist's theorem is extended to the case in which the distribution of electrons is disturbed by a steady electric field.

537.311.4 **2903**

Transient Behaviour of the Ohmic Contact.—M. A. Lampert & A. Rose. (*Phys. Rev.*, 1st March 1959, Vol. 113, No. 5, pp. 1236–1239.) The behaviour of ohmic injecting contacts is analysed for transient currents at a fixed voltage. These occur when the free-carrier density in the solid is changed by some exciting agent as in photoconductivity or bombardment-induced conductivity.

537.311.5 : 538.566 **2904**

The Calculation of the Field in a Homogeneous Conductor with a Wavy Interface.—J. R. Wait. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1155–1156.) Analysis showing that the perturbation of an e.m. field in the conductor due to the ripples is proportional to their amplitude.

537.311.5 : 621.3.015.3 **2905**

Penetration of Transient Electromagnetic Fields into a Conductor.—A. Grumet. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 682–686.) Theory for a uniform electric field abruptly applied to a plane boundary.

537.322.1 **2906**

On the Theory of the Peltier Heat Pump.—E. S. Rittner. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 702–707.) The figure of merit for a single-stage pump is optimized in the region of partial Fermi degeneracy.

537.527 : 537.56 **2907**

The Space-Charge Field-Emission Hypothesis applied to Hayashi Data on Discharges through Gases.—H. Ritow. (*J. Electronics Control*, March 1959, Vol. 6, No. 3, pp. 236–245.)

537.533 **2908**

Concerning the Nature of the Aberrations in Electron Sheet Beams.—W. E. Waters. (*J. opt. Soc. Amer.*, March 1959, Vol. 49, No. 3, pp. 304–307.) A power-series expansion is used to derive expressions for the aberrations up to the third order in electron sheet beams subject to purely electrostatic focusing. Four purely geometric aberrations and four aberrations due to chromatic effects are found.

537.542 **2909**

New Hollow-Cathode Glow Discharge.—A. D. White. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 711–719.) Current densities of 0·5 A/cm² can be obtained with a cathode consisting of a refractory metal with a spherical cavity. In neon, stable characteristics at a few milliamperes are obtained.

537.56 : 538.56 **2910**

New Experimental Results for Plasma Electron Oscillations.—D. W. Mahaffey. (*J. Electronics Control*, March 1959, Vol. 6, No. 3, pp. 193–203.) Study of oscillations in low-pressure mercury vapour discharges with plane oxide-coated cathodes.

537.56 : 538.56 **2911**

A Lagrangian Formulation of the Boltzmann-Vlasov Equation for Plasmas.—F. E. Low. (*Proc. roy. Soc. A*, 11th Nov. 1958, Vol. 248, No. 1253, pp. 282–287.) A variational principle is found which leads to a new formulation of the problem of small oscillations about equilibrium.

537.581 **2912**

Wave-Mechanical Correction of the Richardson-Dushman Emission Formula.—F. Ollendorff. (*Arch. Elektrotech.*, 12th Feb. 1959, Vol. 44, No. 3, pp. 177–188.) An attempt is made to overcome the discrepancies between the spin-corrected theory of thermionic electron emission and empirical results.

538.1 **2913**

Bose-Einstein Lattice Gases equivalent to the Heisenberg Model of Ferro-, Antiferro- and Ferri-Magnetism.—T. Morita. (*Progr. theor. Phys.*, Nov. 1958, Vol. 20, No. 5, pp. 614–624.) A Hamiltonian is presented that has the form of a finite series of Bose operators and is equivalent to the Heisenberg model. See also *ibid.*, pp. 728–736.

538.3 : 535.13 **2914**

Formation of Discontinuities in Classical Nonlinear Electrodynamics.—M. Lutzky & J. S. Toll. (*Phys. Rev.*, 15th March 1959, Vol. 113, No. 6, pp. 1649–1652.)

538.566 **2915**

Polarization and Angle Dependence of the Reflection Factor of Absorbers for Centimetre Electromagnetic Waves.—K. Walther. (*Z. angew. Phys.*, June 1958, Vol. 10, No. 6, pp. 285–295.) The dependence of the reflection factor on the angle of incidence and plane of polarization of e.m. waves is investigated for various types of absorbers and results are confirmed experimentally.

538.566 **2916**

Transients in Conducting Media.—P. I. Richards. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 178–182. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

538.566 : 535.42] + 534.26 **2917**

The Effect of Incident Wave Fluctuations on the Mean Intensity Distribution near the Focal Point of a Lens.—M. N. Krom & L. A. Chernov. (*Akust. Zh.*, Oct./Dec. 1958, Vol. 4, No. 4, pp. 341–347.) An extension of Chernov's analysis (3772 of 1958) to the case of fluctuations of arbitrary amplitude.

538.566 : 535.42 **2918**

The Kirchhoff-Young Theory of the Diffraction of Electromagnetic Waves.—O. Laporte & J. Meixner. (*Z. Phys.*, 14th Nov. 1958, Vol. 153, No. 2, pp. 129–148.) A transformation is discussed which facilitates the evaluation of Kirchhoff's double integrals.

538.566 : 535.43] + 534.26 **2919**

On Propagation of Waves in Slightly Rough Ducts.—J. C. Samuels. (*J. acoust. Soc. Amer.*, March 1959, Vol. 31, No. 3, pp. 319–325.) Mathematical treatment of acoustic and e.m. wave propagation assuming that the heights of the roughness peaks are small compared to the average separation of the duct walls.

538.566.2 **2920**

The Propagation of a Variable Electromagnetic Field in a Stratified Anisotropic Medium.—A. N. Tikhonov. (*Dokl. Ak.Nauk S.S.S.R.*, 11th June 1959, Vol. 126, No. 5, pp. 967–970.) Computation of the field on the surface of an anisotropic conducting medium due to a dipole lying in the surface. See also 3036 of 1956 (Tikhonov & Shakhsuvarov).

538.566.2 : 548 **2921**

On the Propagation of Electromagnetic Waves in a Medium with Appreciable Spatial Dispersion.—V. M. Agranovich & A. A. Rukhadze. (*Zh. eksp. teor. Fiz.*, Oct. 1958, Vol. 35, No. 4(10), pp. 982–984.) Brief description of a method more detailed then that of Ginzburg (1169 of April), in which expansions are obtained for 'direct' and 'inverse' dispersion. It is shown that in cubic crystals inclusion of the spatial dispersion leads to a weak anisotropy of the index of refraction.

538.569.4 **2922**

A General Theory of Magnetic Double Resonance.—K. Tomita. (*Progr.theor.Phys.*, Nov. 1958, Vol. 20, No. 5, pp. 743–773.) The theory describes a system consisting of two interacting different species of spin, one being saturated by a strong resonant radiation field and the other being detected by a weak field. See also 95 of January.

538.569.4 **2923**

Multiple-Quantum Transitions in Nuclear Magnetic Resonance.—S. Yatsiv. (*Phys. Rev.*, 15th March 1959, Vol. 113, No. 6, pp. 1522–1537.)

538.569.4 **2924**

The Application of Magnetic Resonance to Solid-State Electronics.—D. J. E. Ingram. (*J. Brit. Instn Radio Engrs*, June 1959, Vol. 19, No. 6, pp. 357–367.) A description of the basic principles and techniques and an outline of some recent applications.

538.569.4 **2925**

Excitation of Spin Waves in an Antiferromagnet by a Uniform R.F. Field.—R. Orbach & P. Pincus. (*Phys. Rev.*, 1st March 1959, Vol. 113, No. 5, pp. 1213–1215.) It is possible to excite spin waves in an antiferromagnet by a uniform r.f. field provided that spins on the surface of the specimen experience anisotropy interactions different from those acting on spins in the interior.

538.569.4 **2926**

Exchange Effects in Ferromagnetic Resonance.—M. A. Gintsburg. (*Zh. eksp. teor. Fiz.*, Oct. 1958, Vol. 35, No. 4(10), pp. 1047–1049.) A single dispersion law for transverse e.m. waves and for spin waves is derived which takes account of both relativistic and exchange interactions.

538.569.4 : 538.222 **2927**

Paramagnetic Electron-Resonance Induction.—E. Lutze & D. Bösnecker. (*Naturwissenschaften*, July 1958, Vol. 45, No. 14, p. 332.) Preliminary note on investigations of induced emission at paramagnetic resonance. $CuSO_4 \cdot 5H_2O$ was used at room temperature and a wavelength of 3·33 cm.

538.569.4 : 621.318.132 **2928**

Ferrimagnetic Resonance Modes in Spheres.—P. C. Fletcher & R. O. Bell. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 687–698.) The magnetostatic solutions of ferrimagnetic resonance in ferrite spheres are briefly derived. Some experimental results are compared with the theory.

538.569.4 : 621.375.9 **2929**

Role of Double-Quantum Transitions in Masers.—Yatsiv. (See 2890.)

538.652 **2930**

Form Effect in Linear Magnetostriction.—H. E. Stauss. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 698–701.)

539.2 **2931**

Electron Interaction in Solids. Characteristic Energy Loss Spectrum.—P. Nozières & D. Pines. (*Phys. Rev.*, 1st March 1959, Vol. 113, No. 5, pp. 1254–1267.) The characteristic energy loss spectrum is analysed with the aid of the dielectric formulation of the many-body problem.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.164 : 621.396.677.8 **2932**

Improved Measurements of the Positions of 17 Intense Radio Stars.—B. Elsmore. (*Mon. Not. R. astr. Soc.*, 1958, Vol. 118, No. 6, pp. 603–608.) Observations have been made at 1·9 m λ, using the Cambridge radio telescope as a crossed-axis interferometer. See also 103 of January (Edge et al.).

523.164.32 **2933**

The Extension of Solar Radio Spectroscopy to Decametre Wavelengths.—K. V. Sheridan, G. H. Trent & J. P. Wild. (*Observatory*, April 1959, Vol. 79, No. 909, pp. 51–53.) Preliminary report on spectrographic investigations in the frequency range 24–40 Mc/s.

523.164.32 **2934**

On Short Periodic Variations in Solar Noise Storms on 200 Mc/s.—Ø. Hauge. (*Astrophys. norveg.*, Jan. 1958, Vol. 6, No. 5, pp. 43–54.) 19 days of enhanced solar radiation on 200 Mc/s in June, July and August 1955 are investigated by an autocorrelation method in a search for short periodic variations with repetition times between 7·5 and 90 min. Results indicate that some noise storms are characterized by periodic variations with repetition times differing from day to day, while other noise storms exhibit no periodic variations. It is possible that a specific noise storm area retains its characteristics of short periodic variations in radio emission for a solar rotation or longer.

523.164.32 2935

On the Fine Structure of Solar Bursts in the 200-Mc/s Range and their Drift in Frequency.—Ø. Elgarøy. (*Astrophys. norveg.*, Jan. 1958, Vol. 6, No. 6, pp. 55–74.) High-speed records have been obtained simultaneously on 199 Mc/s and 200·5 Mc/s with a twin-channel receiver at the Harestua Solar Observatory during the period February–September 1957. An analysis of the records shows that 48 % of the bursts occur first on the lower frequency, 34 % first on the higher frequency and 18 % simultaneously. The results are discussed and the receiving equipment is described.

523.164.32 : 621.396.677.3 2936

A New High-Resolution Interferometer for Solar Studies.—M. R. Kundu. (*J. Instn Telecommun. Engrs, India.*, March 1959, Vol. 5, No. 2, pp. 77–85.) The device is essentially a two-element interferometer with the two aerials aligned equatorially which permits use far from the median plane and gives a resolving power of the order of 1′. See 2733 of 1957 (Alon et al.).

523.164.4 2937

A High-Resolution Survey of the Andromeda Nebula at 408 Mc/s.—M. I. Large, D. S. Mathewson & C. G. T. Haslam. (*Nature, Lond.*, 2nd May 1959, Vol. 183, No. 4670, pp. 1250–1251.) A report of observations made with the Jodrell Bank radio telescope.

523.164.4 2938

A High-Resolution Survey of the Coma Cluster of Galaxies at 408 Mc/s.—M. I. Large, D. S. Mathewson & C. G. T. Haslam. (*Nature, Lond.*, 13th June 1959, Vol. 183, No. 4676, pp. 1663–1664.)

523.164.4 : 621.396.11 : 523.755 2939

The Scattering of Radio Waves in the Solar Corona.—A. Hewish. (*Mon. Not. R. astr. Soc.*, 1958, Vol. 118, No. 6, pp. 534–546.) An account is given of measurements carried out each June during the period 1952–1958 of the radio emission from the Crab nebula at wavelengths of 7·9, 3·7 and 1·9 m. Results indicate a pronounced sunspot-cycle variation in certain regions of the corona, a scatter anisotropy, and the presence of refraction effects in addition to scattering. See also 2286 of 1955.

523.5 : 621.396.11 2940

Theory of the Radio-Echo Meteor Height Distribution in a Non-isothermal Atmosphere.—A. A. Weiss. (*Aust. J. Phys.*, March 1959, Vol. 12, No. 1, pp. 54–64.) The height distribution of echoing points of shower and sporadic meteors belonging to a homogeneous velocity group is calculated for a model atmosphere whose scale height is a linear function of height. Experimental cut-off and the theoretical approximations involved limit the accuracy with which actual scale height and density may be found from observed meteor trails.

523.5 : 621.396.11 2941

Elevation, Height, and Electron Density of Echoing Points of Meteor Trails.—A. A. Weiss. (*Aust. J. Phys.*, March 1959, Vol. 12, No. 1, pp. 65–76.) These parameters may be evaluated by the continuous operation of c.w. equipment on 27 Mc/s. At least 60 % of all echoes are found to be distorted. The electron density distributions are in qualitative agreement with known meteor mass distributions and trail shapes.

523.745 : 523.165 2942

Solar Activity and Transient Decreases in Cosmic-Ray Intensity.—D. Venkatesan. (*J. geophys. Res.*, May 1959, Vol. 64, No. 5, pp. 505–520.)

523.755 2943

A New Theory of the Solar Corona. P. J. Kellogg & E. P. Ney. (*Nature, Lond.*, 9th May 1959, Vol. 183, No. 4671, pp. 1297–1301.) It is proposed that the solar corona consists of trapped charged particles moving in the magnetic fields of the sun. Experimental data are discussed in terms of this model.

550.385 2944

Disturbances of the Earth's Magnetic Field considered as Relaxation Variations.—P. Herrinck. (*Ann. Géophys.*, July–Sept. 1957, Vol. 13, No. 3, pp. 211–221.) Records of the horizontal magnetic component at Elisabethville and elsewhere show relaxation processes analogous to post-disturbances of magnetic storms and subject to the 27-day recurrence tendency.

550.385 2945

Possible Causes of Geomagnetic Fluctuations having a 6-sec Period.—H. J. Duffus, J. A. Shand & C. Wright. (*Nature, Lond.*, 23rd May 1959, Vol. 183, No. 4673, pp. 1479–1480.) Comment on 1532 of May (Daniels). Short- and long-period oscillations, sometimes preceding but more often accompanying a main train of magnetic activity are described. They are considered to be associated and of electromagnetic origin.

550.385.37 2946

Geographical Variations in Geomagnetic Micropulsations. — H. J. Duffus, J. A. Shand, C. S. Wright, P. W. Nasmyth & J. A. Jacobs. (*J. geophys. Res.*, May 1959, Vol. 64, No. 5, pp. 581–583.) Significant differences consistently occur in simultaneous data obtained at stations 25 miles apart.

550.385.37 : 551.594.5 2947

On a Possible Auroral Origin of Certain Geomagnetic Pulsations.—J. Coulomb. (*Ann. Géophys.*, April–June 1957, Vol. 13, No. 2, pp. 91–102.)

550.385.4 : 523.745 2948

The Relation between the Sudden Disappearance of Filaments and Magnetic Storms.—M. Dizer. (*Ann. Géophys.*, Oct.–Dec. 1957, Vol. 13, No. 4, p. 325.) An analysis of records shows a correlation between the sudden disappearance of filaments close to the sun's central meridian and magnetic disturbances.

550.386 : 523.755 2949

Green Coronal Line Intensity and Geomagnetism.—C. Warwick. (*J. geophys. Res.*, May 1959, Vol. 64, No. 5, pp. 527–531.) Statistical analysis indicates a minimum in geomagnetic activity following the central meridian passage of regions of high green-line intensity.

550.389.2 : 629.19 2950

Laws of Motion of an Earth Satellite.—Yu. A. Pobedonostsev. (*Priroda, Mosk.*, Jan. 1958, No. 1, pp. 19–25.) The principles of multistage rocket flight are considered and formulae for rocket velocity are derived. Tables give the satellite velocity and duration of flight for heights up to 6 000 km.

550.389.2 : 629.19 2951

A Discussion on Observations of the Russian Artificial Earth Satellites and their Analysis.—(*Proc. roy. Soc. A*, 28th Oct. 1958, Vol. 248, No. 1252, pp. 1–87.) The text is given of fifteen papers discussed at a meeting in London, 29th November 1957. These include results obtained using radio telescopes and interferometers, Doppler recorders and direction-finding and field-strength measuring equipment. Applications are made to the computation of orbit parameters. See also 1720 of 1958 for a similar discussion.

550.389.2 : 629.19 2952

Observations on the U.S.S.R. Earth Satellites and the Study of Radio-Wave Propagation.—W. C. Bain & E. D. R. Shearman. (*Proc. Instn elect. Engrs*, Part B, May 1959, Vol. 106, No. 27, pp. 259–263.) Measurements of bearing, angle of elevation and Doppler frequency shift were made at 20 and 40 Mc/s. The observed phenomena could be explained in terms of existing knowledge of ionospheric propagation. The derivation of orbital parameters from the observations is discussed.

