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WIRELESS ENGINEER

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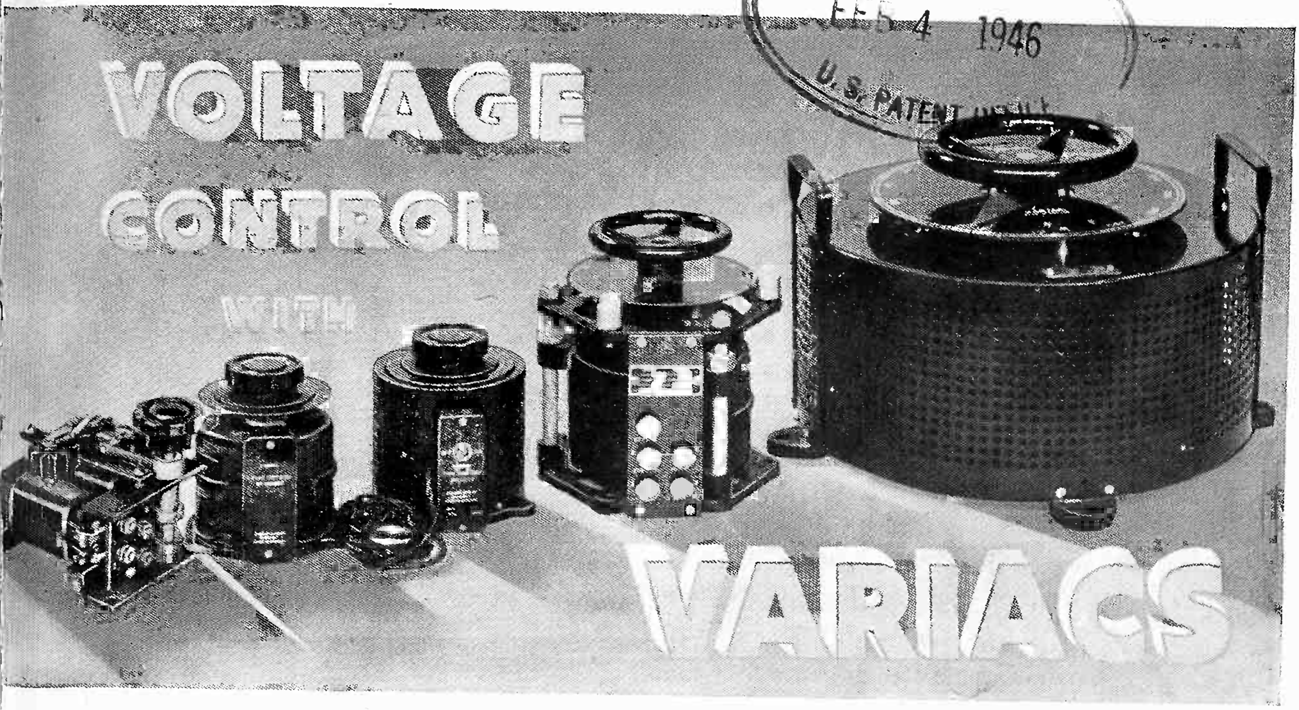

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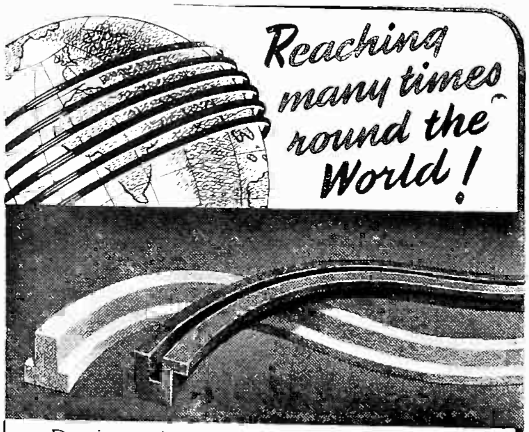
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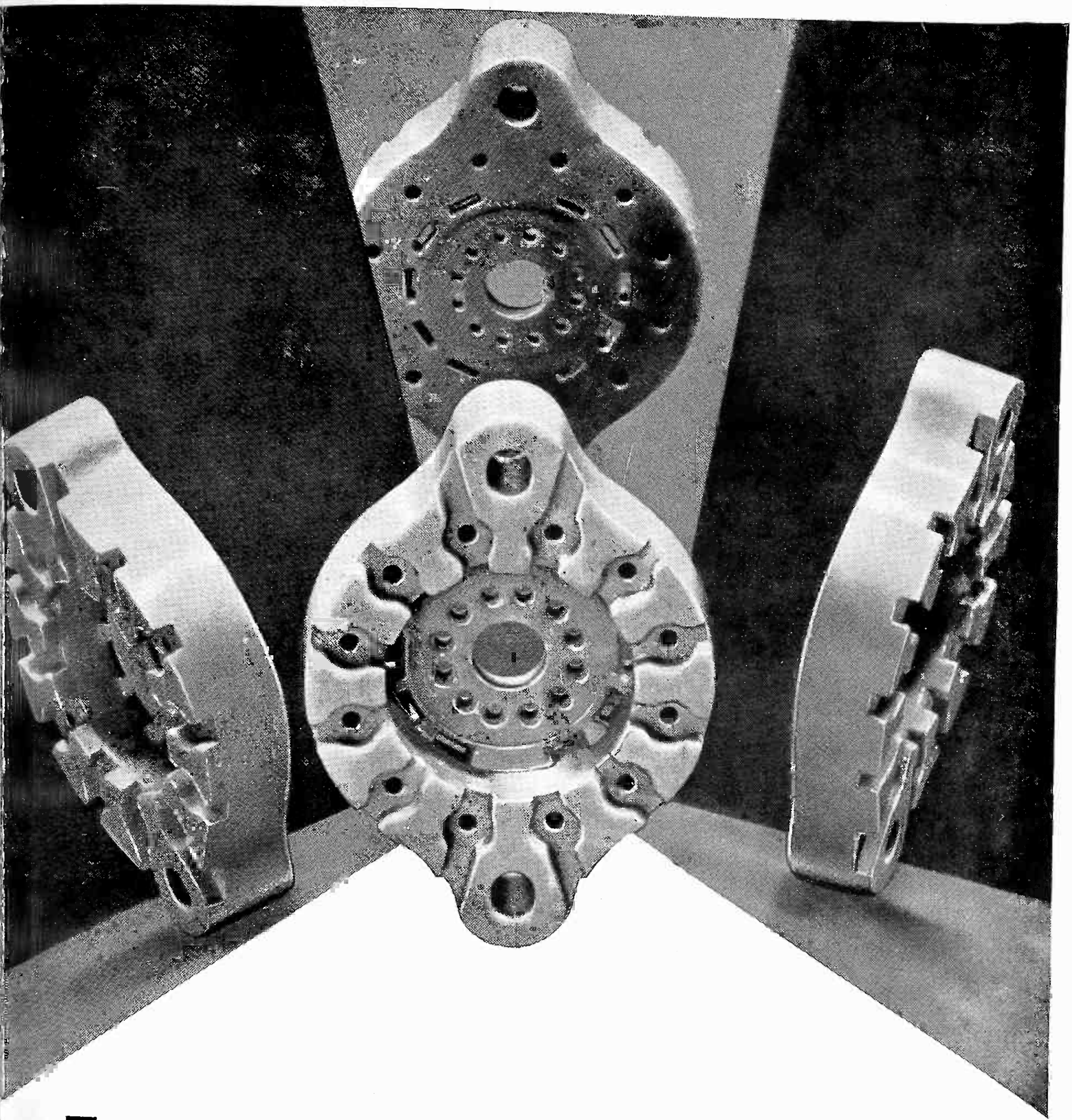

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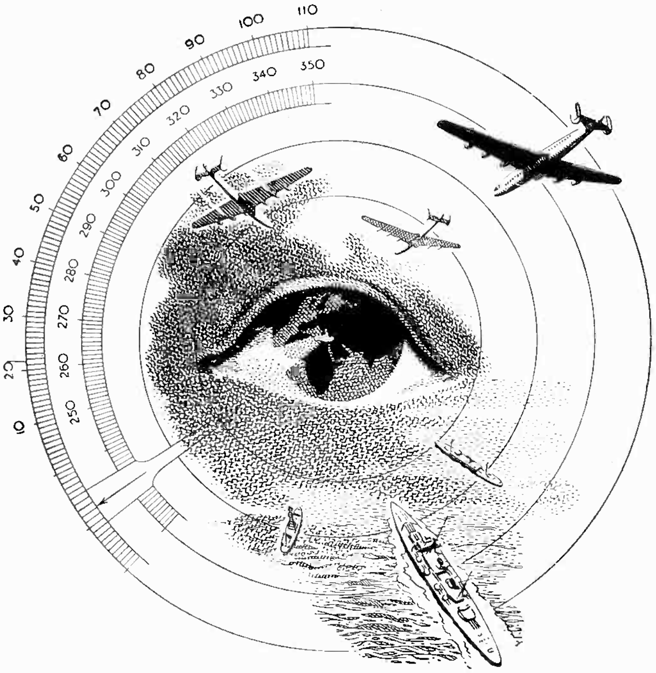

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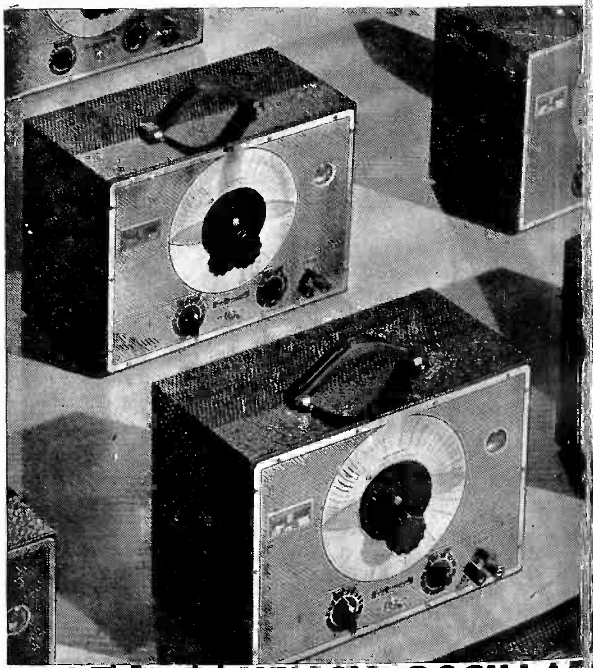