550.389.2 : 629.19 2953

A Type of Variation of the Signal Strength from 1958 δ2 (Sputnik 3).—L. Liszka. (*Nature, Lond.*, 16th May 1959, Vol. 183, No. 4672, pp. 1383–1384.) Fluctuations of signal strength relative to the satellite position in orbit indicate that the satellite produces heavily ionized tracks of very long lifetime. Observations have been made to test this hypothesis and results are given.

550.389.2 : 629.19 2954

Diurnal Lapse of Signals from Sputnik III.—G. H. Munro. (*Nature, Lond.*, 30th May 1959, Vol. 183, No. 4674, p. 1549.) A brief note, dated 28th April 1959, states that systematic observations have established that pulse modulation is present only when the satellite 1958δ 2 is in sunlight. On very close transits the c.w. signal can be detected with sufficient strength to record the Doppler shift.

550.389.2 : 629.19 2955

Density of the Atmosphere at Heights between 200 km and 400 km from Analysis of Artificial-Satellite Orbits.—D. G. King-Hele. (*Nature, Lond.*, 2nd May 1959, Vol. 183, No. 4670, pp. 1224–1227.)

550.389.2 : 629.19 2956

Fluctuations in the Brightness of the Second Artificial Earth Satellite.—V. P.

Tsesevich. (*Priroda, Mosk.*, April 1958, No. 4, pp. 78–79.) These brightness fluctuations are explained by the rotation of the satellite on its axis, its maximum brightness corresponding to its greatest cross-section as seen by the observer. A graph shows these brightness variations as recorded by the Odessa Observatory.

550.389.2 : 629.19 **2957**
The Antipodal Reception of Sputnik III.—E. Woyk (Chvojková). (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, p. 1144.) The mechanism of the propagation of waves around the earth within the ionospheric layers is discussed and the best conditions for antipodal reception are deduced. It is concluded that at Stanford, Calif., the best conditions for frequent reception occur from the south-east during summer afternoons. This is in agreement with observations.

550.389.2 : 629.19 **2958**
Satellite-Measured Radiation.—G. W. Stuart. (*Phys. Rev. Lett.*, 15th May 1959, Vol. 2, No. 10, pp. 417–418.) The relevance of atomic change-exchange processes to the nature of the radiation belt is noted.

550.389.2 : 629.19 **2959**
Some Results of Investigations on Cosmic Rays using Artificial Earth Satellites.—L. V. Kurnosova. (*Priroda, Mosk.*, June 1958, No. 6, pp. 85–86.) The intensity variations of cosmic rays as recorded during the flight of the second sputnik are shown. There were no appreciable corresponding variations at ground level.

550.389.2 : 629.19 **2960**
Corpuscular Radiation and the Acceleration of Artificial Satellites.—L. G. Jacchia. (*Nature, Lond.*, 13th June 1959, Vol. 183, No. 4676, pp. 1662–1663.) Observations of satellites 1958 $\beta 2$ and $\delta 1$ have been re-examined and more accurate values of acceleration have been calculated at twice the original resolution (see 2564 of August). Correlation with 10·7-cm solar radiation is higher for $\beta 2$ than $\delta 1$, probably due to greater observational accuracy. An increased acceleration of $\delta 1$ at the time of two major geomagnetic disturbances following flares indicates the effect of corpuscular radiation on atmospheric density at the 200-km level.

550.389.2 : 629.19 : 551.510.535 **2961**
On the Existence of a Strong Magneto-ionic Effect Topside of the F Maximum of the Kennelly-Heaviside Layer.—P. R. Arendt. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 793–795.) Observations of the Faraday effect in 108-Mc/s signals from artificial satellites showed noticeable magneto-ionic effects at altitudes up to 2 000 km.

550.389.2 : 629.19 : 621.375.9 **2962**
Parametric Amplifier Receives Space Signals.—(See 2895.)

550.389.2 : 629.19 : 621.396.11 **2963**
Radio Reflections from Satellite-Produced Ionization.—C. R. Roberts, P. H. Kirchner & D. W. Bray. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1156–1157.) Observations have been made on frequencies of 5, 10, 15 and 20 Mc/s and two very different effects obtained on both 10 and 15 Mc/s are described.

550.389.2 : 629.19 : 621.398 **2964**
Cosmic-Ray Instrumentation in the First U.S. Earth Satellite.—G. H. Ludwig. (*Rev. sci. Instrum.*, April 1959, Vol. 30, No. 4, pp. 223–229.) The instrumentation was designed for conservation of electrical power and for stable and reliable operation over a wide range of temperatures.

551.510.535 **2965**
Some Results of Investigations of the Upper Atmosphere.—V. V. Mikhnevich. (*Priroda, Mosk.*, May 1958, No. 5, pp. 71–72.) Vertical rocket investigations carried out in U.S.S.R. between 1949 and 1958 showed that, contrary to established opinion, above the E-layer there is only a very shallow minimum in electron density. The electron density increases up to 250–300 km with a maximum at 300 km and then slowly decreases so that at 470 km the density is 10^6 electrons/cm^3.

551.510.535 **2966**
A Theoretical Study of the Dynamical Structure of the Ionosphere.—T. Shimazaki. (*J. Radio Res. Labs, Japan*, March 1959, Vol. 6, No. 24, pp. 109–241.) A comprehensive survey of the modifications to Chapman theory which are necessary to explain the actual behaviour of the ionosphere. Both the large F_2-layer anomalies and the smaller ones for the E and F_1 layers are discussed. Over 100 references.

551.510.535 **2967**
Conditions in the Outer Ionosphere.—Ya. L. Al'pert. (*Priroda, Mosk.*, June 1958, No. 6, pp. 86–87.) It is found that the electron concentration in the outer ionosphere decreases with the height considerably less rapidly than it increases at lower levels. The values obtained show that at 2 000–3 000 km the concentrations of electrons and neutral particles are of the order of 10^3–10^2 and 1 per cm^3 respectively.

551.510.535 **2968**
Investigation of the Equatorial Electrojet by Rocket Magnetometer.—L. J. Cahill, Jr. (*J. geophys. Res.*, May 1959, Vol. 64, No. 5, pp. 489–503.) Two layers of electrical current were detected, one existing near an altitude of 100 km and the other about 20–25 km higher.

551.510.535 **2969**
Geophysical Effects of High-Altitude Nuclear Explosions.—T. Obayashi, S. C. Coroniti & E. T. Pierce. (*Nature, Lond.*, 23rd May 1959, Vol. 183, No. 4673, pp. 1476–1478.) A report of observations made at Hiraiso Observatory on 1st and 12th August 1958. Fade-outs on frequencies between 10 and 20 Mc/s and an enhancement of atmospheric noise at 28 Kc/s have been recorded. These effects are attributed to an increase in D-layer ionization extending over much greater distances than had previously been envisaged.

551.510.535 **2970**
Sporadic E-Region Ionization, 'Spread F', and the Twinkling of Radio Stars.—D. F. Martyn. (*Nature, Lond.*, 16th May 1959, Vol. 183, No. 4672, pp. 1382–1383.) Kinematic instability in the ionization gradient of a medium drifting across a magnetic field is considered to be responsible for the three phenomena.

551.510.535 **2971**
The Effect of Sudden Ionospheric Disturbances (S.I.D.'s) on 2·28 Mc/s Pulse Reflections from the Lower Ionosphere.—F. F. Gardner. (*Aust. J. Phys.*, March 1959, Vol. 12, No. 1, pp. 42–53.) During a typical large S.I.D., associated with a class 2 or class 3 flare, the increase in ionization might vary from 20/1 at 65 km through 3/1 at 90 km to unity at 110 km. The amplitude recovery of the E-layer echo lagged about 4 min behind the recovery of the lower echoes around 85 km. At all heights below 85 km, echo recovery occurred simultaneously.

551.510.535 : 621.396.11 **2972**
Rocket Measurements of Absorption in the Lower Ionosphere.—H. Mende, K. Rawer & E. Vassy. (*Ann. Géophys.*, July–Sept. 1957, Vol. 13, No. 3, pp. 231–233.) Results are given of measurements of the field strength of one long-wave and two medium-wave transmitters. The D-layer minimum height is about 70 km and medium-wave observations indicate maximum absorption at 80 km, the attenuation being 1·2 dB/km for normal incidence.

551.510.535 : 621.396.11 : 523.164 **2973**
Refraction of Extraterrestrial Radio Waves in the Ionosphere.—M. M. Komesaroff & C. A. Shain. (*Nature, Lond.*, 6th June 1959, Vol. 183, No. 4675, pp. 1584–1585.) Expressions are derived for estimating ionospheric refraction at low frequencies. Horizontal gradients of electron density are considered. Positions of a discrete source obtained from observation at 19·7 Mc/s after applying corrections for refraction are within a few minutes of arc of the observed position at 85·5 Mc/s.

551.594 **2974**
Simultaneous Occurrence of Sub-visual Aurorae and Radio Noise Bursts on 4·6 kc/s.—R. A. Duncan & G. R. Ellis. (*Nature, Lond.*, 6th June 1959, Vol. 183, No. 4675, pp. 1618–1619.) Records show that there is a correlation between aurorae and noise bursts but anomalies exist which cannot be explained satisfactorily.

551.594.5 **2975**
Auroral Isochasms.—B. Hultqvist. (*Nature, Lond.*, 23rd May 1959, Vol. 183, No. 4673, pp. 1478–1479.) Observed isochasms and projections of circles in the equational plane along the geomagnetic lines of force are compared.

551.594.6 : 621.3.087.4 : 621.372.57 **2976**

Investigation of an Apparatus for Recording Atmospherics. — Benoit & Kernevez. (See 2870.)

551.594.6 : 621.396.11.029.45/.51 : 551.510.535 **2977**

An Experimental Proof of the Mode Theory of V.L.F. Ionospheric Propagation.—Obayashi, Fujii & Kidokoro. (See 3094.)

LOCATION AND AIDS TO NAVIGATION

621.396.93 **2978**

Radio Aids to Navigation.—(*Engineering, Lond.*, 5th Sept. 1958, Vol. 186, No. 4826, pp. 313–323.) Three papers presented at the British Association meeting in Glasgow, September 1958.

(*a*) Position Finding by Radio.—R. L. Smith-Rose (pp. 313–315).

(*b*) Marine Radio Navigational Aids.—B. G. Pressey (pp. 316–318).

(*c*) Radio Aids and Aeronautical Navigation.—C. Williams (pp. 318–323).

621.396.96 **2979**

Doppler Radar Navigation.—F. B. Berger. (*Electronics*, 8th May 1959, Vol. 32, No. 19, pp. 62–63.) A table of characteristics of existing airborne systems.

621.396.96 : 621.314.63 **2980**

Using Silicon Diodes in Radar Modulators.—Gray. (See 3110.)

621.396.963 : 621.374.32 **2981**

Digital-Counter Techniques increase Doppler Uses.—B. E. Keiser. (*Electronics*, 22nd May 1959, Vol. 32, No. 21, pp. 46–50.) The frequency of an oscillator is adjusted automatically to the Doppler frequency of the returned signal and is measured using a circuit which counts 100 pulses per 360° cycle.

621.396.969.3 **2982**

'Ring Angels' over South-East England.—E. Eastwood, J. D. Bell & N. R. Phelp. (*Nature, Lond.*, 20th June 1959, Vol. 183, No. 4677, pp. 1759–1760.) The unexplained phenomena described have been observed on high-power L-band radar equipment during the sunrise period at heights up to 2 000 ft. The rings expand as ripples at a velocity of 25–55 m.p.h., the maximum diameter recorded being 30 miles.

621.396.969.33 **2983**

'Escort'—a Marine Radar with Unusual Features.—(*Beama J.*, May 1959, Vol. 66, No. 2, pp. 57–59.) Four types of p.p.i. display can be selected and provision is made for automatic resetting of the ship's own position on the display and for automatic alignment correction.

621.396.969.34 + 621.396.934 **2984**

Anti-aircraft Radiolocation Techniques.—K. Trofimov. (*Radio, Mosk.*, Feb. 1958, No. 2, pp. 27–31.) A description of radar techniques for the location of enemy aircraft and their destruction by guided missiles.

MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 : 621.385.032.22 **2985**

Measurements of Gas Evolution or Sorption of Anode Materials under Simulated Life Conditions.—C. H. Rehkopf. (*Sylvania Technologist*, Oct. 1958, Vol. 11, No. 4, pp. 114–116.) A brief description of techniques and results of measurements.

533.58 **2986**

Electrical Absorption of Gases in the High-Vacuum Pressure Range.—G. Strotzer. (*Z. angew. Phys.*, May 1958, Vol. 10, No. 5, pp. 207–216.) Various hypotheses for the 'clean-up' effect in low-pressure gases are investigated.

535.215 : 538.6 : 546.682.86 **2987**

Indium Antimonide Photoelectromagnetic Infrared Detector.—P. W. Kruse. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 770–778.) The theory of operation, construction, and performance data are presented.

535.215 : 539.2 **2988**

Photoconductor Performance, Space-Charge Currents, and the Steady-State Fermi Level.—A. Rose & M. A. Lampert. (*Phys. Rev.*, 1st March 1959, Vol. 113, No. 5, pp. 1227–1235.) "The performance of a photoconductor is analysed, via the concept of the steady-state Fermi level, and shown to be limited by the injection of space charge. Using the gain-bandwidth product G/τ_0 as a measure of performance, it is found that $G/\tau_0 = M/\tau_r$ where τ_r is the dielectric relaxation time under operating conditions, and $M = \mathfrak{N}_A/\mathfrak{N}_T$, with $e\mathfrak{N}_A$ the total charge on the anode and $e\mathfrak{N}_T$ the total volume charge, free plus trapped, effectively in thermal contact with the free charge."

535.215 : 546.472.21 **2989**

Anomalous Photovoltaic Effect in ZnS Single Crystals. — A. Lempicki. (*Phys. Rev.*, 1st March 1959, Vol. 113, No. 5, pp. 1204–1209.) Photovoltages larger than the band gap have been observed in both cubic and hexagonal crystals with stacking faults but not in hexagonal crystals free of such faults.

535.215 : 546.482.21 **2990**

Lattice Scattering Mobility of Electrons in Cadmium Sulphide.—H. Miyazawa, H. Maeda & H. Tomishima. (*J. phys. Soc. Japan*, Jan. 1959, Vol. 14, No. 1, pp. 41–47.) The temperature variation of the lattice scattering mobility is found to be given by the expression $\mu_L = A\,\{\exp\,(\Theta/T) - 1\}$ with $A = 92\cdot5 \pm 15$ cm²/V.sec and $\Theta = 370 \pm 30\,°K$. The Conwell-Weisskopf formula is used to correct for impurity scattering.

535.215 : 546.482.21 **2991**

Polarization of Photoconductivity Excitation Bands in CdS Single Crystals.—R. L. Kelly & W. J. Fredericks. (*Phys. Rev. Lett.*, 1st May 1959, Vol. 2, No. 9, pp. 389–390.) The wavelength of incident light exciting maximum photoconductivity was measured as a function of its angle of polarization with respect to crystal orientation. Results are interpreted with an energy-level model.

535.215 : 546.482.21 : 538.63 **2992**

Relaxation-Time Anisotropy in Cadmium Sulphide Studied with Electrical Resistivity and Magnetoresistance Effect.—T. Mazumi. (*J. phys. Soc. Japan*, Jan. 1959, Vol. 14, No. 1, pp. 47–56.) Experimental results indicate unusual anisotropic temperature dependence of the galvanomagnetic effects in hexagonal CdS single crystals.

535.215 : 546.482.21 : 539.23 **2993**

Electric Breakdown of Vapour-Deposited CdS Films.—K. W. Böer, U. Kümmel & W. Misselwitz. (*Naturwissenschaften*, July 1958, Vol. 45, No. 14, p. 331.) Breakdown field-strength is plotted as a function of film thickness for both polarities of the applied voltage.

535.215 : 546.817.221 : 539.23 **2994**

Effect of Thickness of Thin Films of Lead Sulphide on the Spectral Response of Photoconductivity.—H. E. Spencer. (*Phys. Rev.*, 15th March 1959, Vol. 113, No. 6, pp. 1417–1420.)

535.215 : 548.73 **2995**

Crystal Structure of Sodium-Potassium Antimonide (Na_2KSb).—J. J. Scheer & P. Zalm. (*Philips Res. Rep.*, April 1959, Vol. 14, No. 2, pp. 143–150.) The structure of Na_2KSb, a photoemissive material, has been determined by X-ray analysis. It closely resembles that of Cs_3Sb.

535.37 **2996**

Two-Stage Optical Excitation in Sulphide Phosphors.—R. E. Halsted, E. F. Apple & J. S. Prener. (*Phys. Rev. Lett.*, 15th May 1959, Vol. 2, No. 10, pp. 420–421.) Optical evidence shows that the same impurities give rise to electron transitions involving energy levels near or in the valence band as well as the conduction band.

535.37 : 061.3 **2997**

Transactions of the 5th Conference on Luminescence (Crystal Phosphors).—(*Izv. Ak. Nauk S.S.S.R., Ser. fiz.*, April & May 1957, Vol. 21, Nos. 4 & 5, pp. 475–784.) The text is given of 98 papers presented at the conference held in Tartu, Estonia, 25th–30th June 1956. For a list of titles in English, see *Translated Contents Lists of Russian Periodicals*, Feb. & May 1958, Nos. 107 & 110, pp. 43–45 & 47–50.

535.37 : 539.2 **2998**

Energy-Level Positions of Silver Luminescent Centres in Sulphides.—C. C. Klick. (*Phys. Rev. Lett.*, 15th May 1959, Vol. 2, No. 10, pp. 418–420.)

535.37 : 546.472.21 **2999**

Excitation Spectra and Temperature Dependence of the Luminescence of ZnS Single Crystals.—A. Halperin & H. Arbell. (*Phys. Rev.*, 1st March 1959, Vol. 113, No. 5, pp. 1216–1221.) "The luminescence of ZnS : Cl and ZnS : Cu : Cl crystals was measured for the temperature region 80–500° K and for different wavelengths of exciting light. The behaviour of the luminescence versus temperature curves differed from similar curves for powders reported in literature."

535.376 **3000**
A.C.-D.C. Electroluminescence.—W. A. Thornton. (*Phys. Rev.*, 1st March 1959, Vol. 113, No. 5, pp. 1187–1191.) The addition of a direct voltage to an alternating voltage exciting visible electroluminescence in certain ZnS powders increases the emission by as much as 250 times under conditions where the d.c. luminescence alone is about equal to the initial a.c. luminescence.

535.376 **3001**
Rise and Decay of Intensity of Luminescence of Short - Persistence Phosphors.—R. Feinberg. (*Nature, Lond.*, 30th May 1959, Vol. 183, No. 4674, pp. 1546–1547.) Results of measurements made on three c.r. tube phosphors are discussed in relation to theory.

535.376 : 537.533.2 **3002**
Investigations of Exo-electron Emission and Luminescence of Inorganic Crystals.—G. Gourgé. (*Z. Phys.*, 14th Nov. 1958, Vol. 153, No. 2, pp. 186–206.) The investigations discussed were carried out to determine the relation between exo-electron emission and luminescence; measurements were made at temperatures down to −165° C.

535.376 : 546.281.26 **3003**
Electroluminescence of Silicon Carbide.—D. Rücker. (*Z. angew. Phys.*, June 1958, Vol. 10, No. 6, pp. 254–263.) The external and internal light emission observed on d.c.-excited SiC junctions [see e.g. 3890 of 1957 (Patrick)], is investigated on blue and green single crystals, and an interpretation of the various effects is given.

535.376 : 546.482.21 **3004**
On the Mechanism for Carrier Excitation in CdS.—D. D. Snyder & C. E. Bleil. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 736–739.) The production and absorption of X-rays in the experimental crystals have been calculated and some confirmatory data presented.

535.376 : 546.561-31 **3005**
Electroluminescence in Cuprous Oxide.—R. Frerichs & R. Handy. (*Phys. Rev.*, 1st March 1959, Vol. 113, No. 5, pp. 1191–1198.) The electroluminescent properties of Cu_2O are not directly analogous to those of a semiconductor such as Ge or an insulating phosphor such as ZnS. A detail study has been made of current creep effects occurring in Cu_2O plate rectifiers with d.c. excitation.

537.226/.228.1 **3006**
Studies on (Ba-Pb) (Ti-Zr)O_3 System.—T. Ikeda. (*J. phys. Soc. Japan.*) Feb. 1959, Vol. 14, No. 2, pp. 168–174.)

537.226/.227 : 546.431.824-31 **3007**
Polarization Reversal in Barium Titanate.—(*Bell Lab. Rec.*, April 1959, Vol. 37, No. 4, p. 144.) A note on the polarization reversal in single crystals which occurs by extensive sideways motion of domain walls. See 155 of January (Miller).

537.227 : 547.476.3 **3008**
Ferroelectric Hysteresis and After-Effect Phenomena in Rochelle Salt.—H. E. Müser. (*Z. angew. Phys.*, June 1958, Vol. 10, No. 6, pp. 249–254.) Investigation of the constriction of ferroelectric hysteresis loops observed in Rochelle salt. For a similar anomaly in $BaTiO_3$ see e.g. 2757 of 1958 (Hegenbarth).

537.228.1 : 549.514.51 **3009**
β-Quartz as High-Temperature Piezoelectric Material.—D. L. White. (*J. acoust. Soc. Amer.*, March 1959, Vol. 31, No. 3, pp. 311–314.) Lengthwise extensional, face shear and thickness shear modes can be excited piezoelectrically by suitable rotation of the crystal plate.

537.311.33 **3010**
On a Simple Model for Impurity-Band Conduction.—K. Helmers. (*Philips Res. Rep.*, Feb. 1959, Vol. 14, No. 1, pp. 1–10.) A study of the influence of impurity-centre distribution on the resistance of the sample using a stochastic resistance network.

537.311.33 **3011**
Some Optical Characteristics of Semiconductors.—O. Simpson. (*Research, Lond.*, April 1959, Vol. 12, No. 4, pp. 127–132.) A number of optical phenomena are described and related to the electronic structure of semiconductors.

537.311.33 **3012**
Space Charge in Semiconductors resulting from Low-Level Injection.—M. Green. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 744–747.) A solution of the continuity equations is obtained for the space-charge distribution by assuming that (*a*) deviations from neutrality are small, and (*b*) the space-charge fields give rise to pure diffusion and pure 'drift-wave' terms with time-dependent coefficients.

537.311.33 **3013**
Role of Single Phonon Emission in Low-Field Breakdown of Semiconductors at Low Temperatures.—M. A. Lampert, F. Herman & M. C. Steele. (*Phys. Rev. Lett.*, 1st May 1959, Vol. 2, No. 9, pp. 394–397.) Observations of low-field breakdown are correlated with the known energy-band structure and phonon spectra of Ge and Si. A simple, necessary condition for breakdown is suggested.

537.311.33 : 535.34-15 **3014**
Effect of Pressure on the Infrared Absorption of Semiconductors.—L. J. Neuringer. (*Phys. Rev.*, 15th March 1959, Vol. 113, No. 6, pp. 1495–1503.) Measurements were made on Ge, Si, and Te in the pressure range 1–2 000 atm. The pressure coefficients were used to calculate the thermal dilation term in the equation for the change of the energy gap with temperature and hence the magnitude of the electron-lattice interaction.

537.311.33 : 537.32 **3015**
On the Theory of the Thermoelectricity in Two-Band Semiconductors.—E. Haga. (*J. phys. Soc. Japan.*, Jan. 1959, Vol. 14, No. 1, pp. 35–38.) A theory is developed taking account of the temperature dependence of the energy gap. The Thomson relations are shown to be satisfied.

537.311.33 : 537.533 **3016**
Field Emission from Semiconductors.—G. Busch & T. Fischer. (*Brown Boveri Rev.*, Nov./Dec. 1958, Vol. 45, Nos. 11/12, pp. 532–539.) Theoretical and experimental work on field emission is reviewed. Results are discussed of an investigation carried out on SiC point electrodes, which confirm the exponential relation between current and field which is characteristic of field emission.

537.311.33 : 538.214 **3017**
The Effect of Concentration on the Magnetic Susceptibility of Trapped Electrons and Holes in Semiconductors.—F. T. Hedgcock. (*Canad. J. Phys.*, March 1959, Vol. 37, No. 3, pp. 381–383.) A model proposed to explain the anomalous magnetic susceptibility of certain impurity semiconductors at low temperatures [see 2800 of 1957 and 3513 of 1958 (Sonder & Stevens)] is found to be attractive qualitatively but quite inadequate quantitatively.

537.311.33 : 538.614 **3018**
The Faraday Effect in Anisotropic Semiconductors.—I. G. Austin. (*J. Electronics Control*, March 1959, Vol. 6, No. 3, pp. 271–274.) "The theory of the Faraday effect in semiconductors is extended to uniaxial crystals with spheriodal energy surfaces, using the classical Drude-Zener theory. Expressions applicable at infrared frequencies are given and used to discuss preliminary measurements on Bi_2Te_3."

537.311.33 : [546.28 + 546.289 **3019**
Semiconductor Surface Phenomena.—A. Many. (*Sylvania Technologist*, Oct. 1958, Vol. 11, No. 4, pp. 117–124.) 'Slow' and 'fast' surface states have been established for Ge and Si; their characteristics are summarized and discussed.

537.311.33 : [546.28 + 546.289 **3020**
Metallurgy of Semiconductors, in Particular Germanium and Silicon.—A. J. Goss. (*Marconi Rev.*, 1st Quarter 1959, Vol. 22, No. 132, pp. 3–17.) 54 references.

537.311.33 : 546.28 **3021**
The Effects of Seed Rotation on Silicon Crystals.—A. J. Goss & R. E. Adlington. (*Marconi Rev.*, 1st Quarter 1959, Vol. 22, No. 132, pp. 18–36.) Single crystals pulled in an argon atmosphere at rotation rates up to 200 r.p.m. have been examined. The effect of rotation on crystal pulling, the growth interface, dislocations, etching, resistivity, 9μ absorption data and heat treatment of the crystal are given. Results are discussed in relation to a mechanical model of stirring in the melt.

537.311.33 : 546.281.26 **3022**

Some Surface Properties of Silicon Carbide Crystals.—J. A. Dillon, Jr, R. E. Schlier & H. E. Farnsworth. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 675–679.) Both work-function and electron-diffraction studies indicated that SiC surfaces obtained by ion bombardment and annealing were nonstoichiometric.

537.311.33 : 546.289 **3023**

High-Electric-Field Effects in Germanium *p-n* Junction.—J. Yamaguchi & Y. Hamakawa. (*J. phys. Soc. Japan.*, Jan. 1959, Vol. 14, No. 1, pp. 15–21.) Increase of ambient temperature caused the critical voltage for avalanche breakdown to increase and the voltage for the onset of negative resistance to decrease. The barrier temperature was independent of the ambient temperature.

537.311.33 : 546.289 **3024**

Barrier Temperature at Turnover in Germanium *p-n* Junction.—J. Yamaguchi & Y. Hamakawa. (*J. phys. Soc. Japan.*, Feb. 1959, Vol. 14, No. 2, pp. 232–233.)

537.311.33 : 546.289 **3025**

Injection and Extraction of Minority Carriers at the Surface of a Germanium Electrode as a Result of Electrochemical Processes.—Yu. V. Pleskov. (*Dokl. Ak. Nauk S.S.S.R.*, 1st May 1959, Vol. 126, No. 1, pp. 111–114.)

537.311.33 : 546.289 **3026**

Sb Distribution in Quenched Ge-Sb Alloys.—G. Pröpstl & G. Zielasek. (*Z. angew. Phys.*, May 1958, Vol. 10, No. 5, pp. 201–204.) The distribution of Sb in alloys prepared for doping Ge single crystals is investigated using a radioactive isotope. A considerable degree of inhomogeneity is observed in spite of rapid quenching. This difficulty can be overcome by zone melting.

537.311.33 : 546.289 : 535.215 **3027**

The Photoconduction of Germanium after Bombardment with Fast Electrons.—F. Stöckmann, E. E. Klontz, J. MacKay, H. Y. Fan & K. Lark-Horovitz. (*Z. Phys.*, 5th Dec. 1958, Vol. 153, No. 3, pp. 331–337.) The spectral distribution of photoconduction was measured on differently doped specimens of single-crystal Ge after bombardment with 4·5-MeV electrons.

537.311.33 : 546.289 : 548.4 **3028**

The Generation of Dislocations by Thermal Stresses.—P. Penning. (*Philips tech. Rev.*, 22nd Aug. 1958, Vol. 19, No. 12, pp. 357–364.) A study is made of etch-pit distribution over the cross-section of a Ge rod to assess the influence of the cooling rate on its internal perfection. The theoretical dislocation distribution is calculated assuming that stresses are only partially relieved by plastic flow. Results are in good agreement with observations. See also 2459 of 1958.

537.311.33 : 546.289 : 548.5 **3029**

The Pulling of Germanium Single Crystals from 'Floating Crucibles'.—J. Goorissen & F. Karstensen. (*Z. Metallkde*, Jan. 1959, Vol. 50, No. 1, pp. 46–50.) The floating-crucible technique is described and its theoretical yield is compared with that of the Czochralski and zone-refining methods.

537.311.33 : 546.623.86 **3030**

The Formation of Barrier Layers in Aluminium Antimonide by the Alloying Method.—H. J. Henkel. (*Z. Metallkde*, Jan. 1959, Vol. 50, No. 1, pp. 51–53.) A *p-n* function is produced by alloying *n*-type AlSb with Zn-doped aluminium foil.

537.311.33 : 546.681.241 **3031**

The Changes in the Crystal Structure of Gallium Telluride (Ga_2Te_3) Doped with Copper.—G. Harbeke & G. Lautz. (*Naturwissenschaften*, June 1958, Vol. 45, No. 12, pp. 283–284.)

537.311.33 : 546.682.19 **3032**

Effect of Heat Treatment upon the Electrical Properties of Indium Arsenide.—J. R. Dixon & D. P. Enright. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, pp. 753–759.) Large reversible variations in carrier concentration, Hall Mobility, and carrier lifetime have been produced in InAs by heat treatment. The observed phenomena are consistent with a model involving the segregation and dispersion of donor impurities to and from dislocations.

537.311.33 : 546.682.86 **3033**

Properties of the Semiconductor InSb.—M. Rodot. (*J. Phys. Radium*, Feb. 1958, Vol. 19, No. 2, pp. 140–150.) Properties are reviewed with special reference to the value of the effective mass of the electrons and the scattering mechanism. The theory of thermoelectric and thermomagnetic effects is given and experimental results are presented. See 2469 of 1958.

537.311.33 : 546.824-31 **3034**

Infrared Absorption of Reduced Rutile TiO_2 Single Crystals.—D. C. Cronemeyer. (*Phys. Rev.*, 1st March 1959, Vol. 113, No. 5, pp. 1222–1226.)

538 : 061.3 **3035**

Transactions of the 3rd Conference on the Physics of Magnetic Phenomena.—(*Izv. Ak. Nauk S.S.S.R., Ser. fiz.*, June, Aug. & Sept. 1957, Vol. 61, Nos. 6, 8 & 9, pp. 787–904, 1038–1212 & 1215–1336.) The text is given of 74 papers presented at the conference held in Moscow, 23rd–31st May 1956. For a list of titles in English, see *Translated Contents Lists of Russian Periodicals*, May & June 1958, Nos. 110 & 111, pp. 50–51 & 32–34.

538.22 : 538.569.4 **3036**

Indirect Coupling of Nuclear Spins in Antiferromagnet with Particular Reference to MnF_2 at Very Low Temperatures.—T. Nakamura. (*Progr. theor. Phys.*, Oct. 1958, Vol. 20, No. 4, pp. 542–552.) The line width ($\approx$14 oersteds) of the F^{19} nuclear magnetic resonance in MnF_2 at 1·4° K observed by Jaccarino & Shulman (527 of 1958) is shown to come mainly from indirect coupling of nuclear spins through hyperfine interaction with spin waves. The line width of the Mn^{55} resonance is about 600 oersteds.

538.22 : 538.569.4 : 621.375.9 **3037**

Two-Level Maser Materials.—R. H. Hoskins. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, p. 797.) Comment on some advantages of paramagnetic ions in ionic crystals as materials for two-level solid-state masers.

538.221 **3038**

Distribution of Magnetic Domains between the Two Phases in a Single-Crystal Flat Disk of Iron.—K. F. Niessen. (*Philips Res. Rep.*, April 1959, Vol. 14, No. 2, pp. 101–110.)

538.221 : 539.23 **3039**

Magnetic Properties of Very Thin Films of Nickel.—G. Goureaux & A. Colombani. (*C. R. Acad. Sci., Paris*, 26th Jan. 1959, Vol. 248, No. 4, pp. 543–546.)

538.221 : 539.234 : 538.63 **3040**

Determination of the Distribution of Orientation of the Magnetization Vectors in Nickel and Iron Vapour-Deposited Films using the Magneto-resistance Effect.—W. Hellenthal. (*Z. Phys.*, 5th Dec. 1958, Vol. 153, No. 3, pp. 359–371.)

538.221 : 621.318.134 **3041**

Temperature Dependence of the Paramagnetic Susceptibility of Nickel-Zinc Ferrites.—V. I. Chechernikov & Yu. D. Volkov. (*Zh. eksp. teor. Fiz.*, Oct. 1958, Vol. 35, No. 4, (10), pp. 875–879.) The reciprocal of molar susceptibility for a range of Ni-Zn ferrites is plotted as a function of temperature in the range 300°–1500° K. Near the ferromagnetic Curie point the dependence of specific magnetization σ on magnetic field strength H is expressed in the form $H = a\sigma + b\sigma^3$, where the coefficients a and b depend on temperature and pressure.

538.221 : 621.318.134 : 538.569.4 **3042**

Magnetic Resonance Studies in the Reaction of Nickel Cobalt Ferrite.—S. L. Blum & M. H. Sirvetz. (*J. appl. Phys.*, May 1959, Vol. 30, No. 5, p. 795.) Use is made of the analysis of ferromagnetic-resonance line shapes to obtain indications of the course of the reaction as a function of the reaction conditions.

538.221 : 621.318.134 : 538.569.4.029.64 **3043**

Microwave Resonance in Gadolinium-Iron Garnet Crystals.—W. V. Smith, J. Overmeyer & B. A. Calhoun. (*IBM J. Res. Developm.*, April 1959, Vol. 3, No. 2, pp. 153–162.) Ferrimagnetic resonance at 9479 and 23 725 Mc/s is described in terms of a two-sublattice model.

538.221 : 621.318.134 : 621.318.57 **3044**

Reciprocity Relationships for Gyrotropic Media.—R. F. Harrington & A. T. Villeneuve. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 308–310. Abstract, *Proc. Inst. Radio Engrs*, Oct. 1958, Vol. 46, No. 10, p. 1777.)

538.221 : 621.318.134 : 621.375.9 **3045**

Power-Flow Relations in Lossless Nonlinear Media.—H. A. Haus. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 317–324. Abstract, *Proc. Inst. Radio Engrs*, Oct. 1958, Vol. 46, No. 10, p. 1777.)

621.315.3 (083.7) **3046**

Wire in the Electronic Industry.—(*Electronic Ind.*, Dec. 1958, Vol. 17, No. 12, pp. 89..97.) U.S. specifications, wire codes and general information are tabulated.