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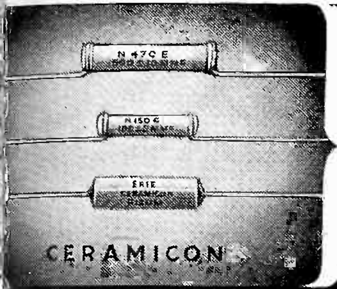
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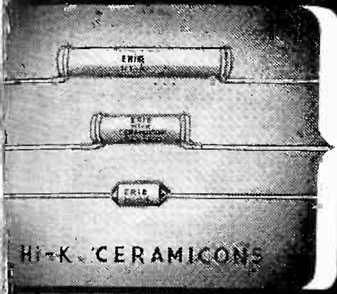
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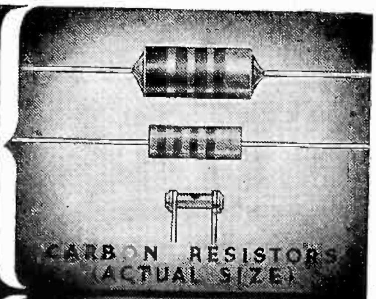
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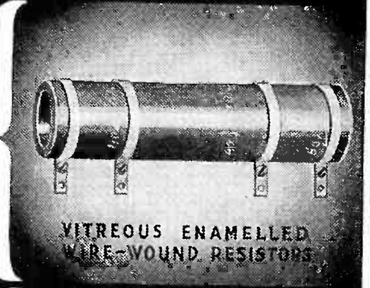
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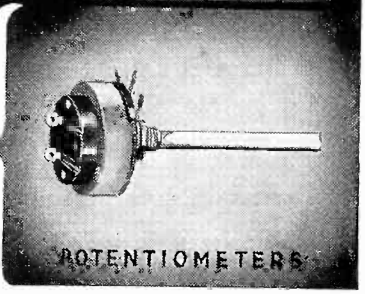
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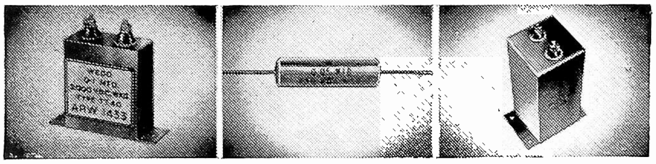
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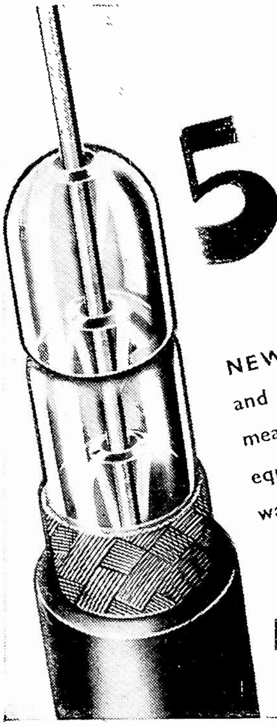


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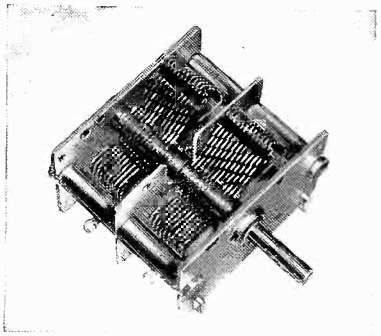

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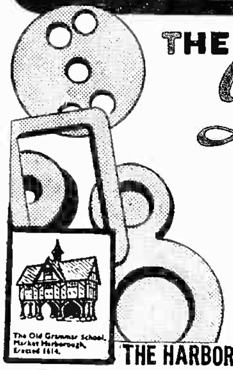

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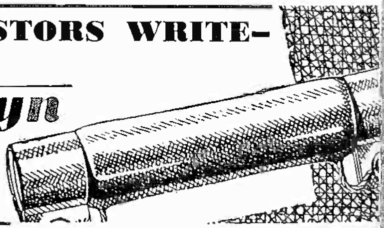

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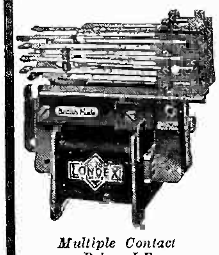

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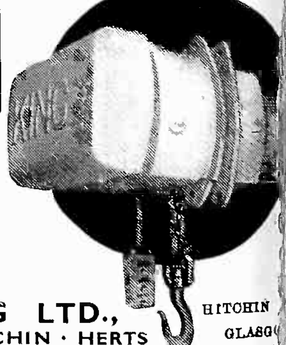

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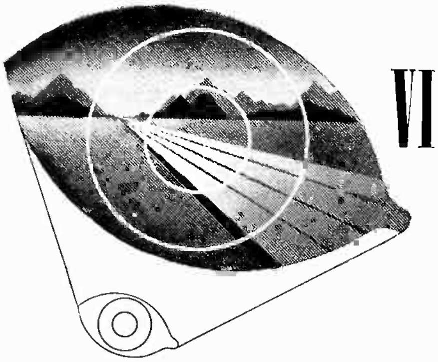

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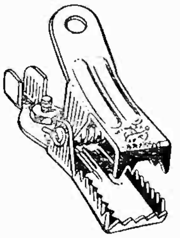

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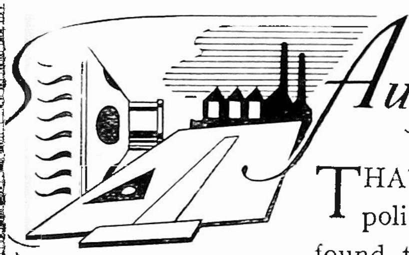

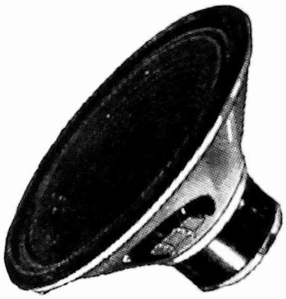

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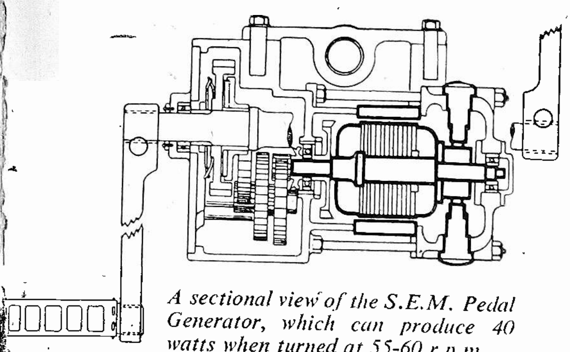

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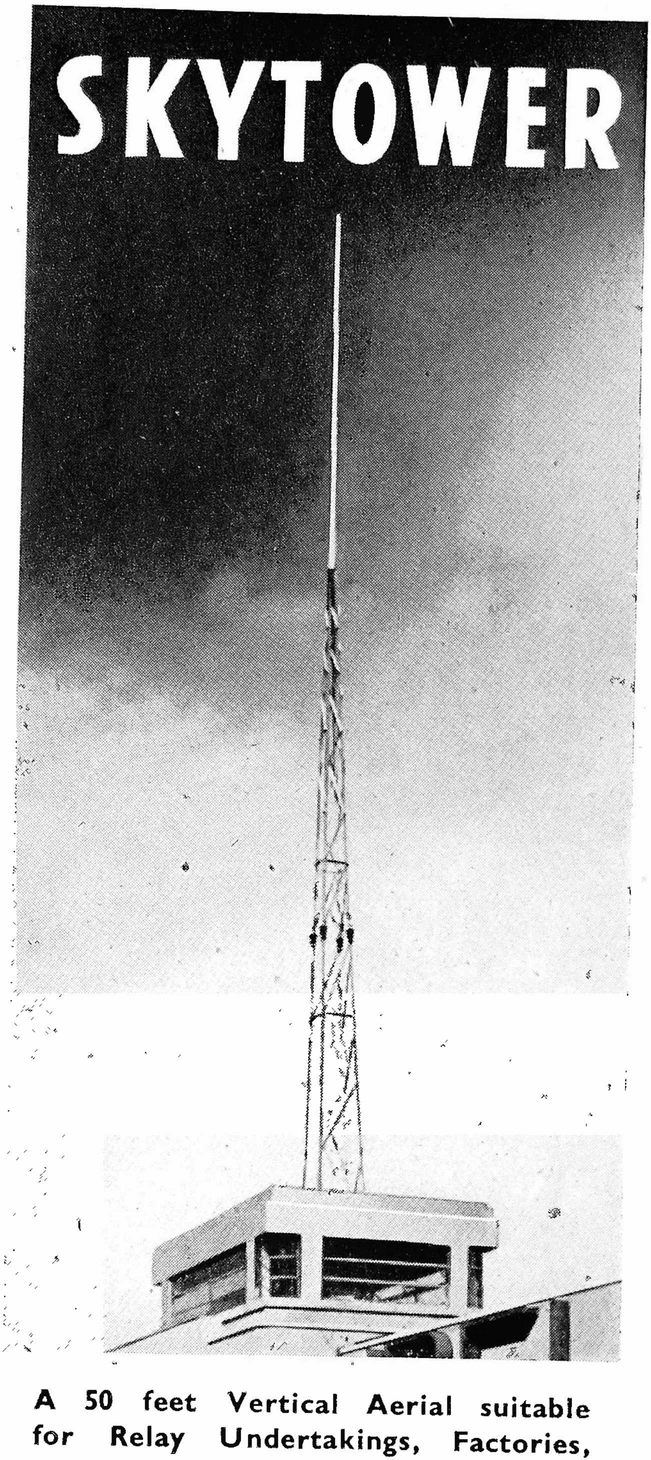

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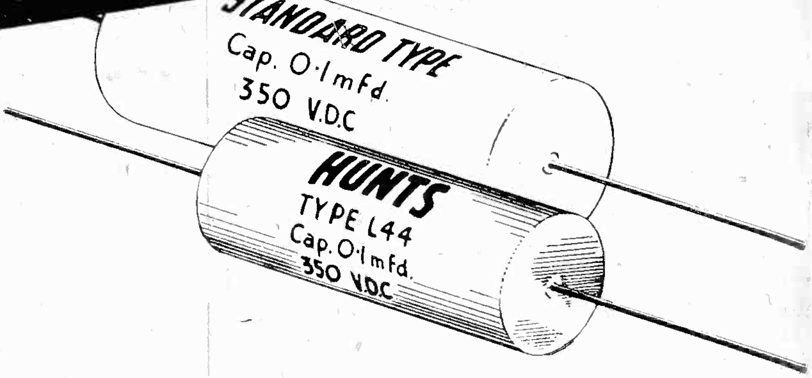

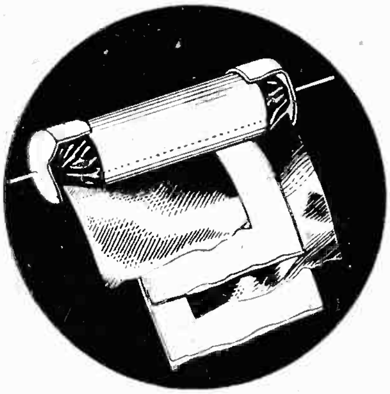

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WIRELESS ENGINEER

JANUARY 1946

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EDITORIAL

Another Problem of Two Electrons

WHETHER as a result of our Editorial of March 1944, on "A problem of two electrons and Newton's third law" or not we do not know, but a number of somewhat similar paradoxes have recently appeared in *Electrical Engineering*, the journal of the American Institute of Electrical Engineers, under the title of "Electrical Essays for Recreation." As one correspondent says: "Material of this sort stimulates discussion and thinking about the fundamental principles of electrical engineering, and should therefore be highly welcome." Most of the examples given are of a relatively simple type, in which the apparent paradox is due to an easily detected false assumption, but one correspondent raises the time-honoured question of the two electrons moving adjacent to each other at high speed in a straight line, as in a beam of a cathode-ray tube." He says:* "These electrons are moving charges and therefore constitute currents. Hence, there should be an attractive force between them since they are adjacent currents having the same direction. (This is in addition to the normal electrostatic repulsion between like charges.) However, if the observer should travel along at the same speed as the electrons, they will appear to be at rest and he will conclude that for these stationary charges there is no attractive force. Obviously, whether or not this force exists must be entirely independent of what the observer does, so that some fallacy must exist in the above reasoning." We are pleased to note that this correspondent sticks to realisable conditions and pictures the electrons in the beam of a cathode-ray tube; they are usually stated to be moving through remote space, without any indication as to how they got there or where they are going.

What does one mean when one says that an electron is moving? There is only one reasonable answer to this question and that is, that the electron is moving relatively to the body, circuit, or system of which it forms an integral part. This is the velocity that is implied in any law involving electronic velocities and not the velocity relative to some acrobatic observer. When we say that the steady current in some d.c. transmission line is really a slow drift of electrons in the conducting material, it is, of course, open to anyone walking along the route in the same direction as the drift—he would have to move very slowly—to maintain that there was no drift of electrons, but that the copper wires, both go and return, were moving slowly in the opposite direction. He would also have to agree that there was a drift of electrons in the other wire at twice the velocity of the copper. You may say that this would be ridiculous, but would it be any more ridiculous than to maintain that the electrons in the cathode-ray tube are at rest and that consequently the cathode and anode and all the rest of the system of which the electrons are an integral part are moving at a high velocity

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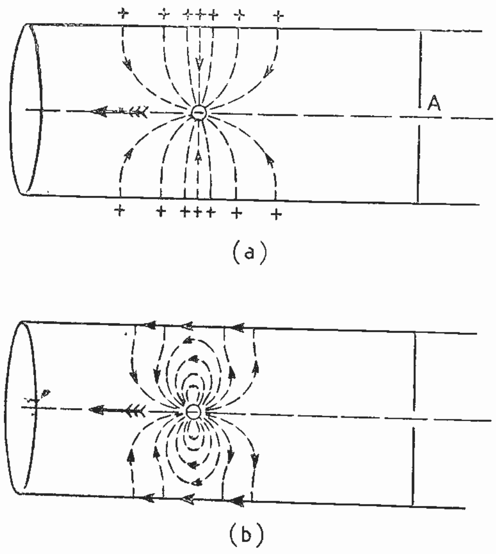
* *Loc. cit.*, October 1945, p. 381.

in the opposite direction? One may retort that the result, so far as any attraction between the electrons is concerned, must be independent of the speed of the observer; this is true, but the expression of the laws governing the phenomena is not necessarily independent. Whether the electrons are flying through the tube from cathode to anode or returning leisurely through the external circuit, their velocity in any calculation or expression of laws is understood to be that relative to the system. This greatly simplifies matters because one is not concerned with any movements of the positive charges produced by the removal of the electrons.

These considerations led us to a further examination of the nature of the field surrounding a solitary electron moving along the axis of a cathode-ray tube.

In Fig. 1 an electron is assumed to have been emitted from a cathode somewhere to the right, to have arrived at the anode A at a high velocity and to have passed through the central aperture in the anode. It is shown still moving axially along a metal tubular extension of the anode. Fig. 1 (*a*) shows the electric field, and the charges on the tube; Fig. 1 (*b*) shows the distribution of electric currents—conduction currents in the metal and displacement currents in the vacuous space. This diagram is worth a little careful consideration; it should be compared with Fig. 5 of March 1944, in which the outer conductor was assumed to be far removed. Near the electron the displacement currents will still be much the same as before, but they are very much modified as the field departs more and more from the spherically radial distribution. At the surface of the metal tube the displacement currents must be normal to the surface, assuming the metal to be a perfect conductor. The total resultant current crossing any normal cross-section of the tube must be zero; if the plane passes through the electron, the conduction current at that point of the tube together with the sum of the displacement currents will just counterbalance the electronic current. At any other cross-section the sum of the conduction and displacement currents must be zero.



(a)

(b)

Fig. 1.

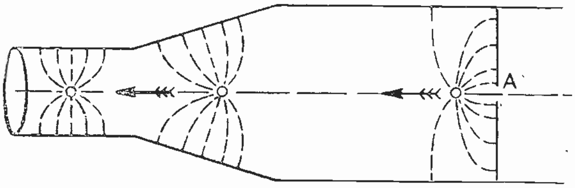


Fig. 2.

When the electron emerged from the aperture *A* it slowed down to some extent due to its electric field passing to the back of the anode and exerting a longitudinal retarding force on the electron. If the tube were now made conical as shown in Fig. 2 the electric field would exert an accelerating force on the electron which would therefore enter the smaller tube at an increased velocity. The displacement current density and therefor the energy per cubic centimetre due to the magnetic field in the neighbourhood of the electron would be increased, the latter varying as the square of the velocity. This would compensate for the reduction in the space occupied by the field, so that, as the diameter changed the speed would adjust itself so as to keep the total energy of the moving electron, that is, the energy of its magnetic and electric fields, constant. As the diameter of the tube decreased some of the electric field energy would be expended in accelerating the electron and thus converted into magnetic energy.

We have discussed this example in order to show how the ordinary expression of the electro-magnetic laws is based on certain assumptions. We would not relish the task of explaining the phenomena involved on the assumption that the electron was at rest and the apparatus flying through the air at a terrific but variable speed.

G. W. O. H.

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Valve-Voltmeter with a Stable Zero Adjustment

By M. Levy, A.M.I.E.E.

Summary.—If a uni-directional voltage is applied on one diagonal (supply input), a fraction appears on the second diagonal (output). Two methods are described which enable one to suppress this disturbance: the first method is to apply a convenient bias on the non-linear element; and the second is to simulate the voltage-current characteristic of the non-linear element on one of the three other arms of the bridge. It is shown that this can be obtained by simple means such as a combination of a neon tube and some resistances.

When the bridge is balanced in this way, the output will be practically unaffected by any variation at the supply input and will depend only on the signals applied directly to the non-linear element.

By the application of the above methods, the usual zero fluctuations of valve-voltmeters are reduced to a small percentage of their usual value. This enables the sensitivity to be increased without increasing the zero fluctuations. Some circuits of very sensitive valve-voltmeters are described, and their average characteristics are as follows:—

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Stability of calibration: Less than two per cent. for the above H.T. supply voltage variation.

Detailed characteristics are given.

FIG. 1 represents a usual valve-voltmeter circuit. This is a bridge circuit in which the anode-cathode resistance of the valve forms one arm, the cathode resistance R_c a second arm and the resistances R_1 and R_2 the two other arms. The H.T. voltage is applied across one diagonal and the meter across the second one. The detected voltage to be measured is applied between grid and earth. The elements of the bridge are adjusted so that the meter gives no deflection (or full-scale deflection) when there is no signal. When a signal is applied on the grid, the anode-cathode resistance varies, the bridge is unbalanced and a deflection appears on the meter.

The sensitivity of this circuit is usually limited by the fluctuations of the needle around the zero in the absence of a signal. These fluctuations may be produced,—

(*a*) by variations of the characteristics of the valve,

(*b*) by variations of the heater voltage,

(*c*) by variations of the H.T. supply voltage.

It is well known that variations of the characteristics of the valve can be greatly reduced by negative feed-back. In practice, these variations are slow and of secondary importance. Variations of the heater voltage do not produce great fluctuations as the anode current is practically independent of the heater voltage within large limits. The zero fluctuations are mostly produced by variations of the H.T. supply voltage. It is well known that the anode-cathode resistance of the valve does not behave as a real resistance, that is to say the current is not proportional to the voltage. If the bridge is balanced for one value of the H.T. supply voltage, this balance will not be maintained for other values of this voltage. In practical circuits a variation of 10 per cent. of the H.T. voltage may produce a deflection of the meter of nearly 20 or 30 per cent. of the scale. Thus a stabilised H.T. supply voltage is necessary, especially in case of sensitive circuits.

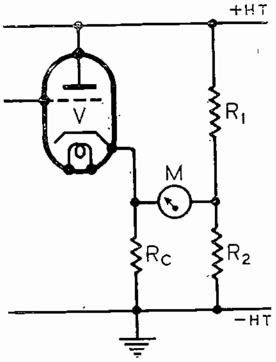

Fig. 1. *Usual bridge circuit for valve voltmeters.*

This solution is efficient but not very practical in many applications. If the valve-voltmeter is used as an independent unit, a stabilised H.T. supply can be obtained either with a saturated coil or with a neon-

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* MS. accepted by the Editor, July 1945.

stabiliser circuit. In the first case the power unit is very large for the very small power supplied and produces a strong radiation field ; in the second case the power supplied to the neon-stabiliser circuit is high compared to the power feeding the bridge circuit. If the valve-voltmeter is part of a circuit, one has either to stabilise the voltage supplying the valve-voltmeter only or to stabilise the whole H.T. supply. In the first case the solution may not be practical for the reasons mentioned above and in the second case for evident reasons.