621.793 : 621.3.049.75 **3047**

Electroless Copper Plating in Printed Circuitry.—E. B. Saubestre. (*Sylvania Technologist*, Jan. 1959, Vol. 12, No. 1, pp. 6–11.) The deposition of copper films on plastic printed-circuit boards by chemical reduction is discussed, and a procedure for producing 'plated-through' holes is described. An extension of the plating process for unclad laminates is noted.

MATHEMATICS

512 : 621.318.57 : 681.142 **3048**

Classification and Minimization of Switching Functions: Part 1.—N. C. de Troye. (*Philips Res. Rep.*, April 1959, Vol. 14, No. 2, pp. 151–193.) An attempt to find from a given Boolean function either the minimal sum of products or the minimal product of sums.

516.7 : 621.3 **3049**

Geometric-Analytic Theory of Transition in Electrical Engineering.—E. F. Bolinder. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1124–1129.)

517.942.9 : 517.949.8 **3050**

Numerical Solution of Laplace's Equation, given Cauchy Conditions.—I. Sugai. (*IBM J. Res. Developm.*, April 1959, Vol. 3, No. 2, pp. 187–188.) An expression giving the order of magnitude of the propagated errors is obtained for numerical analysis by methods of finite differences. For the practical aspect in the design of electron guns with curved electron trajectories see *Proc. Inst. Radio Engrs*, Jan. 1959, Vol. 47, No. 1, pp. 87–88.

MEASUREMENTS AND TEST GEAR

621.3.011.4 (083.74) **3051**

The Cylindrical Cross-Capacitor as a Calculable Standard.—A. M. Thompson. (*Proc. Instn elect. Engrs*, Part B, May 1959, Vol. 106, No. 27, pp. 307–310.) The capacitor consists of a hollow conducting cylinder divided into four insulated sections by gaps parallel to the axis. A practical form described consists of four parallel bars of circular cross-section. The capacitance can be computed with precision.

621.3.018.41 (083.74) **3052**

A Portable Frequency Standard.—L. F. Koerner. (*Bell Lab. Rec.*, May 1959, Vol. 37, No. 5, pp. 173–176.) Description of a unit, the size of a miniature camera, which operates at about 15 Mc/s with an accuracy within 1 part in 10^6.

621.3.018.41 (083.74) **3053**

Construction of a Mobile Caesium Frequency Standard.—A. H. W. Beck & J. Lytollis. (*Proc. Instn elect. Engrs*, Part B, 1958, Vol. 105, Supplement No. 11, pp. 712–715. Discussion.) Practical details of the construction of a sealed-off version are given.

621.3.018.41 (083.74) : 538.569.4 **3054**

Construction and Application of a Frequency Standard for Microwave Spectrometers.—H. G. Fitzky. (*Z. angew. Phys.*, July 1958, Vol. 10, No. 7, pp. 297–303.) A 10-Mc/s crystal oscillator and frequency multiplication to 1 080 Mc/s are used in the equipment described for measurements of frequency up to 25 kMc/s with an accuracy better than 1 part in 10^7.

621.317.3 : 621.396.822 **3055**

Measurement of Equivalent Noise Resistance of a Noise-Thermometer Amplifier.—H. Pursey & E. C. Pyatt. (*J. sci. Instrum.*, June 1959, Vol. 36, No. 6, pp. 260–264.) Amplifier noise is compared with that of a wire-wound resistance at a standard temperature, using a vibrating switch to connect the sources alternately to a single channel. An accuracy within 1% is obtained.

621.317.4 : 538.569.4 **3056**

Measurement of Magnetic Flux Density by Paramagnetic Resonance.—C. P. Allen & M. Sherry. (*J. Electronics Control*, March 1959, Vol. 6, No. 3, pp. 264–270.) The method is based on measurement of the frequency of paramagnetic resonance in an organic compound. It uses a simple coaxial-line probe unit and enables flux densities in the range of a few hundreds up to some thousands of gauss to be measured to an absolute accuracy of $\pm 0{\cdot}06$ %.

621.317.4 : 621.3.042.1 : 621.397.62 **3057**

Magnetic Measurements on Ferrite U-Cores for Horizontal-Deflection Output Transformers.—R. Fälker & E. E. Hücking. (*Elektronische Rundschau*, Aug. 1958, Vol. 12, No. 8, pp. 270–274.) Methods of measurement are reviewed and a specially designed core tester is described.

621.317.42 : 550.385 **3058**

The Influence of the Self-Inductance of Magnetic-Core Windings used for the Recording of Rapid Variations of the Earth's Magnetic Field.—G. Grenet. (*Ann. Géophys.*, July–Sept. 1957, Vol. 13, No. 3, pp. 249–251.)

621.317.61 : 621.385.1 **3059**

A Method for the Accurate Measurement of Mutual Conductance of Thermionic Valves.—M. R. Child & D. J. Sargent. (*Proc. Instn elect. Engrs*, Part B, May 1959, Vol. 106, No. 27, pp. 311–314.) Absolute errors are estimated to be less than 0·25 %, and comparative error less than 0·1 %. Adaptations for measurement of anode conductance and screen-grid amplification factor are described.

621.317.7 : 621.314.7 **3060**

A Transistor Characteristic Curve Tracer.—J. F. Young. (*Electronic Engng*, June 1959, Vol. 31, No. 376, pp. 330–336.) "A Dekatron is used to develop a stepped voltage controlling the base current of the transistor under test. At each step a half sinusoidal voltage is applied to the transistor and the resulting collector current is plotted against voltage on an external oscilloscope. A series resistor provides the current signal and limits the transistor dissipation. The unit can also be used to plot the characteristics of normal or of Zener diodes."

621.317.733 : 621.375.2.024 **3061**

Use of a Direct-Current Amplifier and Recorder to Balance a Mueller Resistance Bridge.—G. T. Armstrong, P. K. Wong & L. A. Krieger. (*Rev. sci. Instrum.*, May 1959, Vol. 30, No. 5, pp. 339–343.) Methods of reducing system noise to give improved sensitivity.

621.317.733.011.4 : 621.372.54 **3062**

The Balanced Unsymmetrical Parallel-T Network as a Three-Terminal Frequency-Dependent Bridge for the Measurement of Capacitance and Dissipation Factor.—K. Posel. (*Trans. S. Afr. Inst. elect. Engrs*, Aug. 1958, Vol. 49, Part 8, pp. 287–298.) The theory of operation of the bridge and its design are detailed. See also 2656 of 1958.

621.317.733.029.62 **3063**

Coaxial Displacement Dielectric Cell for Liquids Usable to 250 Mc/s.—S. E. Lovell & R. H. Cole. (*Rev. sci. Instrum.*, May 1959, Vol. 30, No. 5, pp. 361–362.) Construction details of a bridge element useful in the determination of capacitance, dielectric loss, or conductivity.

621.317.74 : 534.2-8 : 621.373.52 **3064**

Zero-Crossing Technique syncs Wave-Train Outputs.—J. A. Wereb, Jr. (*Electronics*, 8th May 1959, Vol. 32, No. 19, pp. 64–65.) A technique for producing a sinusoidal wave-train starting from the zero-crossing point of another sine wave. The generator is used in testing ultrasonic equipment.

621.317.75.087.6 **3065**

Homodyne Detector for Reproduction of Periodic Waveforms.—C. Lagercrantz. (*J. sci. Instrum.*, June 1959, Vol. 36, No. 6, pp. 257–259.) An a.f. signal is scanned using 20-μs gating impulses whose phase is shifted slowly and linearly. The gated output is recorded on a pen recorder. The circuit and performance tests are described.

621.317.763.029.64 : 621.372.413 **3066**

The Design of Broad-Band Circular Wavemeters.—P. Andrews. (*Brit. Commun. Electronics*, May 1959, Vol. 6, No. 5, pp. 354–357.) The design is considered mainly with cylindrical cavities in the TE_{11} mode. Mode suppression and the temperature coefficient of wavemeters are treated.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.721 : 621.397.9 **3067**
The Video Differential Planimeter.—M. Tobin. (*Rev. sci. Instrum.*, May 1959, Vol. 30, No. 5, pp. 323–327.) Description of an instrument for measuring variations in the projected area of a remote object by means of a television camera system or flying-spot scanner.

538.566.029.6 : 541.126 **3068**
Observations of Detonation in Solid Explosives by Microwave Interferometry.—G. F. Cawsey, J. L. Farrands & S. Thomas (*Proc. roy. Soc. A*, 9th Dec. 1958, Vol. 248, No. 1255, pp. 499–521.) Confined detonation processes have been studied by a method noted earlier [1833 of 1956 (Farrands & Cawsey)], using apparatus developed from that described by Froome (3532 of 1952).

550.340 : 621.3.087.6 **3069**
An Electronic Seismic Transducer for Visual Recording.—P. Gouin. (*Ann. Géophys.*, July–Sept. 1957, Vol. 13, No. 3, pp. 234–241. In English.) A detailed description of the capacitance-type transducer, amplifier and recorder.

551.508.71 : 621.372.413 **3070**
Recording Microwave Hygrometer. J. Sargent. (*Rev. sci. Instrum.*, May 1959, Vol. 30, No. 5, pp. 348–355.) A description is given of a microwave refractometer designed at the National Bureau of Standards for measurement of low water-vapour pressures in a moving air stream.

621.384.6 : 621.319.3 **3071**
Electrostatic-Transformer-Type Particle Accelerator using Ceramic $BaTiO_3$—Ferrostac.—T. Shibata, A. Toi & T. Suita. (*J. Phys. Soc. Japan*, Feb. 1959, Vol. 14, No. 2, p. 227.) A note on the construction of a 150-kV accelerator in which the h.v. generator has rotating ferroelectric disks which carry electric charges.

621.384.8 : 621.318.381 : 621.316.7.078.3 **3072**
Current and Field Stabilization of the 9-kW Electromagnet of the A.E.I. Magnetic Spectrograph.—R. Bailey & E. C. Fellows. (*J. Brit. Instn Radio Engrs*, May 1959, Vol. 19, No. 5, pp. 309–321.) Signals obtained from nuclear resonance are used to control the strength of a magnetic field to within $\pm 0 \cdot 01$ %.

621.385.833 **3073**
Numerical Computation of Electrostatic Immersion Objectives.—E. Hahn. (*Optik, Stuttgart*, Aug. 1958, Vol. 15, No. 8, pp. 500–515.)

621.385.833 **3074**
Space-Charge Aberration and Resolving Power in Electron Microscopes.—W. E. Meyer. (*Optik, Stuttgart*, July 1958, Vol. 15, No. 7, pp. 398–406.) Space-charge effects may limit the resolving power more than spherical aberration. Methods of reducing the influence of space charge are indicated.

621.385.833 **3075**
Stigmatic Image in Rotationally Asymmetric Electron Lenses.—F. Lenz. (*Optik, Stuttgart*, July 1958, Vol. 15, No. 7, pp. 393–397.)

621.385.833 : 535.317.3 **3076**
Compensation of the Chromatic Dependence of Magnification in the Electrostatic Electron Microscope.—W. Weitsch. (*Optik, Stuttgart*, Aug. 1958, Vol. 15, No. 8, pp. 492–499.)

621.385.833 : 621.3.032.21 **3077**
Some Electron-Optical Properties of Point Cathodes.—S. Maruse & Y. Sakaki. (*Optik, Stuttgart*, Aug. 1958, Vol. 15, No. 8, pp. 485–491.) Experimental results show that electron emission of the point cathode is mainly determined by the Schottky effect. The use of the point cathode as a cold cathode in electron microscopes is discussed. See also 245 of 1957 (Sakaki & Möllenstedt).

621.385.833 : 621.3.032.213.6 **3078**
Oxide-Cored Cathode.—K. Ando, O. Kamigaito, Y. Kamiya, S. Takahashi & R. Uyeda.—(*J. Phys. Soc. Japan*, Feb. 1959, Vol. 14, No. 2, pp. 180–185.) Description of a cathode for electron microscopy consisting of a drawn platinum wire filled with oxide powder. The method of preparation and performance tests are described.

621.387.424 **3079**
Improved Design for Halogen-Quenched End-Window Geiger Counters.—K. van Duuren & J. Hermsen. (*Rev. sci. Instrum.*, May 1959, Vol. 30, No. 5, pp. 367–368.)

621.387.464 **3080**
Modern Development of Scintillation Counters.—W. Hanle & H. Schneider. (*Z. angew. Phys.*, May 1958, Vol. 10, No. 5, pp. 228–248.) Detailed review of design, construction and applications. 242 references.

621.387.464 : 621.383.27 **3081**
The Resolving Power of Scintillation Multipliers and the Influence on it of Various Parameters.—P. Görlich, A. Krohs, H. J. Pohl, R. Reichel & L. Schmidt. (*Z. angew. Phys.*, July 1958, Vol. 10, No. 7, pp. 303–309.) Results of measurements on a photomultiplier for scintillation counting are discussed.

621.397.9 : 522.2 **3082**
Using TV Techniques in Astronomy.—J. Borgman. (*Electronics*, 8th May 1959, Vol. 32, No. 19, pp. 66–68.) A variable star is detected by a differential photographic method which eliminates constant features. Television techniques are used to display the difference signals.

621.397.9 : 522.2 **3083**
Television Techniques in Astronomy.—N. F. Kuprevich. (*Priroda, Mosk.*, March 1958, No. 3, pp. 50–54.) Two systems are described based on: (*a*) a two-stage electron-optical converter consisting of a photocathode emitting electrons which form an image on a 35-mm luminous screen with a possible increase of brightness up to 100–130 times; (*b*) the use of an orthicon-type 625-line television screen on which an image is obtained with magnification up to 6·5 times.

621.398 **3084**
Radio Telemetry: Part 1—Systems.—A. J. Shimmins. (*Proc. Instn Radio Engrs, Aust.*, Dec. 1958, Vol. 19, No. 12, pp. 775–787.) Factors which determine system performance are analysed, taking as an example the R.A.E. subminiature f.m./a.m. system.

621.398 : 616.831-073.97 **3085**
A Miniature Electroencephalograph Telemeter System.—D. C. Gold & W. J. Perkins. (*Electronic Engng*, June 1959, Vol. 31, No. 376, pp. 337–339.) Transmits the electrical activity of the brain of an unrestrained cat on a 6·8-Mc/s a.m. carrier.

681.61 : 621.319 **3086**
High-Speed Read-Out for Data Processing.—R. E. West. (*Electronics*, 29th May 1959, Vol. 32, No. 22, pp. 83–85.) Description of an e.s. teletypewriter which can print more than 3 000 words/min. Input pulses to the print heads charge the surface of paper to which powdered ink adheres.

PROPAGATION OF WAVES

621.396.11 : 550.389.2 : 629.19 **3087**
Radio Reflections from Satellite-Produced Ionization.—Roberts, Kirchner & Bray. (See 2963.)

621.396.11 : 551.510.52 **3088**
The Role of Turbulent Mixing in Scatter Propagation.—R. Belgiano, Jr. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 161–168. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1438.)

621.396.11 : 551.510.52 **3089**
The Influence of Moisture in the Ground, Temperature and Terrain on Ground Wave Propagation in the V.H.F. Band.—B. Josephson & Å. Blomquist. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 169–172. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

621.396.11 : 551.510.52 **3090**
Distance Dependence, Fading Characteristics and Pulse Distortion of 3 000-Mc/s Transhorizon Signals.—B. Josephson & G. Carlson. (*Trans Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 173–175. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

621.396.11 : 551.510.52 **3091**
Some Microwave Propagation Experiences from a 'Just-Below-Horizon' Path.

—B. Josephson & F. Eklund. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 176–178. Abstract, *Proc. Inst. Radio Engrs*, July 1958, Vol. 46, No. 7, p. 1439.)

621.396.11 : 551.510.52 **3092**

The Diffraction of Electromagnetic Waves by the Earth's Curvature—a Theory of Tropospheric Propagation Near and Beyond the Radio Horizon.—O. Tukizi. (*Rep. elect. Commun. Lab., Japan*, Nov. 1958, Vol. 6, No. 11, pp. 421–425.) Classical diffraction theory is modified to account for the slow rate of decrease of field-strength well beyond the horizon. A saddle-point method is used to take into account the contribution of all the terms of the residue series.

621.396.11 : 551.510.535 : 523.164 **3093**

Refraction of Extraterrestrial Radio Waves in the Ionosphere.—Komesaroff & Shain. (See 2973.)

621.396.11.029.45/.51 : 551.510.535 : 551.594.6 **3094**

An Experimental Proof of the Mode Theory of V.L.F. Ionospheric Propagation.—T. Obayashi, S. Fujii & T. Kidokoro. (*J. Geomag. Geoelect.*, 1959, Vol. 10, No. 2, pp. 47–55.) V.l.f. atmospherics are received on a receiver which continuously sweeps over the frequency band 5–70 kc/s. The output is displayed on an intensity-modulated c.r. tube which is photographed on continuously moving film. There is an intensity maximum near 10 kc/s and selective absorption bands which vary with time of day and may be associated with the cut-off frequencies of the earth–ionosphere waveguide. The effects of solar flares are also discussed.

621.396.11.029.63 **3095**

A Contribution to the Knowledge of Propagation Conditions at 1.3 Gc/s based on Measurements over a Transmission Path within Optical Range.—U. Kühn. (*Tech. Mitt. BRF, Berlin*, Oct. 1957, Vol. 1, No. 1, pp. 4–10.) Statistical analysis of field-strength recordings taken in one year over an 82-km path, and comparison with meteorological data for the same period.

621.396.11.029.63 **3096**

Measurements of 1250-Mc/s Scatter Propagation as Function of Meteorology.—D. L. Ringwalt, W. S. Ament & F. C. MacDonald. (*Trans. Inst. Radio Engrs*, April 1958, Vol. AP-6, No. 2, pp. 208–209.) Short detailed report and discussion of the results of measurements made over a 262-mile over-water path between Florida and the Bahamas in December 1956. Ground and airborne field-strength measurements, refractometer soundings, radiosonde data and visual observations were recorded.

621.396.11.029.63 **3097**

Apparent Correlation between Tropopause Height and Long-Distance Transmission Loss at 490 Mc/s.—D. R. Hay. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1144–1145.) For a 640-mile path in June-July 1957 signals were low and steady when the tropopause was low, but were higher and fluctuated more when the tropopause was high.

621.396.812 **3098**

Prolonged Signal Fade-Out on a Short Microwave Path.—D. R. Hay & G. E. Poaps. (*Canad. J. Phys.*, March 1959, Vol. 37, No. 3, pp. 313–321.) During a period of one year, the incidence of signal fade-out has been observed in 2-kMc/s transmissions over a 21-mile path near Ottawa. Fade-out durations varied from a few minutes to several hours, with the most frequent occurrence in the summer and during the night. An analysis of the refractivity of the air at the middle of the radio path indicates that fade-out is associated with a shallow horizontal transition zone in vapour pressure at a level near the aerial heights.

RECEPTION

621.376 **3099**

Correlation Devices Detect Weak Signals.—H. R. Raemer & A. B. Reich. (*Electronics*, 22nd May 1959, Vol. 32, No. 21, pp. 58–60.) Operating principles of autocorrelators, cross-correlators, and radiometers are described.

621.396.621 : 621.314.7 **3100**

How to Design Reflexed Transistor Receivers.—J. Waring. (*Electronics*, 8th May 1959, Vol. 32, No. 19, pp. 70–72.) Methods for obtaining i.f. and a.f. gain in the same stage without motorboating.

621.396.66 : 621.396.828 **3101**

Negative-Supply Outboard Codan.—R. L. Ives. (*Audio*, May 1959, Vol. 43, No. 5, pp. 22–23..73.) Details are given of a circuit which silences the a.f. stages of a receiver when the carrier amplitude falls below a predetermined level. The circuit does not alter the characteristics of the receiver to which it is connected.

621.396.812.3 : 621.396.666 **3102**

Linear Diversity Combining Techniques.—D. G. Brennan. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1075–1102.) An analysis and results of measurements of the relative performance are given for three types of diversity combining techniques: (*a*) selection diversity, (*b*) maximal-ratio diversity, and (*c*) equal-gain diversity systems. The effects of various departures from the ideal conditions are considered and the relative merits of predetection and post-detection combining and of long-term distributions are discussed.

STATIONS AND COMMUNICATION SYSTEMS

621.391 **3103**

On Asymmetric Information Channels.—R. B. Banerji. (*J. Brit. Instn Radio Engrs*, May 1959, Vol. 19, No. 5, pp. 305–308.) A study of channel capacity in terms of the probability of possible errors, and application to p.c.m. with amplitude keying.

621.396.3 : 621.391 **3104**

Some Operational Considerations Affecting the Use of Automatic Error Correcting Equipment on H.F. Telegraph Networks.—E. G. Copper. (*Point to Point Telecommun.*, Feb. 1959, Vol. 3, No. 2, pp. 21–34.) A discussion of some of the problems associated with the radio error-correcting multiplex (REM) system.

621.396.5 : 534.76 **3105**

Compatible Stereo Radio using A.M/F.M. Multiplex.—H. E. Sweeney. (*Electronics*, 8th May 1959, Vol. 32, No. 19, pp. 56–58.) Transmission of two channels by amplitude and frequency modulation of the same carrier. A circuit is given for the addition of a f.m. channel to an a.m. receiver.

621.396.65 **3106**

The TJ Radio System.—S. D. Hathaway & H. H. Haas. (*Bell Lab. Rec.*, April 1959 Vol. 37, No. 4, pp. 129–133.) Description of a 6-channel 11-kMc/s relay system using dual frequency-diversity transmission, giving details of arrangement of subcarriers in the spectrum and examples of use for telephony, television and data transmission.

621.396.65 : 621.396.41 **3107**

F.M. Multiplexing for Studio-Transmitter Links.—D. Harkins. (*Electronics*, 22nd May 1959, Vol. 32, No. 21, pp. 44–45.) Three program signals modulate subcarriers at 26, 65 and 175 kc/s, which are combined to modulate a 946 Mc/s carrier for transmission to the transmitter site 16 miles away.

SUBSIDIARY APPARATUS

621.3.087.45 : 621.395.625.3 **3108**

A Multiple-Channel D.C. Recording System.—H. D. Scott. (*Electronic Engng*, June 1959, Vol. 31, No. 376, pp. 340–344.) Describes an a.m. system with tape-noise cancellation enabling up to twelve 0–10-c/s channels to be recorded on a conventional single-track recorder together with speech and timing signals.

621.314.63 : 546.289 **3109**

The Thermal Behaviour of Semiconductor Rectifiers.—O. Jakits. (*Brown Boveri Rev.*, Nov./Dec. 1958, Vol. 45, Nos. 11/12, pp. 540–544.) Measurements are described which were made on heavy-current Ge diodes to determine the thermal inertia. The effect of cooling on the overload characteristic is discussed.

621.314.63 : 621.396.96 **3110**

Using Silicon Diodes in Radar Modulators.—M. G. Gray. (*Electronics*, 12th June 1959, Vol. 32, No. 24, pp. 70–72.) A peak power of 250 kW is developed using

Si diodes for charging the artificial line and for clipping reverse voltage swings. The diodes dissipate instantaneous powers up to 300 kW.

621.314.634 **3111**

Selenium Rectifiers with Artificial Layers of Selenides of Cadmium, Tin, Bismuth and Lead.—Y. Moriguchi. (*J. Phys. Soc. Japan*, Feb. 1959, Vol. 14, No. 2, pp. 152–167.) The action of various selenides as barrier layers has been investigated by measurement of the rectifier d.c. and a.c. characteristics. CdSe and SnSe layers play an important role in rectification but the selenides of Bi and Pb seem to be unsuitable. In general, the layer material should have a resistivity $< 10^4$ Ω cm.

621.314.64 **3112**

Current/Time Relationship in the Forward Direction of Electrolytic Rectifiers.—W. C. van Geel & C. A. Pistorius. (*Philips Res. Rep.*, April 1959, Vol. 14, No. 2, pp. 123–131.) Qualitative explanation of the effects observed on applying alternating rectangular and sinusoidal voltages.

621.316.721.078 : 621.375.2.024 **3113**

Use of Operational Amplifiers in Precision Current Regulators.—K. Eklund. (*Rev. sci. Instrum.*, May 1959, Vol. 30, No. 5, pp. 328–331.) Low-drift high-gain d.c. amplifiers in a control loop can reduce steady-state error.

TELEVISION AND PHOTOTELEGRAPHY

621.397.24 **3114**

Carrier Transmission for Closed-Circuit Television.—L. G. Schimpf. (*Electronics*, 12th June 1959, Vol. 32, No. 24, pp. 66–68.) A simple and inexpensive coaxial-cable transmission system, using transistors in the terminal and repeater circuits is described. D.c. supplies to the repeaters are applied via the signal cable.

621.397.611.2 **3115**

Measurement of the Transmission Characteristics of Television-Camera Preamplifiers.—W. Eckardt. (*Tech. Mitt. BRF, Berlin*, Dec. 1957, Vol. 1, No. 2, pp. 27–32.)

621.397.62 **3116**

Two Realizations of the New Synchrophase.—L. Chrétien & R. Aschen. (*TSF et TV*, March–May 1957, Vol. 33, Nos. 341–343, pp. 71–76, 152–157 & 167–168.) A rejector circuit and a variable video-frequency gain control compensate for phase distortion by altering the shape of the video-frequency response curve. Detailed descriptions are given of a medium-range and a long-range television receiver, with a note on the adjustment of the phase-correction circuit.

621.397.62 **3117**

Television I.F. Amplifiers with Linear Phase Response.—A. N. Thiele. (*Proc. Instn Radio Engrs, Aust.*, Nov. 1958, Vol. 19, No. 11, pp. 652–668.) This type of response is discussed in relation to ease of tuning and alignment and to phase equalization at the transmitter.

621.397.62 : 535.623 **3118**

Automatic Controls for Colour Television.—Z. Wiencek. (*Electronics*, 15th May 1959, Vol. 32, No. 20, pp. 58–59.) A method of control of the phase (hue) and amplitude (chroma) of the colour signal using a low-frequency diode gate.

621.397.62 : 535.623 : 535.88 **3119**

The Projection of Colour-Television Pictures.—T. Poorter & F. W. de Vrijer. (*Philips tech. Rev.*, 22nd Aug. 1958, Vol. 19, No. 12, pp. 338–355.) Three projection-type c.r. tubes are used respectively with red, green and blue fluorescing phosphors. Each is mounted in a Schmidt optical system the superposition of the three images being effected either by dichroic mirrors [1701 of May (van Alphen)] or by mounting the three tubes side by side. Projectors using these systems are described.

621.397.621.2 **3120**

Noise-Immune Synchronizing Circuits for Television Timebase Circuits.—D. J. Howlett & L. Buduls. (*Proc. Instn Radio Engrs, Aust.*, Nov. 1958, Vol. 19, No. 11, pp. 680–689.) Noise limiting and a.g.c. circuits are discussed and details are given of an improved form of the heptode sync separator described by Marks (252 of 1953).

621.397.621.2 **3121**

Some Aspects of Synchronization in Television Receivers.—J. van der Goot. (*Proc. Instn Radio Engrs, Aust.*, Nov. 1958, Vol. 19, No. 11, pp. 690–706.) A discussion of scanning oscillators and a.f.c. systems.

621.397.621.2 **3122**

The Synchronization Separator—an Unexpected Observation.—J. Goldthorp. (*Proc. Instn Radio Engrs, Aust.*, Nov. 1958, Vol. 19, No. 11, pp. 706–707.) A note describing the improved performance obtained using a remote-cut-off pentode as composite sync separator in place of a valve with sharp cut-off.

621.397.621.2 **3123**

Improvements in Television Receivers: Part 5—Stabilization of Line and Frame Output Circuits.—B. G. Dammers, A. G. W. Uitjens, A. Boekhorst & H. Heyligers. (*Electronic Applic.*, Nov. 1958, Vol. 18, No. 4, pp. 129–142.) Detailed descriptions are given of circuits suitable for a 110° c.r. tube. Line output stages with flyback ratios of 16, 18 or 21 % have been stabilized by voltage-dependent resistors (see Part 4: 989 of March). The frame output stage derives its charging voltage from the stabilized boost voltage. A protective circuit to limit beam current is described.

621.397.621.2 **3124**

Improvements in Television Receivers: Part 6—Design Considerations for Stabilized Line Output Circuits.—B. G. Dammers, A. Boekhorst & D. Hoogmoed. (*Electronic Applic.*, Nov. 1958, Vol. 18, No. 4, pp. 143–157.) Essential formulae and graphs are given for a quantitative investigation of circuits in which the line output valve operates above the knee of the I_a/V_a characteristic. For practical circuits see 3123 above.

621.397.621.2 : 535.623 : 621.385.832 **3125**

Errors of Magnetic Deflection: Part 2.—J. Haantjes & G. J. Lubben. (*Philips Res. Rep.*, Feb. 1959, Vol. 14, No. 1, pp. 65–97.) Approximate formulae for the design of deflection coils have been developed from a theoretical study [Part 1: 2990 of 1957]. Convergence errors in the shadow-mask tube and in an experimental tube with three guns vertically in line are discussed. For the latter tube a deflection coil can be designed which makes dynamic convergence unnecessary.

621.397.621.2 : 621.373.444.1 : 621.314.7 **3126**

Transistor Line Deflection Circuits for Television.—P. B. Helsdon. (*Marconi Rev.*, 1st Quarter 1959, Vol. 22, No. 132, pp. 38–70.) The shunt diode circuit and the retrace-driven circuit due to Guggi (2382 of 1957) are analysed and their limitations discussed. A flyback-driven circuit is described with automatic phase control, and reverse base current drive to the shunt diode circuit. The output is sufficient for scanning a 70° picture tube.

621.397.621.2 : 621.385.832 **3127**

A New Approach to Short Picture-Tube Design.—G. A. Burdick. (*Sylvania Technologist*, Jan. 1959, Vol. 12, No. 1, pp. 2–5.) A brief description of the construction and principle of operation of the tripotential focus (TPF) gun which can be focused by varying the potential to any one of the three elements.

621.397.621.2 : 621.385.832.032.269.1 **3128**

A New Electron Gun for Picture Display with Low Drive Signals.—K. Schlesinger. (*J. Telev. Soc.*, Jan.–March 1959, Vol. 9, No. 1, pp. 15–25.) High control sensitivity required for transistor drive is achieved by a new electron-optical approach. Beam focusing and modulation are effected in a cylindrical cavity by two separate e.s. fields: one of circular symmetry for focusing, and one of transverse-plane geometry for modulation.

621.397.7 **3129**

ABN Television Transmitter.—F. M. Shepherd. (*Proc. Instn Radio Engrs, Aust.*, Nov. 1958, Vol. 19, No. 11, pp. 609–614.) A brief description of main and standby equipment at Gore Hill.

621.397.7 **3130**

The ATN Television Centre.—M. H. Stevenson. (*Proc. Instn Radio Engrs, Aust.*, Nov. 1958, Vol. 19, No. 11, pp. 614–621.) A general description of the Centre which is near Sydney. Factors which influenced its design and the provisions made for expansion are discussed.

621.397.7 : 535.623 **3131**

Holding Video Level while Switching Studios.—J. O. Schroeder. (*Electronics*, 29th May 1959, Vol. 32, No. 22, pp. 96–98.) An automatic circuit designed to compensate for wide variations in colour or monochrome input signal levels and to maintain a constant output level.

621.397.7 : 621.396.65 **3132**

Equalization of Aural and Visual Delay.—I. Kerney & W. D. Mischler. (*Bell Lab. Rec.*, May 1959, Vol. 37, No. 5, pp. 182–186.) The delay of audio signals relayed by coaxial cable relative to video signals relayed by microwave link is reduced by bypassing demodulating equipment at coaxial relay points.

621.397.7 : 621.396.677.81 **3133**

The Passive TV Relay and its Practical Possibilities.—Aschen. (See 2851.)

621.397.8 **3134**

Echo Phenomena in Television Images.—J. Polonsky, L. Amster & G. Melchior. (*J. Telev. Soc.*, Jan.–March 1959, Vol. 9, No. 1, pp. 2–14.) English version of 283 of 1957.

621.397.8 **3135**

Results of Investigations on the Recognizability of Small Details on a Television Screen.—F. Below, W. Kroebel & H. Springer. (*Z. angew. Phys.*, June 1958, Vol. 10, No. 6, pp. 277–285.) An objective method of measuring detail recognition is described based on the use of Landoltring test pictures (see 3321 of 1957). The effects of bandwidth limitation and contrast are investigated.

621.397.8 **3136**

The Perceptibility of Image Details in Television Images.—W. Kroebel, F. Arp & H. Baurmeister. (*Z. angew. Phys.*, July 1958, Vol. 10, No. 7, pp. 320–327.) The test described in 3136 below is applied to television images. Results are closely related to those obtained with optically projected images.

621.397.8 **3137**

Phase-Shift Considerations in Television Broadcasting and Reception.—M. W. Davies. (*Proc. Instn Radio Engrs, Aust.*, Nov. 1958, Vol. 19, No. 11, pp. 642–651.) A general description of phase distortion and of the effects this distortion can have on the received signal of a vestigial-sideband system. Methods available for compensation are discussed; see e.g. 3117 above.

621.397.8 : 535.7 **3138**

The Visual Properties of the Human Eye as a Contribution to the Problem of Assessing the Quality of Projection and Television Images.—W. Kroebel, F. Arp & H. Baurmeister. (*Z. angew. Phys.*, July 1958, Vol. 10, No. 7, pp. 309–317.) A test is described for the quantitative assessment of the perception of small objects by the eye and a mathematical expression is derived relating perception to contrast and object size. For the underlying statistical considerations see *ibid.*, pp. 317–320 (Arp).

621.397.8 : 621.396.822 **3139**

Effects of Noise in Television Transmission.—T. Kilvington. (*J. Telev. Soc.*, Jan.–March 1959, Vol. 9, No. 1, pp. 26–31.) The nature of random noise and its effect on sound and vision reception are reviewed. The subjective effects on the picture of both random and periodic noise are described and methods of minimizing them are considered.

621.397.8 : 621.396.822 **3140**

Theoretical and Experimental Characteristics of Random Noise in Television.—R. Fatehchand. (*J. Brit. Instn Radio Engrs*, June 1959, Vol. 19, No. 6, pp. 335–344.) The characteristics of noise distributed uniformly over the frequency band and that concentrated at the high frequency end of the pass-band are compared. The effects of a nonlinear transfer characteristic on noise alone and on noise plus signal are studied and the relation between these effects and noise visibility on a picture tube is examined.

TRANSMISSION

621.396.61 : 629.19 **3141**

Minimum Transmitter System Weight for Space Communications.—R. S. Davies & C. S. Weaver. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, pp. 1151–1152.) A method is given for calculating optimum transmitter weight and aerial size.

621.396.71 **3142**

New Radio Transmitters at Ongar.—(*Engineer, Lond.*, 27th Feb. 1959, Vol. 207, No. 5379, p. 339.) Operational data are given on the seven new radiotelegraphy transmitters of the British Post Office.

VALVES AND THERMIONICS

621.314.63 **3143**

The D.C. and A.C. Characteristics of Point-Contact Diodes.—H. Beneking. (*Z. angew. Phys.*, May 1958, Vol. 10, No. 5, pp. 216–225.) A *p-n* diode of spherical symmetry [see e.g. 2411 of July (Hofmeister & Groschwitz)] is investigated by analogy with calculations for the plane configuration (1398 of April). An interpretation of the injection mechanism of point contacts is obtained. Good agreement between measured and theoretical diode characteristics is found.