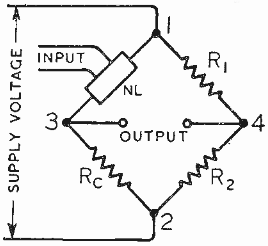

Fig. 2. *Bridge circuit with a non-linear element.*

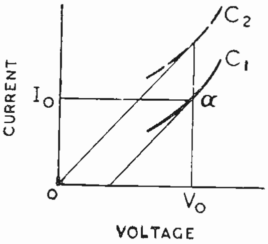

Fig. 3. *Characteristic of the element of Fig 2 ($NL + R_c$).*

The present method makes the bridge circuit practically independent of H.T. supply voltage variations and this voltage therefore need not be stabilised. The method is either to apply a convenient bias to the grid of the valve in order to render the anode current proportional to the anode voltage or to replace one of the resistances of the bridge by a convenient circuit having the same voltage-current characteristic as the valve. In this way the meter becomes insensitive to H.T. variations and sensitive only to voltages applied to the grid of the valve.

The method can be applied to any bridge circuit comprising a non-linear element and will be explained in detail for this general case.

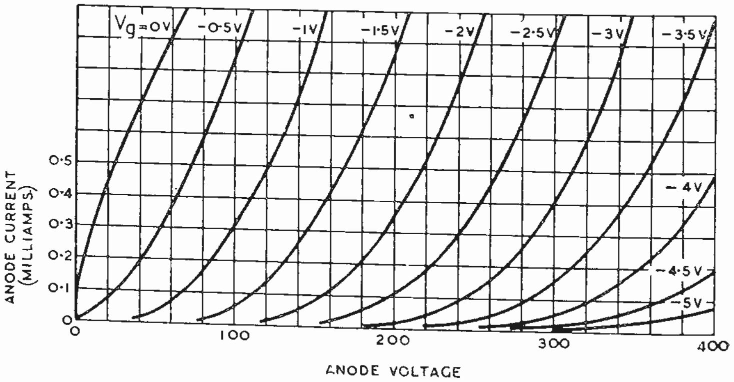

Fig. 4. *Characteristics of a triode. When the grid voltage varies the characteristic is displaced horizontally.*

Fig. 2 represents a bridge circuit composed of a non-linear element NL and three resistances R_1 R_2 R_c. A supply voltage is applied across diagonal 1–2 and a signal to be amplified, detected or measured, is applied on the non-linear element. The output is taken across diagonal 3–4. Assume that in the absence of an input signal the bridge is balanced for a given supply voltage V_0. If the supply voltage is varied, the balance is destroyed and an output voltage, or current, will appear. This is due to the non-linear voltage–current characteristic of the $NL + R_c$ branch. Referring to this characteristic represented in curve C_1 Fig. 3, let α be the actual working point corresponding to a supply voltage V_0. If the variations of V_0 are small, one can replace curve C_1 by its tangent at point α. This tangent usually does not pass through point O, the origin of the axis, and the variation of current across $(NL + R_c)$ is not proportional to the variation of voltage. For this reason if V_0 is varied, the bridge is no longer balanced. However, it is clear that this disturbance can be avoided either by displacing the characteristic from C_1 to C_2, in order that the new tangent corresponding to V_0 may pass through the origin, or by replacing resistance R_1 or R_c by an element having the same voltage-current characteristic as NL.

The way of applying the first method depends on the nature of the non-linear element NL. If it is a valve, the displacement can be obtained by a convenient grid bias as will be explained.

One way of applying the second method is well-known : if R_1 or R_c is replaced by a similar element to NL, the balance is obtained. However, this may not be desirable if the element NL is expensive or has big dimensions or other inconveniences. If NL is a valve R_1 or R_c can be replaced by the same type of valve. However, this solution is not very practical because it increases the dimensions, the wiring and the cost of the circuit. Besides, it may be shown that the sensitivity is then considerably reduced. By means of a neon tube and resistance circuit elements can be produced which have the same characteristics as NL and which have not the drawbacks mentioned above.

Examples of Application of the First Method

Consider the valve-voltmeter circuit of Fig. 1. Fig. 4 represents the current–voltage characteristics of the valve for different grid-bias voltages. It may be observed that a change of grid-bias voltage produces a translation of the characteristic parallel to the voltage axis. From these curves one can deduce the current–voltage characteristic of the valve in series with a resistance R_c. This is represented in Fig. 5 for a grid bias equal to zero and each curve corresponds to a particular value of R_c. In order to give some numerical values, the curves have been traced for a triode Type 75. All these curves are practically straight lines nearly through the same point. It may be shown that the effect of applying a grid-bias voltage is to displace these curves by a translation parallel to the voltage axis exactly as for the curves of Fig. 4. A negative bias displaces the curves to the right. Thus it may be seen that for each value of R_c a convenient bias will make the corresponding characteristic pass through the original O. This value has been indicated on each line. It varies from 0 to nearly 0.5 volt.

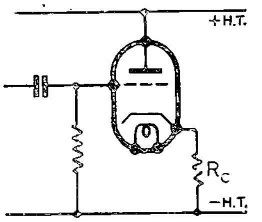

Fig. 5. *Characteristics of a triode with a cathode resistance R_c and grid connected to earth. The curves approximate to straight lines radiating from point of negative voltage.*

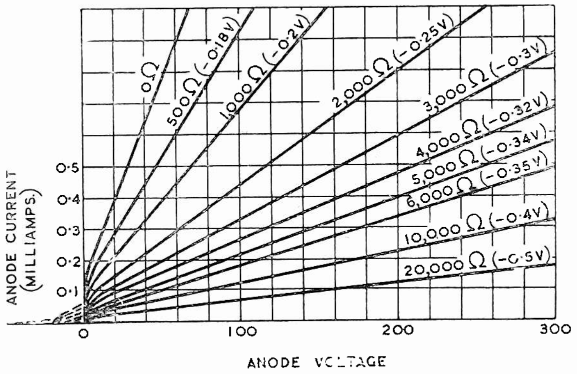

Fig. 6 represents an application of this idea to a complete valve voltmeter circuit. The alternating voltage to be detected and measured is applied across terminals 1, 2. The diode D in connection with the filter R_bC detects this voltage and produces a negative voltage across condenser C. This voltage is applied to the grid of valve V and is measured on the meter M. To make the zero adjustment of the meter independent of H.T. voltage variations, the grid of this valve must be biased correctly. Note that even in the absence of a signal at terminals 1, 2, there is a small diode current which produces a drop of potential across resistance R_a. This drop can be used as bias if it has the right value, but usually, for high values of R_a, this drop is of the order of 1 volt and the negative bias on the grid of valve V is too great unless the cathode of the diode is connected to a positive bias of the order of a fraction of a volt. This can be done by connecting the cathode of the diode to the tapping T of a potential divider connected between H.T. and earth. *The zero adjustment is carried out by adjustment of R_2, and the stability of zero by adjusting the tap T.*

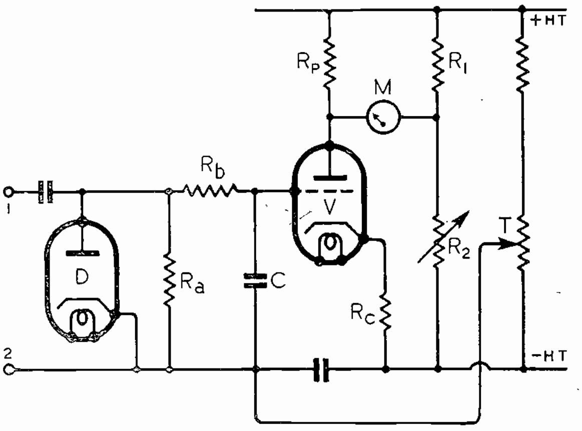

Fig. 6. *Valve-voltmeter circuit in which the grid is biased by means of potentiometer T.*

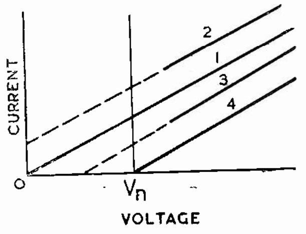

Fig. 7. *Voltage circuit characteristics. Curve 1 of a simple resistance; curve 2 for circuit of Fig. 8; curve 3 for circuit of Fig. 9 (b); curve 4 for circuit of Fig. 9 (a).*

Although this circuit gives good results its scope is limited because once the H.T. voltage and the sensitivity (determined by R_c) are chosen, the anode current of the valve is fixed and in some cases may be too small. By the methods which will be now described the same stability effects can be obtained for any value of sensitivity, H.T. voltage *and anode current.*

Second Method and Examples of Application

The voltage–current characteristic of a resistance is a line passing through the origin, such as curve 1 Fig. 7. Means are described for displacing this curve upwards or downwards. Fig. 8 shows a circuit for displacing the curve upwards and Fig. 9 circuits for displacing it downwards.

In Fig. 8 the H.T. voltage is applied to two resistances R_1 and R_2 in series. It will be assumed for simplicity that R_2 is small compared to R_1. Then the current flowing in R_1 is proportional to the H.T. voltage and may be represented by curve 1 of Fig. 7. The current flowing in R_2 is the resultant of the current flowing in R_1 and the current coming from the neon tube N_1 through resistance R_4. It will also be assumed for simplicity that the voltage across R_2 is small compared with the voltage across the neon tube, so that resistance R_4 is large compared with R_2. Then the current flowing in R_2 and coming from the neon tube is constant and practically independent of the H.T. voltage. The current flowing in R_2 is thus the sum of a current proportional to the H.T. voltage and a current of constant value. It may be represented by curve 2 of Fig. 7, which is obtained by displacing curve 1 vertically by an amount equal to the constant current coming from the neon tube. The value of this displacement can be changed by adjusting R_4.

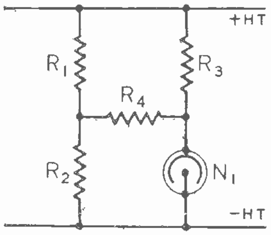

Fig. 8. *Circuit giving in resistance R_2 a current following the law of curve 2 of Fig. 7.*

Fig. 9 gives circuits which displace curve 1 downwards. In Fig. 9 (*a*) the H.T. voltage is applied to a resistance R_2 through the neon tube N_2. The current in R_2 is proportional to the voltage applied to it, that is to say to the H.T. voltage reduced by V_N volts, V_N being the constant voltage across the neon tube. Thus this current may be represented by curve 4 in Fig. 7. The limitation of this circuit is due to the fact that curve 4 meets the voltage axis at the fixed point V_N and cannot be displaced. This can be done with the circuit of Fig. 9 (*b*) which is similar to the one of Fig. 8 except that the neon tube is connected to the + H.T. instead of the − H.T. terminal. This produces a displacement downwards of curve 1 (curve 3, Fig. 7) instead of upwards.