621.314.63 : 621.318.57 **3144**

Millimicrosecond Switching Diodes.—J. Halpern & R. H. Rediker. (*Electronics*, 5th June 1959, Vol. 32, No. 23, pp. 66–67.) Describes briefly the construction of Ge-In-Sb diffusion diodes for switching speeds of 2–3 mμs (see 2909 of 1958). A method of measuring the reverse recovery time is outlined.

621.314.63 : 621.372.632 **3145**

Transmitting Frequency Converter in which Gold- or Silver-Bonded Diode is Used.—S. Kita, H. Sanpei & T. Okajima. (*Rep. elect. Commun. Lab., Japan*, Nov. 1958, Vol. 6, No. 11, pp. 415–420.) More than 8 dB conversion gain with output frequency 4130 Mc/s has been obtained using non-linear-capacitance Ge diodes [see *Proc. Inst. Radio Engrs*, June 1958, Vol. 46, No. 6, p. 1307 (Kita)].

621.314.63 + 621.314.7]-71 (083.57) **3146**

Taking the Heat off Semiconductor Devices.—W. Luft. (*Electronics*, 12th June 1959, Vol. 32, No. 24, pp. 53–56.) Charts and nomograms are given for the design of cooling fins.

621.314.7 + 621.314.63 **3147**

Transistors and Associated Semiconductor Devices.—R. G. Hibberd. (*Proc. Instn elect. Engrs*, Part B, May 1959, Vol. 106, No. 27, pp. 264–278.) Progress in the manufacture and application of these devices is reviewed. Characteristics of many available types are tabulated.

621.314.7 **3148**

Diffusion Capacitance in Transistors.—K. Böke, J. B. M. Spaapen & N. B. Speyer. (*Philips Res. Rep.*, April 1959, Vol. 14, No. 2, pp. 111–122.) Calculations taking into account the influence of the second junction are in agreement with the results of capacitance measurements at different temperatures, voltages and frequencies.

621.314.7 **3149**

A Particular Problem of Temperature Distribution concerning the Theory of Junction Transistors.—A. Pignedoli. (*R.C. Accad. naz. Lincei*, Nov. 1957, Vol. 23, No. 5, pp. 257–262.) The temperature distribution as a function of position and time is analysed for a cylinder of circular or elliptical cross-section; the solution is applicable to the investigation of temperature distribution in a transistor whose junction temperature is raised.

621.314.7 :546.28 : 621.317.3 **3150**

The Measurement of the Temperature Dependence of the Mobility and Effective Lifetime of Minority Carriers in the Base Region of Silicon Transistors.—D. M. Evans. (*J. Electronics Control*, March 1959, Vol. 6, No. 3, pp. 204–208.) The mobility of holes in the base of a fusion-alloy *p-n-p* transistor was found to vary with the absolute temperature T as $T^{-2\cdot1}$; the corresponding result for electrons in the base of a grown-junction *n-p-n* transistor was $T^{-2\cdot5}$. Results for the effective lifetime of minority carriers in the base are also given.

621.314.7 : 621.317.7 **3151**

A Transistor Characteristic Curve Tracer.—Young. (See 3060.)

621.314.7 : 621.385.4 **3152**

Theory and Use of Field-Effect Tetrodes.—H. A. Stone, Jr. (*Electronics*, 15th May 1959, Vol. 32, No. 20, pp. 66–68.) Characteristics and circuit applications of the device are discussed and a description is given of a technique by which laboratory models have been constructed.

621.314.7.012.8 **3153**

Transmission-Line Analogue of a Drift Transistor.—J. te Winkel. (*Philips Res. Rep.*, Feb. 1959, Vol. 14, No. 1, pp. 52–64.) A method is described based on a constant drift field, for deriving base transport parameters and the small-signal equivalent circuit without solving the differential equations explicitly.

621.314.7.012.8 **3154**

Three-Dimensional Electric-Circuit Model of the High-Frequency Phenomena in a Junction Transistor.—G. Brouwer. (*Philips Res. Rep.*, April 1959, Vol. 14, No. 2, pp. 132–142.) The linearized problem, corresponding to small-signal operation of a transistor, is solved with the aid of a model.

621.383.27 **3155**

New Photoelectron Multipliers.—N. S. Khlebnikov. (*Izv. Ak. Nauk S.S.S.R., Ser. fiz.*, Jan. 1958, Vol. 22, No. 1, pp. 70–77.) Five types of photomultiplier are briefly described. Typical field distributions and electron paths are illustrated and operating characteristics are tabulated.

621.383.27 **3156**

Manufacture of Photoelectron Multipliers and Their Basic Parameters.—A. E. Melamid. (*Izv. Ak. Nauk S.S.S.R., Ser. fiz.*, Jan. 1958, Vol. 22, No. 1, pp. 78–82.)

621.383.42 **3157**

The Open-Circuit Electromotive Force of a Selenium Photocell at Low Temperatures.—G. Blet. (*J. Phys. Radium*, Feb. 1958, Vol. 19, No. 2, pp. 166–169.) Assumptions concerning the internal mechanism of photocells are checked and a general expression, independent of photocell size, is given.

621.383.5 **3158**

Photovoltaic Effect in Se Photocells having Artificial Intermediate Layers of CdSe, CdTe, ZnSe and ZnTe.—H. Tubota & H. Suzuki. (*J. phys. Soc. Japan.*, Jan. 1959, Vol. 14, No. 1, pp. 38–40.)

621.385.029.6 **3159**

International Convention on Microwave Valves.—(*Proc. Instn elect. Engrs*, Part B, 1958, Vol. 105. Supplement No. 11, pp. 609–812.) The text is given of the following papers which were included among those read at the I.E.E. Convention held in London 19th–23rd May 1958. Others are abstracted separately. For titles of papers included in Supplement No. 10 see 2788 and 2800 of August.

Technology:

(*a*) A new Ceramic Waveguide Window for Use on X-Band Valves.—W. F. Gibbons & A. V. Whale (pp. 609–613).

(*b*) Photo-etching Molybdenum Foil.—H. A. C. Hogg (pp. 614–616).

(*c*) High-Power Windows at Microwave Frequencies.—J. V. Lebacqz, J. Jasberg, H. J. Shaw and S. Sonkin (pp. 617–622).

(*d*) Study of the Lives of Dispenser-Type Barium-Tungsten Cathodes.—T. Hashimoto (p. 622).

(*e*) Application of Discharge Machining to Millimetre-Wave Magnetrons.—M. Nishimaki & T. Asaba (p. 623).

Space-Charge Waves:

(*f*) Large-Signal Linear-Beam Tube Theory.—C. C. Wang (pp. 624–632).

(*g*) A Variation Principle for Small-Amplitude Disturbances of Electron Beams.—P. A. Sturrock (pp. 632–634).

(*h*) Space-Charge Waves on Annular Beams in Drift Tubes.—A. H. W. Beck & P. E. Deering (pp. 635–641).

(*i*) Magnetic Oscillations in Electron Beams.—R. H. C. Newton (pp. 642–644).

(*j*) Microwave Amplification using an Unstable Electron Beam in Crossed Electric and Magnetic Fields.—D. J. Harris (pp. 645–648).

Semiconductors and New Methods of Generation:

(*k*) Parametric Amplification of Space-Charge Waves.—A. Ashkin, T. J. Bridges, W. H. Lousell & C. F. Quate (pp. 649–651). See 1025 of March.

(*l*) Some Proposals for Generating High-Frequency Electromagnetic Waves using the Doppler Effect.—R. B. R. Shersby-Harvie (pp. 652–655).

(*m*) Fast-Wave Interactions with an Electron Film at Cyclotron Resonance.—A. Karp (pp. 656–661).

(*n*) Junction Diodes in Microwave Circuits.—A. Uhlir (p. 661).

(*o*) Theory of the Microwave Crystal Mixer.—C. Baron (pp. 662–664).

(*p*) Microwave Amplification by means of Intrinsic Negative Resistances.—E. Rostas & F. Hülster (pp. 665–673).

Resonators and Slow-Wave Structures:

(*q*) Dielectric Loading for U.H.F. Valves.—G. B. Walker (pp. 717–718).

(*r*) A Structure, using Resonant Coupling Elements, suitable for a High-Power Travelling-Wave Tube.—A. F. Pearce (pp. 719–726).

(*s*) Results on Delay Lines for High-Power Travelling-Wave Tubes.—P. Palluel & J. Arnaud (pp. 727–729).

(*t*) Theoretical Investigation of some Closed Delay Structures for High-Power Travelling-Wave Tubes.—F. Sellberg (pp. 730–735).

Discussion (pp. 735–736).

(*u*) A New Type of Slow-Wave Structure for Millimetre Wavelengths.—E. A. Ash (pp. 737–745).

(*v*) Multiple Ladder Circuits for Millimetre-Wavelength Tubes.—R. M. White, C. K. Birdsall & R. W. Grow (p. 746).

Discussion (p. 746).

(*w*) Dispersion Curves for a Helix in a Glass Tube.—D. T. Swift-Hook (pp. 747–755).

(*x*) Some Aspects of the Design of a Helical Coupler for a Travelling-Wave Tube Operating in the 2-Gc/s Band.—P. A. Lindsay & K. D. Collins (pp. 756–761).

(*y*) Modified Transmission-Line Couplers for Helices.—E. A. Ash & J. D. Pattenden (pp. 762–768).

(*z*) The Coupling of Three Coaxial Helices.—B. Minakovic (pp. 769–778).

Discussion (pp. 778–779).

(*aa*) Characteristics of Interdigital Circuits and their Use for Amplifiers.—J. Hirano (pp. 780–785).

Noise:

(*bb*) Calculations concerning the Noisiness of a Drifting Stream of Electrons.—J. R. Pierce (pp. 786–789).

(*cc*) Progress in Low-Noise Microwave Tube Design.—W. R. Beam (pp. 790–795).

(*dd*) Frequency Noise in Travelling-Wave Tubes.—R. Liebscher & R. Müller (pp. 796–799).

(*ee*) Noise in Backward-Wave Oscillators.—N. W. W. Smith (pp. 800–804).

(*ff*) Oxide Cathodes for Low-Noise Travelling-Wave Tubes.—E. Windsor (pp. 805–809).

621.385.029.6 **3160**

Kinetic Theory of Space-Charge: Part 2—Electron Collisional Damping in the Magnetron (and Diode).—L. Gold. (*J. Electronics Control*, March 1959, Vol. 6, No. 3, pp. 209–235.) A detailed analysis of the part played by scattering in determining the field and charge distribution in a planar diode or magnetron. Various combinations of magnetic field, scattering frequency and transit time are considered. Part 1: 3696 of 1957.

621.385.029.6 **3161**

A.C. Operation of Continuous-Wave Magnetrons.—W. Schmidt. (*Electronic Applic.*, Nov. 1958, Vol. 18, No. 4, pp. 158–162.) English version of 4013 of 1958.

621.385.029.6 **3162**

Current Limitation of A.C.-Operated Continuous-Wave Magnetrons by means of Inductance.—E. G. Dorgelo. (*Electronic Applic.*, Nov. 1958, Vol. 18, No. 4, pp. 163–170.) Adjustment of the angle of flow, combined with high efficiency, can be achieved using a supply unit of low resistance incorporating an inductance of suitable value in the form of stray inductance or a choke.

621.385.029.6 **3163**

A Proposed Ferrite-Tuned Magnetron.—A. Singh & R. A. Rao. (*J. Instn Telecommun. Engrs, India*, March 1959, Vol. 5, No. 2, pp. 72–76.) The frequency of an inverted interdigital magnetron can be controlled by varying a biasing magnetic field applied to a ferrite cylinder placed near the shorted end of a coaxial line which is coupled to the interdigital resonator. A tuning range of 5–10 % may be expected as shown by a theoretically evaluated tuning curve.

621.385.029.6 : 621.372.8 **3164**

Backward-Wave Oscillations in an Unloaded Waveguide.—R. H. Pantell. (*Proc. Inst. Radio Engrs*, June 1959, Vol. 47, No. 6, p. 1146.) Using a system in which electrons travel in a helical beam in ordinary S-band waveguide, oscillations have been observed in the range 2·5–4 kMc/s at a power level of 0·4 W.

621.385.029.6 : 621.396.822 **3165**

An Experimental Study of Interception Noise in Electron Streams at Microwave Frequencies.—B. A. McIntosh. (*Canad. J. Phys.*, March 1959, Vol. 37, No. 3, pp. 285–299.) The frequency used was 3 kMc/s. An electron beam was produced in a demountable vacuum system by a parallel-flow Pierce gun in a confining magnetic field. A series of circular apertures and mesh grids on a plate capable of being moved within the vacuum chamber intercepted various fractions of the beam current. The excess noise caused by interception was measured at the anode of the electron gun and at various points in a drift region. Interception noise caused by mesh grids was much greater than that caused by circular apertures.

621.385.032.213.13 : 538.632 **3166**

Hall Effect in Oxide Cathodes.—T. Yabumoto. (*J. phys. Soc. Japan*, Feb. 1959, Vol. 14, No. 2, pp. 134–139.) The apparent electron mobility in the range 700° K–1 200° K was about 10^3–10^4 cm²/V.sec which is very high as compared with the values obtained for single crystals. The pore conduction hypothesis is discussed.

621.385.1 : 621.3.049.7 **3167**

Thermionic Integrated-Micro-modules.—Beggs, Grattidge, Molenda, Haase & Dickerson. (See 2863.)

621.385.1 : 621.314·7 : 621.373.43 **3168**

Tube-Transistor Hybrids Provide Design Economy.—Dunn & Hekimian. (See 2877.)

621.385.1 : 621.317.61 **3169**

A Method for the Accurate Measurement of Mutual Conductance of Thermionic Valves.—Child & Sargent. (See 3059.)

621.385.1.012.7 **3170**

The Mu of Ordinary Receiving Tubes.—G. D. O'Neill. (*Sylvania Technologist*, Oct. 1958, Vol. 11, No. 4, pp. 125–132.) A distinction is made between the electronic mu and the electrostatic mu. A new formula is given for mu in terms of electrode dimensions; it is simple to evaluate and more accurate than others which are available.

621.385.832 : 621.397.62 **3171**

Design of a Flat Rectangular C. R. Tube.—W. R. Aitken. (*Electronic Equipm. Engng*, Dec. 1958, Vol. 6, No. 12, pp. 24–28.) A qualitative description with a note on operating experience. See 977 of 1958 for detailed analysis.

621.385.832 : 621.397.621.2 : 535.623 **3172**

Errors of Magnetic Deflection: Part 2.—Haantjes & Lubben. (See 3125.)

621.385.832.032.36 **3173**

Energy Losses of Cathode Rays at Binder Films of the Phosphor Screens of Cathode-Ray Tubes.—G. Gergely & I. Hangos. (*Z. angew. Phys.*, May 1958, Vol. 10, No. 5, pp. 225–228.) Measurements of light emission were made on a number of phosphor screens with colloidal binder films of differing composition and thickness, to determine the dependence of losses on electron energy and film characteristics.

621.387 **3174**

The Effect of Trigger Pulse Polarity on the Anode Breakdown Time of the Cold-Cathode-Arc Conduction Tetrode.—R. Feinberg. (*J. Electronics Control*, March 1959, Vol. 6, No. 3, pp. 246–257.) The breakdown time is found to depend on the trigger pulse duration if this pulse is positive, but not if it is negative. The explanation of this result is discussed.

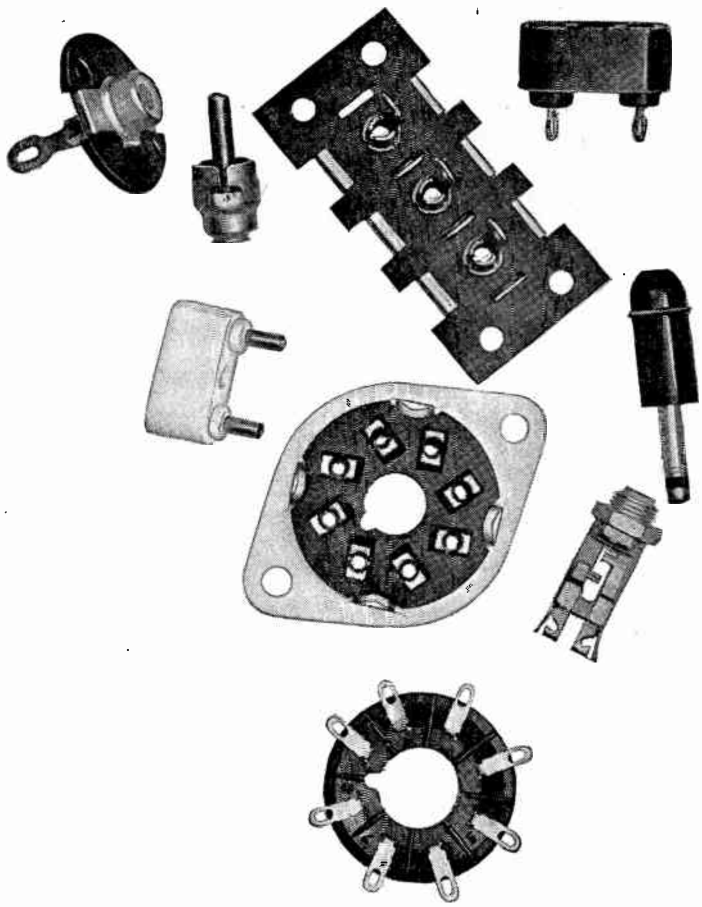
MISCELLANEOUS

621.3.029.6 **3175**

Report of Advances in Microwave Theory and Techniques—1957.—R. E. Beam. (*Trans. Inst. Radio Engrs*, July 1958, Vol. MTT-6, No. 3, pp. 251–263.) 320 references.

621.37/.39(81) **3176**

Electronics and Communications in Brazil.—J. I. Caicoya. (*Brit. Commun. Electronics*, May 1959, Vol. 6, No. 5, pp. 364–370.) Gives details of manufacturing and research organizations.



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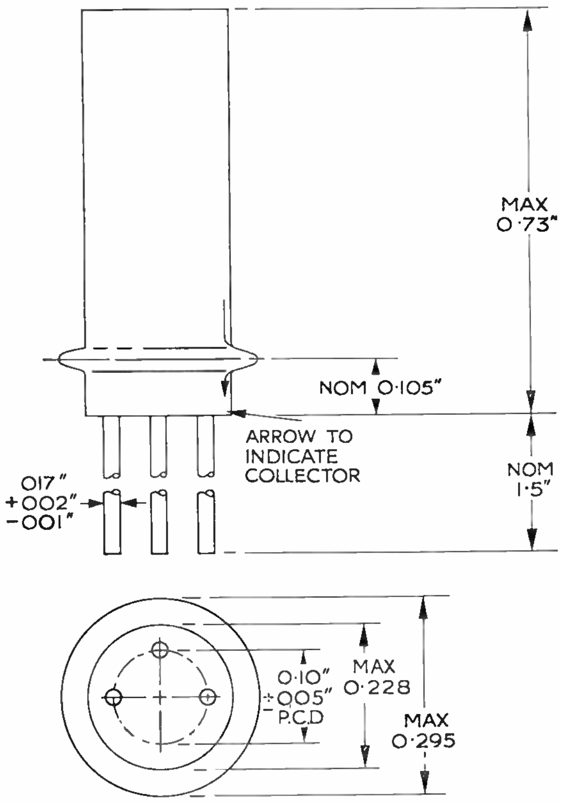

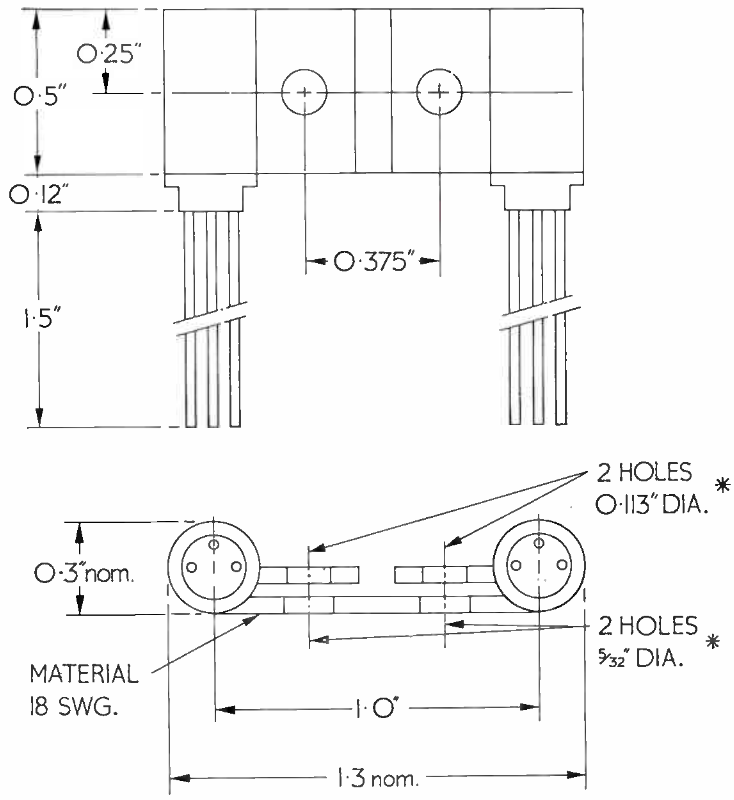

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Maximum Peak or Mean Collector/Emitter Voltage (Common Emitter Circuit)	(volts)	—16
Maximum Peak or Mean Collector/Base Voltage (Common Base Circuit)	(volts)	—35
Maximum Peak Collector/Emitter Voltage with Base driven to cut off (Common Emitter Circuit) or with $R_{b\text{-}e} < 500\ \Omega$	(volts)	—35
Maximum Peak or Mean Emitter/Base Voltage	(volts)	—12
Minimum d.c. β at I_c=—200mA, V_c=—1v		40
Minimum d.c. β at I_c=—50mA, V_c=—1v		48
Maximum Junction Temperature	(°C)	75
Thermal Resistance in Free Air	(°C/mW)	0.2

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Maximum Peak or Mean Emitter/Base voltage	(volts)	—12
Minimum d.c. β at I_c=—200mA, V_c=—1v		40
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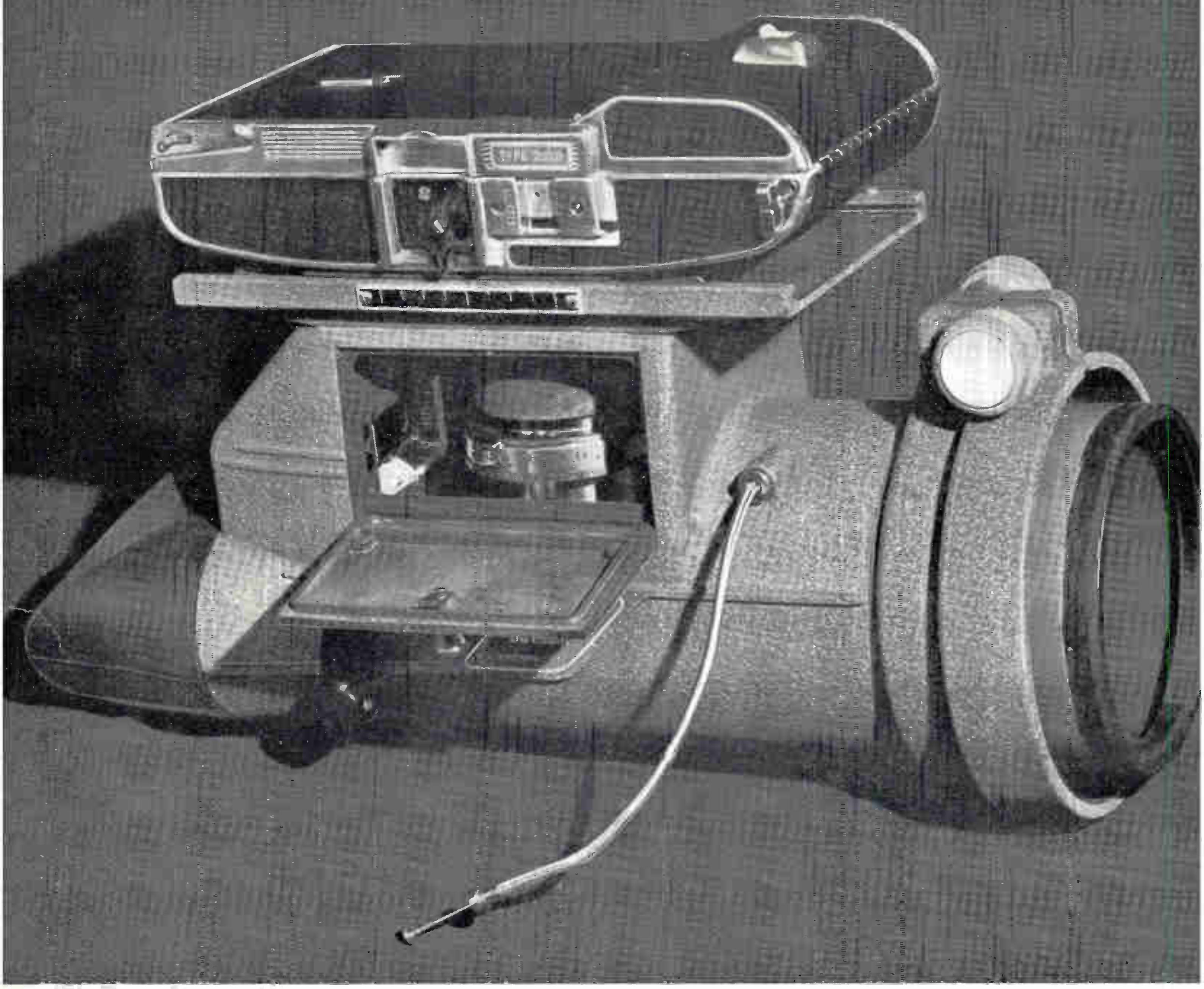

ELECTRONIC & RADIO ENGINEER

Index to Abstracts and References 1959

TWO SHILLINGS AND SIXPENCE

With this index to Abstracts and References is included a title page for inclusion with the bound volume for 1959. When binding, it is suggested that the issues be broken down and assembled in the following order:— Title page; index to editorial (from December issue); all editorial pages together, in proper sequence; all abstracts pages together, in proper sequence; Index to Abstracts. This order has been found the most convenient.

ELECTRONIC & RADIO ENGINEER

Volume 36 · 1959

Published by Iliffe and Sons Limited Dorset House Stamford Street London S.E.1

B

ELECTRONIC & RADIO ENGINEER

INDEX TO ABSTRACTS AND REFERENCES

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Author Index

A name followed by '*and*' is that of the first author of a jointly written paper, while the word '*with*' indicates that the name indexed is that of the second author

Abreviations used in the Abstracts and Index

a.c.	alternating current
d.c.	direct current
h.v.	high voltage
l.v.	low voltage
a.f.	audio frequency
i.f.	intermediate frequency
r.f.	radio frequency, including:—
v.l.f.	very low frequency, <30 kc/s
l.f.	low frequency, 30–300 kc/s
m.f.	medium frequency, 300–3000 kc/s
h.f.	high frequency, 3–30 Mc/s
v.h.f.	very high frequency, 30–300 Mc/s
u.h.f.	ultra high frequency, >300 Mc/s
a.m.	amplitude modulation
f.m.	frequency modulation
p.m.	pulse modulation, including:—
p.a.m.	pulse amplitude modulation
p.c.m.	pulse code modulation
p.f.m.	pulse frequency modulation
p.ph.m.	pulse phase modulation
p.p.m.	pulse position modulation
p.w.m.	pulse width modulation
ph.m.	phase modulation
v.m.	velocity modulation
c.w.	continuous wave
i.c.w. / m.c.w.	modulated c.w.
s.w.*	short wave
u.s.w.*	ultra short wave
λ	wavelength
c.r.	cathode ray
c.r.o.	cathode-ray oscilloscope
d.f.	direction finding
e.m.	electromagnetic, *but*
e.m.f.	electromotive force
e.s.	electrostatic
a.f.c.	automatic frequency control
a.g.c.	automatic gain control
a.ph.c.	automatic phase control
a.v.c.	automatic volume control
m.u.f.	maximum usable frequency
p.p.i.	plan position indicator
s.s.b.	single sideband
d.s.b.	double sideband
s.w.r.	standing-wave ratio
v.f.o.	variable-frequency oscillator
R/T	radiotelephony
W/T	wireless telegraphy
TV	television

* *No clearly defined limits*

AUTHOR INDEX

SUBJECT INDEX

World Radio History

ERRATA

IN ABSTRACTS AND REFERENCES 1959

Abstract No.	
515	Change U.D.C. number to 537.311.33 : 535.215
1052	For 'F. A. Vaniar' read 'F. A. Veniar'
1529	In line 5, for 'auroral' read 'annual'
1824	In line 7, for 'frequency band' read 'energy band'
1958	For 'J. F. Ditton, Jr' read 'J. F. Dillon, Jr'
1986	Change U.D.C. number to 621.384.8 : 537.54
2113	In line 4, for 'three-part' read 'three-port'
2159	In line 7, for 'joints' read 'points'
2278	In title, for 'Electric' read 'Elastic'
2408	In line 7, for '605-line' read '625-line'
2669	For 'S. Asanabo' read 'S. Asanabe'
2720	Change U.D.C. number to 621.384.8 : 537.54
2831	In title, for 'TE$^\circ_{10}$–TE$^\circ_{01}$' read 'TE$^\square_{10}$–TE$^\circ_{01}$'
2857	In title, for '$m\sqrt{N}$' read '$N^{1/m}$'
2958	In line 4, for 'change-exchange' read 'charge-exchange'
3030	In line 5, for 'function' read 'junction'
3136	In line 5, for '3136' read '3138'
3171	For 'W. R. Aitken' read 'W. R. Aiken'
3256	Change U.D.C. number to 538.566 : 535.42
3350	Change U.D.C. number to 537.311.3 : 539.23
3836	For 'J. L. Veshaeghe' read 'J. L. Verhaeghe'

IN PAPERS ABSTRACTED

The practice of allocating individual abstract numbers to corrections has been largely discontinued; a list of published corrections noted during 1959 is given below. The journal in which the correction appeared was in each case the same as that in which the original paper was published.

Abstract No.	
3235 of 1955	Jan. 1959, Vol. 14, No. 1, pp. 115–116
1405 of 1957	July 1957, Vol. AP-5, No. 3, p. 313
2959 of 1957	Dec. 1958, Vol. 5, No. 6, pp. 510–513
84 of 1958	Jan. 1959, Vol. 6, No. 1, p. 80
295 of 1958	Sept. 1959, Vol. 36, No. 9, p. 352
971 of 1958	Sept. 1958, Vol. 29, No. 9, p. 1383
1228 of 1958	Dec. 1959, Vol. 47, No. 12, p. 2105
1858 of 1958	April 1958, Vol. 3, No. 30, p. 312
1892 of 1958	April 1958, Vol. 3, No. 30, p. 312
3028 of 1958	Sept. 1958, Vol. 29, No. 9, p. 1383
3271 of 1958	Dec. 1959, Vol. 47, No. 12, p. 2084
3472 of 1958	Dec. 1958, Vol. 18, No. 12, p. 714
3544 of 1958	15th Dec. 1958, Vol. 112, No. 6, p. 2139
3890 of 1958	15th Sept. 1959, Vol. 115, No. 6, p. 1778
3902 of 1958	15th March 1959, Vol. 113, No. 6, p. 1697
3962 of 1958	Dec. 1958, Vol. 46, No. 12, p. 1913
173 of 1959	15th March 1959, Vol. 113, No. 6, p. 1696
239 of 1959	July 1957, Vol. AP-5, No. 3, p. 313
337 of 1959	Dec. 1957, Vol. CP-4, No. 4, pp. 135–137
379 of 1959	Feb. 1959, Vol. 4, No. 37, p. 220
385 of 1959	May 1959, Vol. 4, No. 39, p. 272
501 of 1959	1st June 1959, Vol. 73, No. 474, p. 976
635 of 1959	Oct. 1958, Vol. 17, No. 10, p. 117
745 of 1959	Feb. 1959, Vol. 4, No. 37, p. 220
855 of 1959	March 1959, Vol. 36, No. 3, p. 95
890 of 1959	March 1959, Vol. 9, Nos. 3/4, p. 340
1233 of 1959	15th June 1959, Vol. 114, No. 6, p. 1652
1368 of 1959	Sept. 1959, Vol. 47, No. 9, pp. 1653–1654
1372 of 1959	June 1958, Vol. 2, No. 3, p. 144
1493 of 1959	Dec. 1958, Vol. 17, No. 12, p. 36
1498 of 1959	Feb. 1959, Vol. 4, No. 37, p. 220
1559 of 1959	April 1959, Vol. 47, No. 4, p. 567
1615 of 1959	1st Sept. 1959, Vol. 3, No. 5, p. 244
1693 of 1959	Feb. 1959, Vol. 4, No. 37, p. 220
1795 of 1959	May 1959, Vol. 65, No. 5, p. 232
1952 of 1959	1st June 1959, Vol. 73, No. 474, p. 976
2024 of 1959	Oct. 1958, Vol. 2, No. 5, p. 252
2202 of 1959	15th June 1959, Vol. 114, No. 6, p. 1652
2408 of 1959	Aug. 1959, Vol. 36, No. 8, p. 314
2410 of 1959	July 1959, Vol. 47, No. 7, p. 1252
2503 of 1959	July 1959, Vol. 31, No. 377, p. 427
2750 of 1959	Aug. 1959, Vol. 47, No. 8, p. 1324
2841 of 1959	Jan. 1959, Vcl. AP-7, No. 1, p. 104
3076 of 1959	Jan. 1959, Vol. 16, No. 1, p. 56
3077 of 1959	Jan. 1959, Vol. 16, No. 1, p. 56
3078 of 1959	April 1959, Vol. 14, No. 4, p. 547
3081 of 1959	Dec. 1958, Vol. 10, No. 12, p. 576
3419 of 1959	Oct. 1958, Vol. 2, No. 5, p. 252
3588 of 1959	Nov. 1959, Vol. 47, No. 11, p. 1840
3965 of 1959	July 1959, Vol. AP-7, No. 3, p. 251

LIST of JOURNALS

A selection of the journals which are regularly scanned is given below, together with the addresses of their publishers or editorial offices and the abbreviations of their titles as used in 'Abstracts and References'. Applications for copies of any journal should be made to the addresses given. Enquiries concerning Russian journals may be made to D.S.I.R. Lending Library Unit, 20 Chester Terrace, London, N.W.1. The full title of each journal is given in bold type and is followed by the address, the abbreviated title being shown within brackets. In a few cases the nature of a journal is indicated, where neither the title nor the address shows it clearly.