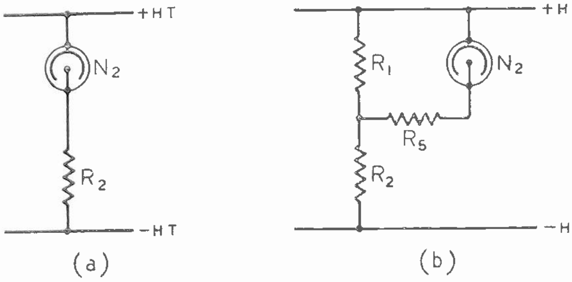

Fig. 9. *Circuit* (*a*) *gives in R_2 a current following the law of curve 4, Fig. 7, and* (*b*) *one corresponding to curve 3*

Some examples of application of these circuits to valve voltmeter circuits are given in Figs. 10, 11 and 12.

Fig. 10 represents a valve voltmeter circuit in which the grid is connected to earth by a high resistance R_g and in which the bias is obtained by a cathode resistance R_c. Thus, the $V_a - I_a$ characteristic of the valve is of the type shown in Fig. 5 or in curve 2 Fig. 7. The current I_a flows through resistance R_c and in order to get a zero adjustment independent of H.T. voltage variations, the same type of current must flow in resistance R_2. To obtain this result the circuit shown in Fig. 8 is used.

The adjustment of this circuit is very easy. First one must obtain in R_2 a current having the required slope in order that any variation of H.T. voltage will produce the same voltage variation in R_c and R_2. This slope is determined by curve 1 (Fig. 7) and can be adjusted by varying resistance R_1. Thus one has first to adjust R_1 in order that the needle

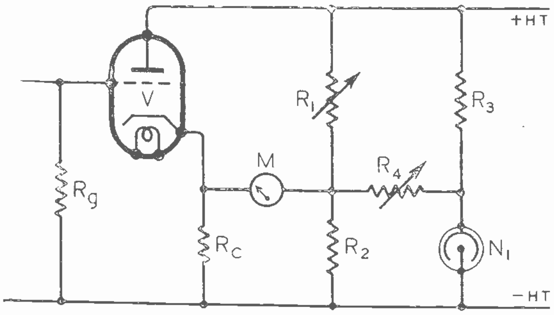

Fig. 10. *Bridge circuit of Fig. 1 combined with circuit of Fig. 8.*

of the meter will not move when the H.T. voltage is varied. This will be obtained usually with a certain deflection of the needle. This deflection will then be reduced to zero by adjusting resistance R_4, that is to say by sending a convenient current through R_2 which remains constant when the H.T. voltage is varied.

A circuit of this type has been tested, using the following values for the components :—Valve = triode Type 75 ; Meter = 200 μA full scale deflection ; R_c = 2,000 Ω ; R_1 = 63,000 Ω ; R_2 = 400 Ω ; R_3 = 55,000 Ω ; R_4 = 100,000 Ω ; Neon tube = S.T.C. Type VLS.405.

The following results were obtained :—

Sensitivity : Full scale deflection for — 0.25 volt applied to the grid.

Zero Stability : ± 0.3 μA when the H.T. voltage is varied from 200 to 300 volts ; ± 2 μA (± 1 per cent. of full-scale deflection) when the heater voltage is varied by ± 10 per cent.

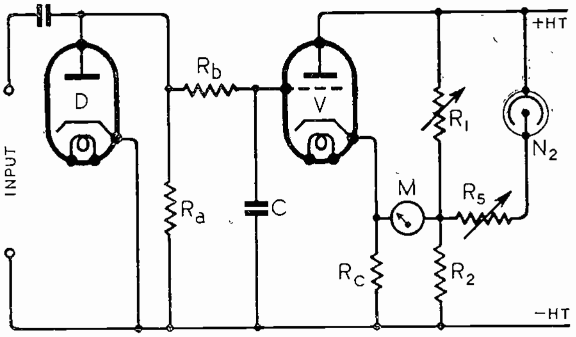

Fig. 11. *Bridge circuit of Fig. 1 combined with a diode detector and Fig. 9 (b).*

Fig. 11 represents the same valve voltmeter as in Fig. 10 except that the grid is connected to a diode detector as in Fig. 6. As has already been explained, the diode circuit introduces a negative bias on the grid of the order of 1 volt. This displaces the characteristics of Fig. 5 to the right so that one obtains a family of curves crossing the voltage axis on the right-hand side of the origin *O* of the axis. These lines are thus of the type represented by curve 4 in Fig. 7 and the circuit of Fig. 9 (*b*) must be used. The circuit of Fig. 11 gives the same stability as the circuit of Fig. 10. The circuit tested had the following values of elements :—Diode = Mullard EA50 ; Triode = Type 75 ; Meter = 200 μA full scale ; Neon tube = S.T.C. type VLS.405 ; R_a = R_b = 2 MΩ ; C = 0.01 μF. ; R_c = 2,000 Ω ; R_1 = 93,000 Ω ; R_2 = 400 Ω ; R_5 = 180,000 Ω.

To obtain a stable zero one must adjust resistances R_1 and R_5. Unfortunately this adjustment must be simultaneous and is more elaborate than in the case of Fig. 10. To use the circuit of Fig. 10 with a diode detector circuit, one must bias the grid of the triode positively. This can be done easily by connecting the cathode of the diode to the moving tap of a potential divider connected across the neon tube N_1. In this way the circuit of Fig. 12 is obtained.

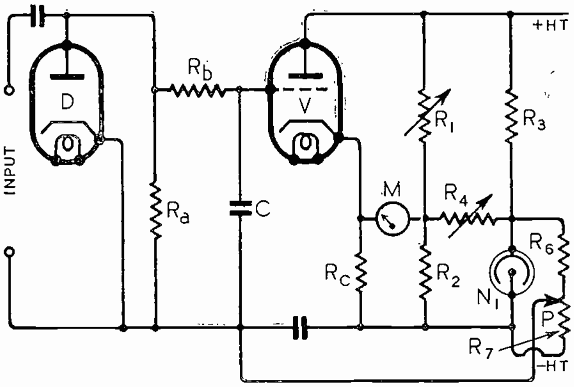

Fig. 12. *Diode detector combined with bridge circuit of Fig. 1 and balancing circuit of Fig. 8.*

A valve voltmeter of this type has been tested. The values of the different elements were as follows :—Diode = Mullard EA50 ; Triode = Type 75 ; Neon tube = S.T.C. type VLS.405 ; Meter = 200 μA full scale deflection ; R_a = 10 MΩ ; R_b = 2 MΩ ; C = .01 μF. ; R_c = 10,000 Ω ; R_1 = 0.23 MΩ ; R_2 = 2,000 Ω ; R_3 = 70,000 Ω ; R_4 = 27,000 Ω ; R_6 = 1 MΩ ; R_7 = 0.1 MΩ approximately.

The characteristics of this circuit were found to be :—

Sensitivity : Full scale deflection for 0.6 volt A.C. applied on the diode.

Zero Stability : Less than 2 μA variation when the H.T. voltage varies from 200 to 300 volts (1 per cent. of full-scale deflection).

Calibration : Less than 2 per cent. variation of sensitivity at full scale when the H.T. voltage is varied from 200 to 300 volts.

The circuits described in this paper are covered by British Patent No. 566710. The author is indebted to Standard Telephones and Cables, Ltd., for permission to publish.

POWER LOSS IN ELECTROMAGNETIC SCREENS*

By C. F. Davidson, R. C. Looser and J. C. Simmonds

SUMMARY.—A method is developed which enables the increase in resistance of an inductor to be calculated when a screen consisting of circular loops of wire is brought near it. The calculated resistance increase agrees within about 20 per cent. or better with experimental values obtained by measurement on small screens.

1. Introduction

IN the past electromagnetic screens consisting of concentric circular loops of copper wire have been used to reduce power losses in nearby objects due to eddy currents induced by large inductors. Screens of this description are relatively simple to erect but no means have been available to enable the number of loops and spacing necessary to reduce the induced eddy currents to a certain relative level to be found. Neither has it been possible, except by rather crude methods, to determine the power loss in the screen. In this paper a method of calculating the power loss in the screen is developed. From this calculated power loss and measurements on the inductor, the effectiveness of the screen can be determined. The dimensions of the systems investigated are assumed small compared with one wavelength at the operating frequency. The rationalised MKS system of units is employed throughout.

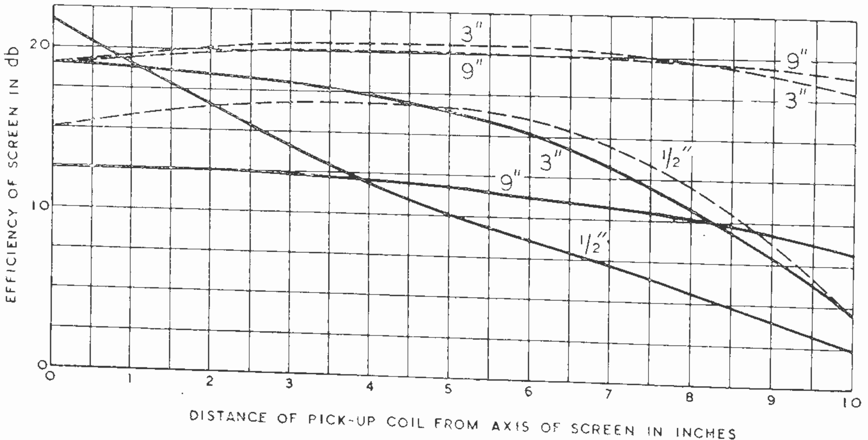

Fig. 1. *These curves of measured screen efficiency are (solid lines) for a screen of 25 concentric loops ranging from $\frac{3}{8}$in. to 11in. diameter and approximately equally spaced. The dotted curves are for a screen of 10 concentric loops with diameters ranging from 1in. to 11in., and then 9 loops up to 20in. in diameter all equally spaced.*

2. Preliminary Measurements

An energising inductor was set up in front of a screen of circular loops of wire, and the voltage induced in a small search coil placed behind the screen was measured. From measurements made at different points behind the screen the efficiency of the screen at these points was found. Measurements were also made to determine the effect of numbers of loops upon the efficiency of the screen.† The results are shown in Figs. 1, 2 and 3, in which the figures shown on the curves give the distance of the pick-up coil behind the plane of the screen; all screen wires were of No. 20 S.W.G. tinned copper wire. The energising coil consisted of 55 turns of 26 S.W.G. wire on a 2-inch diameter former. The turns occupied a length of 1.2 inches and the coil was situated so that the nearest turn was 2 inches from the plane of the screen. For convenience the energising voltage applied to the inductor was at a frequency of 65 kc/s.

From these results it is seen that :—

(1) The efficiency of a large diameter screen, consisting of a large number of loops, is approximately independent of the distance from the axis.

(2) Up to a point the efficiency increases with distance from the screen.

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* MS. accepted by the Editor, August 1945.

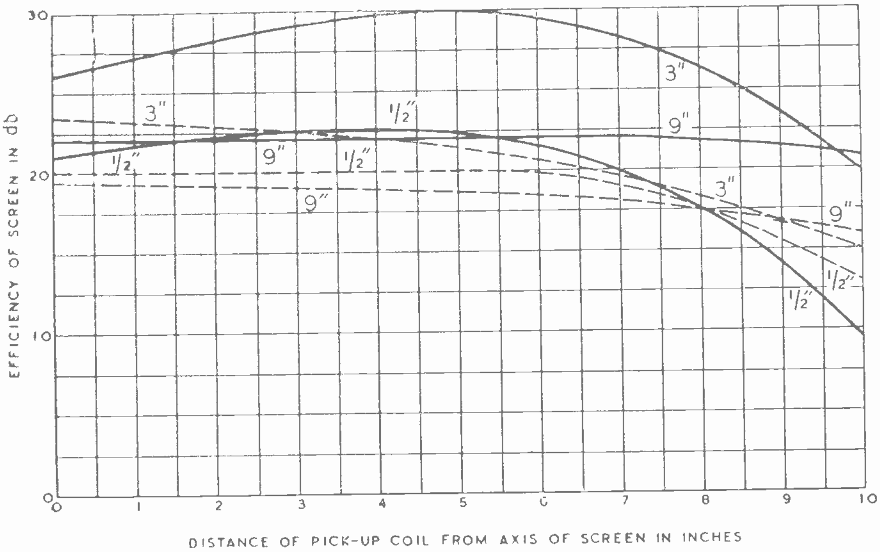
† Screen efficiency is here defined as the logarithmic ratio of the field intensity which would exist at a point behind the screen if the screen were not in position, to the field intensity at the point when the screen is in position.

(3) The efficiency increases with the number of loops.

(4) Loops near the edge of the screen affect the efficiency near the axis.

It was also observed that the direction of the field behind the screen was roughly normal to the plane of the screen even at distances behind the screen approaching half its diameter. This fact would simplify the calculation of the power loss in a homogeneous material placed behind the screen, as, for example, in the case of an earth screen.

Fig. 2 (Right) *These curves are similar to those of Fig. 1, but the full line curves are for 20 loops of 1in. to 11in. diameter and then 9 loops to 20in. diameter. The dotted curves are for a screen of 20 loops of 1in. to 11in. diameter and then 5 loops only with diameters up to 20in.*



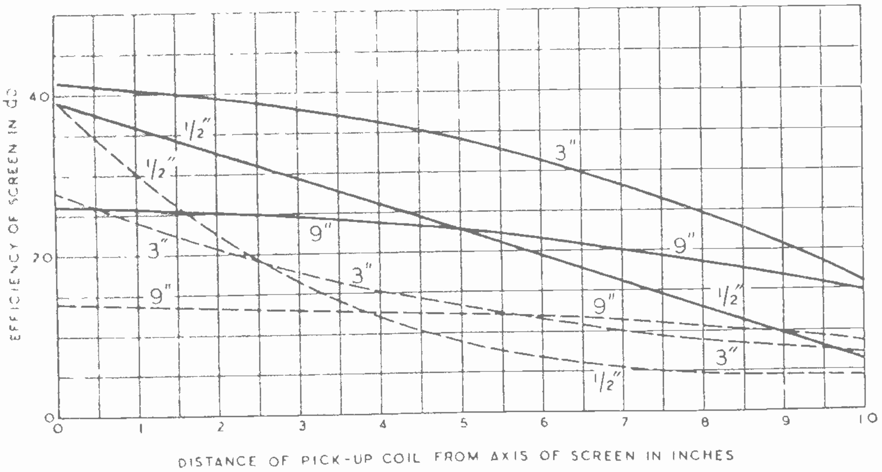


Fig. 3 (Left). *The full-line curves here represent one copper ring of* No. 18 *S.W.G. of* 1in. *internal diameter and* 11in. *external diameter and then* 9 *loops equally spaced to* 20in. *diameter. The dotted curve shows the results without these last* 9 *loops.*

3. Calculation of Power Loss and Screen Efficiency

If we could determine the currents induced in the loops of the screen then the power loss in the screen and the efficiency of the screen could be found. It is, however, impracticable to calculate the loop currents when the number of loops is more than four or five—the inductance of every loop, the mutual inductance between every loop and every other loop, and the mutual inductance between every loop and the inductor must be calculated; a system of simultaneous equations has then to be solved, the number of unknowns and equations being equal to the number of loops. As a screen will rarely consist of less than 10 loops the computational difficulties are readily appreciated. A method of estimating the loop currents must, therefore, be sought.

3.1. *Estimation of loop currents*

The eddy current surface density induced in a thin plane of conducting material by a circular loop carrying a current $I \cos \omega t$ placed at distance a from the plane and parallel to it is given by‡ :—

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‡ See Appendix and Fig. 6.

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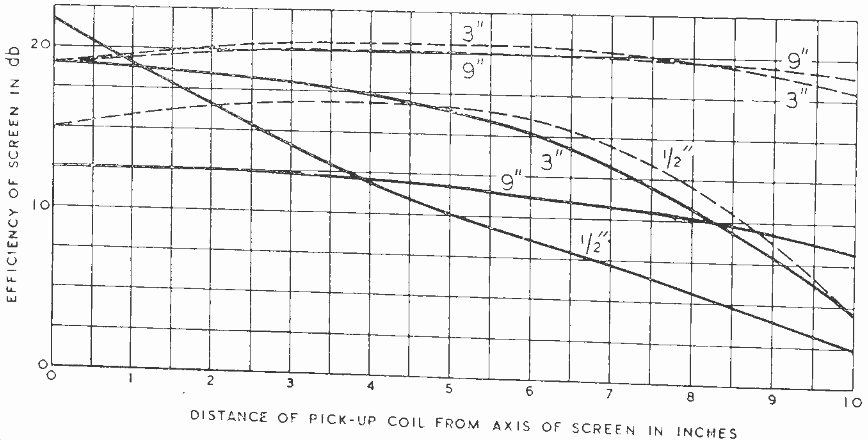

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$$i_\phi = \frac{I \cos \omega t \times k(a/b)}{4\pi\,(\rho/b)^{3/2} \times b}\left\{-\,2K + \frac{2 - k^2}{1 - k^2}E\right\} \quad \ldots \quad \ldots \quad (1)$$

where $k^2 = \dfrac{4\,\rho/b}{[(1 + \rho/b)^2 + (a/b)^2]}$

b = radius of exciting loop
ρ = radius vector in plane
K and E = complete elliptic integrals of the first and second kind respectively and modulus k
ω = 2π × frequency
t = time

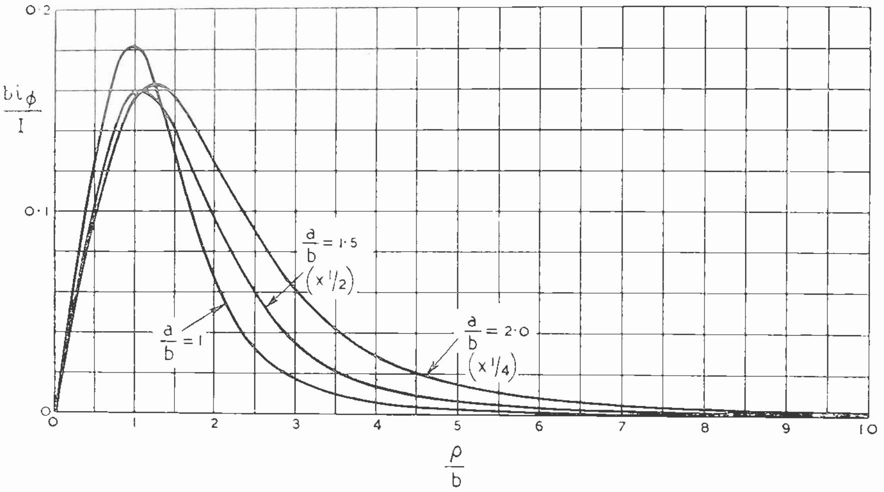

Fig. 4 (Right). *The variation of current density in a plane sheet with distance from the axis of the energising coil is shown here. The curves are for the three different values of a/b and the value read from the curve must be multiplied by the appropriate factor to give bi$_\phi$/I.*

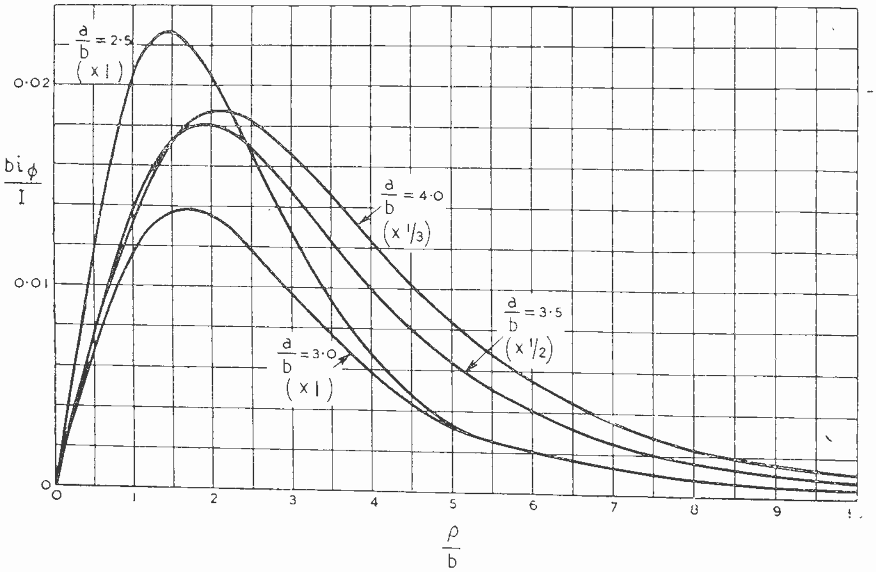

Fig. 5 (Left). *These curves are similar to those of Fig. 4, but for four further values of a/b.*

The currents induced in the conducting plane flow in circles concentric with the axis of the exciting loop. It is not unreasonable to assume that the current carried by a loop of radius ρ in a screen consisting of circular loops d apart, will be approximately equal to the current flowing in a conducting plane over a radial distance $\rho - \frac{d}{2}$ to $\rho + \frac{d}{2}$ when the currents are induced by the same exciting loop. This assumption will be more justified as the relative distance between loops decreases and as the extent of the screen increases.