Acta Polytechnica Scandinavica, Publishing Office, Box 5073, Stockholm 5, Sweden. (*Acta polyt. scand.*)

Acustica, S. Hirzel Verlag, Stuttgart-N, Germany. (*Acustica*)

Advances in Physics, Taylor & Francis Ltd, Red Lion Court, Fleet Street, London, E.C.4, England. (*Advances Phys.*)

Akusticheskii Zhurnal, Moskva, B-64, Podsosenskii per., 21, U.S.S.R. (*Akust. Zh.*)

Akustische Beihefte, as for Acustica. (*Akust. Beihefte*)

Alta Frequenza, Associazione Elettrotecnica Italiana, Milano (202), Via S. Paolo 10, Italy. (*Alta Frequenza*)

Annalen der Physik, J. A. Barth, Leipzig C1, Salomonstrasse 18B, East Germany. (*Ann. Phys., Lpz.*)

Annales de Géophysique, Service des Publications du C.N.R.S., 13 Quai Anatole France, Paris 7ᵉ, France. (*Ann. Géophys.*)

Annales de Physique, Masson & Cie, 120 Boulevard Saint-Germain, Paris 6ᵉ, France. (*Ann. Phys., Paris*)

Annales de Radioélectricité, 10 rue Carducci, Paris 19ᵉ, France. (*Ann. Radioélect.*)

Annales des Télécommunications, 3 & 5 Boulevard Pasteur, Paris 15ᵉ, France. (*Ann. Télécommun.*)

Applied Scientific Research, Martinus Nijhoff, The Hague, Netherlands. (*Appl. sci. Res.*)

Archiv der elektrischen Übertragung, S. Hirzel Verlag, Stuttgart, Germany. (*Arch. elekt. Übertragung*)

Archiv für Elektrotechnik, Springer Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, Germany. (*Arch. Elektrotech.*)

Archiv für technisches Messen, R. Oldenbourg KG, München 8, Rosenheimer Str. 145, Germany. (*Arch. tech. Messen*)

Arkiv för Fysik, published for Royal Swedish Academy of Sciences by Almqvist & Wiksell, Stockholm, Sweden. (*Ark. Fys.*)

A.T.E. Journal, Automatic Telephone & Electric Co. Ltd, Strowger Works, Liverpool 7, England. (*A.T.E. J.*)

Audio, Radio Magazines, Inc., P.O. Box 629, Mineola, N.Y., U.S.A. (*Audio*)

Australian Journal of Physics, Commonwealth Scientific and Industrial Research Organization, 314 Albert Street, East Melbourne C.2, Victoria, Australia. (*Aust. J. Phys.*)

Avtomatika i Telemekhanika, Moskva, I-53, Kalanchevskaya ul., 15a, U.S.S.R. (*Avtomatika i Telemekhanika*)

A.W.A. Technical Review, Amalgamated Wireless (Australasia) Ltd, Sydney, Australia. (*A.W.A. tech. Rev.*)

B.B.C. Engineering Division Monographs, British Broadcasting Corporation, 35 Marylebone High Street, London, W.1, England. (*B.B.C. Engng Div. Monographs*)

Beama Journal, British Electrical and Allied Manufacturers' Association, 36 Kingsway, London, W.C.2, England. (*Beama J.*)

Bell Laboratories Record, 463 West Street, New York 14, N.Y., U.S.A. (*Bell Lab. Rec.*)

Bell System Technical Journal, American Telephone and Telegraph Company, 195 Broadway, New York 7, N.Y., U.S.A. (*Bell Syst. tech. J.*)

British Communications & Electronics, Heywood & Co. Ltd, Drury House, Russell Street, Drury Lane, London, W.C.2, England. (*Brit. Commun. Electronics*)

British Journal of Applied Physics, 47 Belgrave Square, London, S.W.1, England. (*Brit. J. appl. Phys.*)

Brown Boveri Review, Baden, Switzerland. (*Brown Boveri Rev.*)

Bulletin de l'Association Suisse des Électriciens, Seefeldstrasse 301, Zürich 8, Switzerland. (*Bull. schweiz. elektrotech. Ver.*)

Bulletin of the Technical University Istanbul, Istanbul Teknik Üniversitesi, Gümüssuyu, Istanbul, Turkey. (*Bull. tech. Univ. Istanbul*)

Câbles & Transmission, Sotelec, 16 rue de la Baume, Paris 8ᵉ, France. (*Câbles & Transm.*)

Cahiers de Physique, 165 rue de Sèvres, Paris 15ᵉ, France. (*Cah. Phys.*)

Canadian Electronics Engineering, Maclean-Hunter Publishing Co. Ltd, P.O. Box 100, Toronto, Canada. (*Canad. Electronics Engng*)

Canadian Journal of Physics, National Research Council, Ottawa 2, Ont., Canada. (*Canad. J. Phys.*)

Chalmers tekniska Högskolas Handlingar, Gumperts Förlag, Göteborg, Sweden. (*Chalmers tek. Högsk. Handl.*)

Communication and Electronics, American Institute of Electrical Engineers, 20th and Northampton Streets, Easton, Pa, U.S.A. (*Commun. & Electronics*)

Communications on Pure and Applied Mathematics, Interscience Publishers Inc., 250 Fifth Avenue, New York 1, N.Y., U.S.A. (*Commun. pure appl. Math.*)

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, Gauthier-Villars, 55 Quai des Grands-Augustins, Paris 6ᵉ, France. (*C. R. Acad. Sci., Paris*)

Doklady Akademii Nauk S.S.S.R., Moskva, B-64, Podsosenskii per., 21, U.S.S.R. (*Dokl. Ak. Nauk S.S.S.R.*)

E.B.U. Review, 32 Avenue Albert Lancaster, Bruxelles 18, Belgium. (*E.B.U. Rev.*)

Electrical Communication, International Telephone and Telegraph Corporation, 67 Broad Street, New York 4, N.Y., U.S.A. (*Elect. Commun.*)

Electrical Engineering, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N.Y., U.S.A. (*Elect. Engng, N.Y.*)

Electrical Journal, Bouverie House, 154 Fleet Street, London, E.C.4, England. (*Elect. J.*)

Electrical Manufacturing, 205 East 42nd Street, New York 17, N.Y., U.S.A. (*Elect. Mfg*)

Electrical Review, Dorset House, Stamford Street, London, S.E.1, England. (*Elect. Rev., Lond.*)

Electronic Applications, N. V. Philips' Gloeilampenfabrieken, Technical and Scientific Literature Department, Eindhoven, Netherlands. (*Electronic Applic.*)

Electronic Engineering, 28 Essex Street, London, W.C.2, England. (*Electronic Engng*)

Electronic Equipment Engineering, Sutton Publishing Company Inc., 172 South Broadway, White Plains, N.Y., U.S.A. (*Electronic Equipm. Engng*)

Electronic Industries, Chestnut and 56th Sts, Philadelphia 39, Pa, U.S.A. (*Electronic Ind.*)

Electronic & Radio Engineer, Iliffe & Sons Ltd, Dorset House, Stamford Street, London, S.E.1, England. (*Electronic Radio Engr*)

Electronics, 330 West 42nd Street, New York 36, N.Y., U.S.A. (*Electronics*)

Elektronische Rundschau, Verlag für Radio-Foto-Kinotechnik G.m.b.H., Berlin-Borsigwalde, Eichborndamm 141–167, Germany. (*Elektronische Rundschau*)

Elektrosvyaz', Moskva, K-9, ul. Gor'kogo, 7, 8-i pod"ezd, 3-I etazh, U.S.S.R. (*Elektrosvyaz'*)

Elektrotechnik und Maschinenbau, Journal of the Elektrotechnischer Verein Österreichs, Springer Verlag, Wien I, Mölkerbastei 5, Austria. (*Elektrotech. u. Maschinenb.*)

Elektrotechnische Zeitschrift, Edition A & B, VDE-Verlag G.m.b.H., Berlin-Charlottenburg 2, Bismarckstrasse 33, Germany. (*Elektrotech. Z.*)

Endeavour, Imperial Chemical Industries Ltd, North Block, Thames House, Millbank, London, S.W.1, England. (*Endeavour*)

Engineer, 28 Essex Street, London, W.C.2, England. (*Engineer, Lond.*)

Engineering, 36 Bedford Street, London, W.C.2, England. (*Engineering, Lond.*)

Ericsson Review, Telefonaktiebolaget L. M. Ericsson, Stockholm 32, Sweden. (*Ericsson Rev.*)

Ericsson Technics, as for Ericsson Review. (*Ericsson Tech.*)

Fizika Tverdogo Tela, Leningrad, V-164, Mendeleevskaya lin., 1, U.S.S.R. (*Fiz. Tverdogo Tela*)

Frequenz, Fachverlag Schiele & Schön G.m.b.H., Berlin S.W.61, Markgrafenstrasse 11, Germany. (*Frequenz*)

Funk-Technik, Verlag für Radio-Foto-Kinotechnik G.m.b.H., Berlin-Borsigwalde, Eichborndamm 141–167, Germany. (*Funk-Technik, Berlin*)

G.E.C. Journal, General Electric Company Ltd, Magnet House, Kingsway, London, W.C.2, England. (*G.E.C. J.*)

G.E.C. Telecommunications, General Electric Company Ltd, Coventry, England. (*G.E.C. Telecommun.*)

Geofisica Pura e Applicata, Istituto Geofisico Italiano, Milano, Piazza Leonardo da Vinci 12, Italy. (*Geofis. pura appl.*)

Geophysical Journal of the Royal Astronomical Society, Burlington House, London, W.1, England. (*Geophys. J. R. astr. Soc.*)

Helvetica Physica Acta, Journal of the Schweizerische Physikalische Gesellschaft, Birkhäuser Verlag, Basel, Switzerland. (*Helv. phys. Acta*)

Hochfrequenztechnik und Elektroakustik, Akademische Verlagsgesellschaft Geest & Portig K.-G., Leipzig C1, Sternwartenstr. 8, East Germany. (*Hochfrequenztech. u. Elektroakust.*)

IBM Journal of Research and Development, International Business Machines Corporation, 590 Madison Avenue, New York 22, N.Y., U.S.A. (*IBM J. Res. Developm.*)

Indian Journal of Physics (and Proceedings of the Indian Association for the Cultivation of Science), Jadavpur, Calcutta 32, India. (*Indian J. Phys.*)

Izvestiya Akademii Nauk S.S.S.R. (*a*) seriya fizicheskaya, Moskva, B-64, Podsosenskii per., 21, U.S.S.R., (*b*) seriya geofizicheskaya, Moskva, B. Gruzinskaya, 10, U.S.S.R., (*c*) otdelenie tekhnicheskikh nauk, Moskva, M. Khariton'evskii per., 4, U.S.S.R. (*Izv. Ak. Nauk S.S.S.R., (a) ser. fiz., (b) ser. geofiz., (c) otd. tekh. nauk*)

Journal of the Acoustical Society of America, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*J. acoust. Soc. Amer.*)

Journal of the American Ceramic Society, 20th and Northampton Streets, Easton, Pa, U.S.A. (*J. Amer. ceram. Soc.*)

Journal of Applied Physics, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*J. appl. Phys.*)

Journal of Atmospheric and Terrestrial Physics, Pergamon Press Ltd, 4 & 5 Fitzroy Square, London, W.1, England. (*J. atmos. terr. Phys.*)

Journal of the Audio Engineering Society, P.O. Box 12, Old Chelsea Station, New York 11, N.Y., U.S.A. (*J. audio Engng Soc.*)

Journal of the British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1, England. (*J. Brit. Instn Radio Engrs*)

Journal of the British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1, England. (*J. Brit. interplan. Soc.*)

Journal of the Electrochemical Society, 1860 Broadway, New York 23, N.Y., U.S.A. (*J. electrochem. Soc.*)

Journal of Electronics and Control, Taylor & Francis Ltd, Red Lion Court, Fleet Street, London, E.C.4, England. (*J. Electronics Control*)

Journal of the Franklin Institute, Benjamin Franklin Parkway at Twentieth Street, Philadelphia 3, Pa, U.S.A. (*J. Franklin Inst.*)

Journal of Geomagnetism and Geoelectricity, Society of Terrestrial Magnetism and Electricity of Japan, Geophysical Institute, Kyoto University, Kyoto, Japan. (*J. Geomag. Geoelect.*)

Journal of Geophysical Research, 1515 Massachusetts Avenue, N.W., Washington 5, D.C., U.S.A. (*J. geophys. Res.*)

Journal of the Indian Institute of Science, Indian Institute of Science, Bangalore 12, India. (*J. Indian Inst. Sci.*)

Journal of the Institute of Navigation, John Murray Ltd, 50 Albemarle Street, London, W.1, England. (*J. Inst. Nav.*)

Journal of the Institution of Telecommunication Engineers, Post Box 481, New Delhi, India. (*J. Instn Telecommun. Engrs, India*)

Journal of Mathematics and Physics, Massachusetts Institute of Technology, Cambridge 39, Mass., U.S.A. (*J. Math. Phys.*)

Journal of Meteorology, Prince and Lemon Streets, Lancaster, Pennsylvania, U.S.A (*J. Met.*)

Journal of the Optical Society of America, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*J. opt. Soc. Amer.*)

Journal of the Physical Society of Japan, Maruzen Publishing Co., P.O. Box 605 Central, Tokyo, Japan. (*J. phys. Soc. Japan*)

The Journal of the Physics and Chemistry of Solids, Pergamon Press Ltd, 4 & 5 Fitzroy Square, London, W.1, England. (*J. Phys. Chem. Solids*)

Journal de Physique et le Radium, 12 place Henri-Bergson, Paris 8^e, France. (*J. Phys. Radium*)

Journal of the Radio Research Laboratories, Ministry of Posts and Telecommunications, Koganei-shi, Tokyo, Japan. (*J. Radio Res. Labs, Japan*)

Journal of Research of the National Bureau of Standards, U.S. Government Printing Office, Washington 25, D.C., U.S.A. (*J. Res. nat. Bur. Stand.*)

Journal of Scientific Instruments, 47 Belgrave Square, London, S.W.1, England. (*J. sci. Instrum.*)

Journal of the Society of Motion Picture and Television Engineers, 55 West 42nd Street, New York 36, N.Y., U.S.A. (*J. Soc. Mot. Pict. Telev. Engrs*)

Journal of the Television Society, 166 Shaftesbury Avenue, London, W.C.2, England. (*J. Telev. Soc.*)

Marconi Review, Marconi House, Chelmsford, England. (*Marconi Rev.*)

Metal Industry, Iliffe & Sons Ltd, Dorset House, Stamford Street, London, S.E.1, England. (*Metal Ind., Lond.*)

Metallurgia, 31 King Street West, Manchester 3, England. (*Metallurgia, Manchr*)

Meteorological Magazine, Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2, England. (*Met. Mag., Lond.*)

Microtecnic, 23 Avenue de la Gare, Lausanne, Switzerland. (*Microtecnic*)

Modern Plastics, 575 Madison Avenue, New York 22, N.Y., U.S.A. (*Mod. Plast.*)

Monthly Notices of the Royal Astronomical Society, Burlington House, London, W.1, England. (*Mon. Not. R. astr. Soc.*)

Mullard Technical Communications, Mullard House, Torrington Place, London, W.C.1, England. (*Mullard tech. Commun.*)

Nachrichtentechnik, V.E.B. Verlag Technik, Berlin C2, Oranienburger Str. 13/14, East Germany. (*NachrTech.*)

Nachrichtentechnische Zeitschrift, F. Vieweg & Sohn, (20b) Braunschweig, Burgplatz 1, Germany. (*Nachrichtentech. Z.*)

Nature, Macmillan & Co. Ltd, St. Martin's Street, London, W.C.2, England. (*Nature, Lond.*)

Naturwissenschaften, Springer Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, Germany. (*Naturwissenschaften*)

Note Recensioni e Notizie, Istituto Superiore delle Poste e delle Telecomunicazioni, Viale Trastevere 189, Roma, Italy. (*Note Recensioni Notiz.*)

Nucleonics, 330 West 42nd Street, New York 36, N.Y., U.S.A. (*Nucleonics*)

Nuovo Cimento, Editore Nicola Zanichelli, Bologna, Via Irnerio 34, Italy. (*Nuovo Cim.*)

Observatory, Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex, England. (*Observatory*)

l'Onde Électrique, Éditions Chiron, 40, rue de Seine, Paris 6^e, France. (*Onde élect.*)

Optik, Wissenschaftliche Verlagsgesellschaft m.b.H., Stuttgart 1, Postfach 40, Germany. (*Optik, Stuttgart*)

Philips Research Reports, N.V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. (*Philips Res. Rep.*)

Philips Technical Review, as for Philips Research Reports. (*Philips tech. Rev.*)

Philips Telecommunication Review, Philips Telecommunication Division, P.O. Box 32, Hilversum, Netherlands. (*Philips Telecommun. Rev.*)

Philosophical Magazine, Taylor & Francis Ltd, Red Lion Court, Fleet Street, London, E.C.4, England. (*Phil. Mag.*)

Philosophical Transactions of the Royal Society, Burlington House, Piccadilly, London, W.1, England. (*Phil. Trans.*)

Physica, Physica Foundation, Lucas Bolwerk 4, Utrecht, Netherlands. (*Physica*)

Physical Review, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*Phys. Rev.*)

Physical Review Letters, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*Phys. Rev. Lett.*)

Physics and Chemistry of Solids. See Journal of the Physics and Chemistry of Solids.

Point to Point Telecommunications, Communications Division, Marconi's Wireless Telegraph Co. Ltd, Chelmsford, England. (*Point to Point Telecommun.*)

Post Office Electrical Engineers' Journal, Engineer-in-Chief's Office, Alder House, Aldersgate Street, London, E.C.1, England. (*P.O. elect. Engrs' J.*)

Poste e Telecomunicazioni, Roma, Via della Vite 107, Italy. (*Poste e Telecomunicazioni*)

Priroda, Moskva, Tsentr, Malyi Khariton'evskii per., 4, U.S.S.R. (*Priroda, Mosk.*)

Proceedings of the Cambridge Philosophical Society (Mathematical and Physical Sciences), Cambridge University Press, Bentley House, 200 Euston Road, London, N.W.1, England. (*Proc. Camb. phil. Soc.*)

Proceedings of the Institute of Radio Engineers, 1 East 79th Street, New York 21, N.Y., U.S.A. (*Proc. Inst. Radio Engrs*)

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Printed in Great Britain for the Publishers, Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1, by Gibbs & Bamforth, Ltd., St. Albans. Distributed in U.S.A. by Eastern News Company, 306 West 11th Street, New York, 14.