In Figs. 4 and 5 the term $(i_\phi b/I)$ is shown graphically against (ρ/b) for various values of (a/b). From these curves the current in any loop of a screen can be found per ampere in the exciting loop by reading off the value of the term and multiplying by (d/b). The loop current for any current in the exciting loop then follows directly, whilst the loop current for an exciting inductor consisting of a number of loops can be found by adding the loop currents which would be produced by each exciting loop separately.

3.2. *Increase in resistance due to the presence of the screen*

Once the loop currents are found, the power loss in each loop is simply the product of the square of the loop current and the loop resistance, and the total power loss is obtained by summing all the loop losses. The increase in inductor apparent resistance due to the screen is then found by dividing the total screen power loss by the square of the inductor current, or,

$$\Delta R = \frac{1}{I^2} \sum_{n=1}^{n=N} i^2_{\phi n}\, d^2\, R_n,$$

where ΔR = increase in resistance
N = number of loops in screen
R_n = resistance of nth loop

3.3. *The magnetic field produced by the screen currents*

Formulae which enable the magnetic intensity, due to a current flowing in a circular loop, at any point in space to be calculated are available. These formulae, however, are not of a simple form and a fair amount of computational work is involved. The magnetic intensity on the axis of the loop is given, however, by the relatively simple expression :—

$$H = \frac{I}{2\rho\,[1 + (a/\rho)^2]^{3/2}}$$

From this expression the intensity at any point on the axis distant a from the loop can be calculated providing the loop current I is known. The intensity produced by the whole of the loops of a screen can obviously be found by addition. The resultant intensity behind the screen will be the difference between the intensity produced by the screen currents and the intensity produced by the exciting inductor in the absence of the screen, whilst the screen efficiency at the point under consideration is the logarithmic ratio of the resultant field to the field produced by the exciting inductor in the absence of the screen. It will be shown below that, for screens of the type likely to be encountered in practice, the screen efficiencies calculated in this way are quite unreliable, due partly to the fact that the difference between two almost equal magnetic intensities is involved, each of which must be known with a high degree of accuracy.

4. Experimental and Calculated Results

Measurements were made on a number of small screens to justify, if possible, the proposals made in sections 3.2 and 3.3. That is, in effect, to determine to what degree the fundamental assumption made in section 3.1 is justified.

4.1. *Evaluation of resistance increase*

The increase in resistance of an exciting inductor when various loop screens were brought near it was measured at a frequency of 20 kc/s. Owing to the very small resistance change in some cases the measurement accuracy was, in these cases, quite poor. Details of the screens, the calculated resistance increase, the measured resistance increase, and the possible measurement error are given in Table I. A table showing the stages in the calculation of the resistance increase for a particular screen is given in Table II. This table shows very clearly the important parts of the screen from the point of view of power loss—the larger part of the power loss occurs in those loops which are about the same diameter as the exciting inductor. Loops of radius 1 in. to 5in. in this particular screen, Screen 4 in Table I, were replaced by loops of heavier gauge wire converting it to Screen 5 in Table I. The reduction in resistance increase is marked and shows the importance of these loops. Except in those cases (which would not normally arise in practice) where the screen had very few loops or was very near to the exciting inductor, the calculated and measured resistance increases do not disagree by more than 20 per cent. and no doubt some of the difference is due to measurement error.

4.2. *Screen efficiency*

For a point on the axis of, and just behind the screen, the field strengths due to the exciting inductor and to the currents in the loops of the screen were calculated, and the resultant field strength deduced, by the method given in section 3.3. The resultant field strength was also measured. Table III shows the calculated and the measured field strengths ; the agreement is very poor indeed, no doubt largely due to the fact that the difference of two almost equal fields is taken in the calculation. Thus, if the loop currents are in error by 10 per cent. say, the error on the resultant field may be very large indeed, whilst the error on power loss would only be 20 per cent.

5. Conclusions

(1) A method of determining the increase in resistance of an inductor due to the

presence of a loop screen has been developed and checked experimentally. The method should give the resistance increase to within 20 per cent. and, as the resistance increase due to the screen is usually made small compared with the inductor resistance, this degree of accuracy should be ample for most purposes.

(2) The method shows clearly those parts of the screen which contribute most to the power loss and enables steps to be taken to reduce the power loss most economically by increasing the gauge of the strategic loops or by placing them closer together.

(3) A similar method, when applied to the calculation of the screen efficiency, does not give results in agreement with experiment. This is because the difference of two almost equal quantities is involved in the calculation, hence the power loss in material placed behind the screen cannot be calculated directly. The total power loss due to the material of the screen and the material placed behind the screen may, however, be measured and since the former loss may be calculated, the loss due to the material behind the screen is known; steps may then be taken to reduce this loss if necessary.

(4) Experimental results show that to obtain good efficiency behind the screen, even on the axis, the loops must be taken out to such a diameter that the currents in

TABLE I

Calculated and Measured Values for the Increase in Resistance of an Energising Coil due to the Presence of a Screen.

Screen No.	Details of Screens	No. of Turns and Diameter of Energising Coil	Increase in Resistance, Ohms				Possible Measurement Error, %
			Calculated		Measured		
			$\frac{a}{b}$	ΔR	$\frac{a}{b}$	ΔR	
1	12 screening loops, 1¼, 2, 3, 4¼ 6⅛, 8⅛, 10⅛, 12⅛, 14, 16, 18 and 20 ins. diameter.	55 Turns 2″ dia. ($b = 1''$)	1.0	0.273	1.0	0.190	1
			1.5	0.092	1.5	—	—
			2.0	0.039	2.0	0.033	1
			2.5	0.019	2.5	0.016	2
			3.0	0.0105	3.0	0.0090	4
			3.5	0.0062	3.5	0.0055	6
			4.0	0.0038	4.0	0.0035	10
2	24 screening loops, ¾, 1⅛, 1⅜, 1½ 2, 3, 3½, 4⅝, 5, 6¼, 7¼, 8, 9, 10¼, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 ins. diameter.	55 Turns 2″ dia. ($b = 1''$)	1.0	0.166	1.0	0.151	1
			1.5	0.053	1.5	—	—
			2.0	0.022	2.0	0.024	1
			2.5	0.0103	2.5	0.0120	2
			3.0	0.0055	3.0	0.0055	4
			3.5	0.0032	3.5	0.0035	6
			4.0	0.0019	4.0	0.0020	10
3	10 screening loops, 4, 8, 12, 16, 20, 24, 28, 32, 36 and 40 ins. diameter.	110 Turns 4″ dia. ($b = 2''$)	1.0	4.58	1.0	1.258	1
			1.5	1.21	1.5	0.493	1
			2.0	0.454	2.0	0.204	1
			2.5	0.205	2.5	0.113	1
			3.0	0.104	3.0	0.067	2
			3.5	0.057	3.5	0.0385	3
			4.0	0.034	4.0	0.023	4
4	20 screening loops, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38 and 40 ins. diameter.	110 Turns 4″ dia. ($b = 2''$)	1.0	2.130	1.0	1.412	1
			1.5	0.593	1.5	0.495	1
			2.0	0.239	2.0	0.198	1
			2.5	0.102	2.5	0.094	1
			3.0	0.052	3.0	0.047	2
			3.5	0.029	3.5	0.027	3
			4.0	0.016	4.0	0.017	4
5	20 screening loops, as for screen 4, but the 2, 4, 6, 8 and 10 in. dia. loops were replaced by loops of 16 s.w.g. wire.	110 Turns 4″ dia. ($b = 2''$)	2.0	0.107	2.0	0.082	1
			3.0	0.033	3.0	0.032	2

All screening loops are of 20 s.w.g. tinned copper wire unless otherwise stated.

them are less than about 1/10th of the maximum loop current.

(5) If necessary the method of calculation could no doubt be extended to the case of a screen of loops which entirely enclose the inductor, by assuming the loops to lie upon the surface of a circular cylinder or a sphere.

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APPENDIX

The eddy currents induced in an infinite plane conducting sheet by a circular loop

Let a circular loop carrying a current $I \cos \omega t$ be placed with its plane parallel to a thin, infinite, plane, conducting sheet, as shown in Fig. 6. We wish to determine at any point in the sheet the eddy current density

TABLE II

Specimen Calculation for Determining the Increase in the Resistance of a Coil due to the Presence of a Screen

$a = 4''$, $b = 2''$, $\frac{a}{b} = 2$.

Radius of loop (ρ) ins.	$\frac{\rho}{b}$	$\frac{bi_\phi}{I}$ from Fig. 4	d, metres	Wire current (i) $= \left[\frac{bi_\phi}{I}\right] \times \frac{d}{b}$ amps.	Loop resistance, (R) ohms	Power loss in loop, $i^2R \times 10^6$ micro-watts
1	0.5	0.0241	0.0254	0.01205	0.0042	0.61
2	1.0	0.0388	0.0254	0.01940	0.0084	3.16
3	1.5	0.0390	0.0254	0.01950	0.0126	4.79
4	2.0	0.0314	0.0254	0.01570	0.0168	4.14
5	2.5	0.0226	0.0254	0.01130	0.0210	2.68
6	3.0	0.0154	0.0254	0.00769	0.0252	1.49
7	3.5	0.0103	0.0254	0.00518	0.0294	0.79
8	4.0	0.0070	0.0254	0.00350	0.0336	0.41
9	4.5	0.0050	0.0254	0.00251	0.0378	0.24
10	5.0	0.0034	0.0254	0.00171	0.0420	0.12
11	5.5	0.0025	0.0254	0.00127	0.0462	0.07
12	6.0	0.0018	0.0254	0.00092	0.0504	0.04
13	6.5	0.0014	0.0254	0.00072	0.0546	0.03
14	7.0	0.0010	0.0254	0.00052	0.0588	0.02
15	7.5	0.0008	0.0254	0.00040	0.0630	0.01
16	8.0	0.0006	0.0254	0.00032	0.0672	0.01
17	8.5	0.0005	0.0254	0.00028	0.0714	0.01
18	9.0	0.0004	0.0254	0.00020	0.0756	0.00
19	9.5	0.00025	0.0254	0.00016	0.0798	0.00
20	10.0	0.00025	0.0254	0.00016	0.0840	0.00
						19.73

In the above calculation a current of 1 ampere has been assumed in the energising coil.

From Section 3.2 $\Delta R = \frac{1}{I^2} \sum_{n=1}^{n=N} i^2{}_{\phi n} d^2 R_n$

Hence ΔR for one turn $= 1.973 \times 10^{-5}$ ohm.
and ΔR for a coil of 110 turns $= 1.973 \times 10^{-5} \times (110)^2$ ohm.
$= \underline{\underline{0.239 \text{ ohm.}}}$

TABLE III

Calculated and Measured Values of the Field Strength ⅜ in. behind a Concentric Screen.

Screen No.		Field Strength for (M.K.S. Units)		
		$\frac{a}{b} = 2$	$\frac{a}{b} = 2.5$	$\frac{a}{b} = 4$
1	Calculated	1.8×10^{-2}	1.3×10^{-2}	4.0×10^{-3}
See Table I	Measured	5.6×10^{-1}	2.8×10^{-1}	7.1×10^{-2}
2	Calculated	1.7×10^{-2}	4.0×10^{-3}	0.00
See Table I	Measured	2.4×10^{-1}	1.3×10^{-1}	3.2×10^{-2}

induced by the current in the circular loop. In such circumstances it has been shown by Clerk Maxwell that if the vector potential of the field produced by the source is

$$A' = f(t, x, y, z) \qquad \ldots \quad \ldots \quad \ldots \quad (1)$$

i.e., if the vector potential is some arbitrary function of the co-ordinates of the point under consideration and of the time t then at time t the total vector potential of the eddy currents is

$$A = -\int_0^\infty \frac{\partial}{\partial t} f\left(t - \tau, x, y, z + \frac{2s}{\mu}\tau\right) d\tau \qquad \ldots \quad \ldots \quad (2)$$

where s = area resistivity

τ = a time variable.

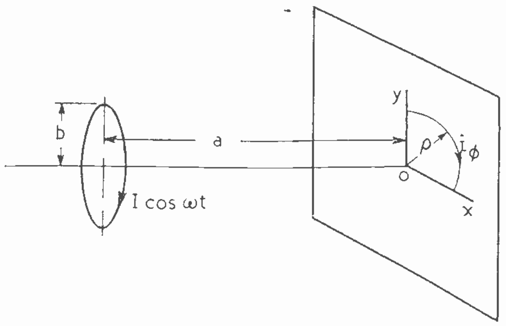

Fig. 6.

This formula depends upon the receding image representation of the field and further information should be sought in Maxwell's treatise or in, for example, W.R. Smythe's treatise.*

If we take the origin of our co-ordinate system in the sheet as shown in the drawing, it is easily proved that the vector potential of the loop current is given by :—

$$A_\phi' = \frac{\mu b I}{\pi} \int_0^{\pi/2} \frac{(2\sin^2\theta - 1)\,d\theta}{[(b+\rho)^2 + (a-z)^2 - 4b\rho\sin^2\theta]^{\frac{1}{2}}} \cos\omega t \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

where $\theta = \left(\frac{\phi}{2} - \frac{\pi}{2}\right)$. The vector potential of the eddy currents is, therefore :—

$$A_\phi = \int_0^\infty \int_0^{\pi/2} \frac{\mu b I \omega \sin\omega(t-\tau) \times (2\sin^2\theta - 1)}{\pi[(b+\rho)^2 + (a - z - \frac{2s}{\mu}\tau)^2 - 4b\rho\sin^2\theta]^{\frac{1}{2}}} \,d\theta\, d\tau \qquad \ldots \quad \ldots \quad \ldots \quad (4)$$

the order of the partial differentiation with respect to time and the integration with respect to θ being reversed. Integrating by parts with respect to τ leads to :—

$$A_\phi + A'_\phi = \frac{-2bIs}{\pi\omega} \sin\omega t \int_0^{\pi/2} \frac{(2\sin^2\theta - 1)(a-z)\,d\theta}{[(b+\rho)^2 + (a-z)^2 - 4b\rho\sin^2\theta]^{3/2}} \qquad \ldots \quad \ldots \quad (5)$$

as an approximation at high frequencies.

Thus, in the sheet, where $z = 0$, the total vector potential is

$$A_\phi + A'_\phi = \frac{-2bIs}{\pi\omega} \sin\omega t \int_0^{\pi/2} \frac{a(2\sin^2\theta - 1)\,d\theta}{[(b+\rho)^2 + a^2 - 4b\rho\sin^2\theta]^{3/2}} \qquad \ldots \quad \ldots \quad (6)$$

The electric intensity is equal to the rate of decrease of vector potential and also equal to the current density multiplied by the area resistance, therefore

$$i_\phi = -\frac{1}{s}\frac{d}{dt}(A_\phi + A_\phi')$$

and $$i_\phi = \frac{2bI}{\pi} \cos\omega t \int_0^{\pi/2} \frac{a(2\sin^2\theta - 1)\,d\theta}{[(b+\rho)^2 + a^2 - 4b\rho\sin^2\theta]^{3/2}} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Now make the substitution $$k^2 = \frac{4b\rho}{[(b+\rho)^2 + a^2]} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

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* Static and Dynamic Electricity.

then $$i_{\phi} = \frac{2}{\pi} abI \cos \omega t \left(\frac{k^2}{4b\rho}\right)^{3/2} \int_0^{\pi/2} \frac{(2 \sin^2 \theta - 1)\, d\theta}{(1 - k^2 \sin^2 \theta)^{3/2}} \quad \ldots \ldots \quad (9)$$

It is not difficult to show that :—

$$\int_0^{\pi/2} \frac{2 \sin^2 \theta - 1}{(1 - k^2 \sin^2 \theta)^{3/2}}\, d\theta = \frac{1}{k^2}\left[- 2K + \frac{k^2 - 2}{k^2 - 1} E\right] \quad \ldots \ldots \quad (10)$$

so that we have finally for the eddy currents

$$i_{\phi} = \frac{1}{4\pi} I \cos \omega t \frac{k(a/b)}{(\rho/b)^{3/2} \times b}\left[- 2K + \frac{2 - k^2}{1 - k^2} E\right] \quad \ldots \ldots \quad (11)$$

where K and E = complete elliptic integrals of the first and second kind respectively and of modulus k.

Equation (11) is not suitable for computation when k is small but the more suitable approximation

$$i_{\phi} = \frac{3}{64} I \cos \omega t \frac{k^5(a/b)}{(\rho/b)^{3/2} \times b} \frac{\left[1 + k^2/4 + \frac{15k^4}{128} + \ldots\right]}{(1 - k)^2} \quad \ldots \ldots \quad (12)$$

is easily established by expanding the elliptic integrals.

NEW BOOKS

Elementary Electric-Circuit Theory

By R. H. FRAZIER. Pp. 434 + x. McGraw-Hill Book Company, 330, West 42nd Street, New York, 18, N.Y. Price \$4.

The author of this book is Associate Professor of Electrical Engineering at Massachusetts Institute of Technology. His aim has been to provide a text book in which the fundamentals of electric-circuit theory are presented in a way suitable for students who will later specialise in either light or heavy-current engineering. This effort is a most laudable one, for many of the standard text-books show more than a bias towards one or other field. It is perhaps inevitable that the communications engineer should feel in reading the book that the author has dwelt overmuch on the power side.

The work opens with definitions and concepts which are clearly, though not rigorously, discussed. The methods of circuit analysis are then introduced in a chapter on resistance networks and the ideas extended to reactive elements. The chapter on complex algebra, in the heading of which the use of *simplex* may confuse the telecommunication engineer, is not excessively long. There is no reason why the student should not consult an algebra book if his mathematical equipment is inadequate. The author then proceeds to more advanced circuit theory, the theory of non-sinusoidal waves and polyphase networks and ends with a chapter on transients. An appendix contains a number of useful tables.

The excellent sections dealing with equivalent, dual and reciprocal networks call for special mention in a work of this kind. Only too often the relation between these forms is obscured rather than clarified. On the other hand the powerful methods of transient analysis based on the Fourier transform are not mentioned and attention is concentrated on the classical approach. The Fourier transform does not present difficulties which the undergraduate should not be able to surmount, and its attractive simplicity makes it a desirable approach if only for the promise of power which it offers when used for simple problems.

The book is produced in accordance with American economy standards and each pair of pages carries the chapter and paragraph number. The references are adequate and include a number of early original papers; the work of Ohm, Coulomb, Ampere and Maxwell is not overlooked in the flood of their followers. Each chapter is followed by a number of questions and problems, though it must be noted that two of the circuits given on page 256 are incorrect.

H. J.

Radio Valve Vade Mecum, 1945. By P. H. BRANS. Algemeene en Technische Boekhandel, Prins Leopoldstr. 28, Antwerpen (Borgt), Belgium.

This book of 208 pages is in four languages—Flemish, French, English and German—and gives, chiefly in tabular form, characteristics and base connections of a vary large number of British, American and Continental (including Russian) valves.

Back Issues

REQUESTS are being received for back issues of *Wireless Engineer* from countries which were under enemy occupation during the war. Readers who have copies dating back to 1940 for disposal are invited to communicate with the Publisher.

THE RECTIFICATION OF SIGNAL AND NOISE*

By V. J. Francis, B.Sc., A.R.C.S., F.Inst.P., A.M.I.E.E., and E. G. James, Ph.D., B.Sc.

(Communication from the Research Staff of the M.O. Valve Company, Limited, at The G.E.C. Research Laboratories, Wembley, England).

SUMMARY.—It is shown that the D.C. component of rectified noise, obtained with a square law triode, is not proportional to the mean square noise unless the valve is biased to cut-off. Unless this condition is fulfilled, errors as large as 3 db. may be obtained if the assumption of proportionality is made.

It is shown that a linear diode with a resistive load shunted by a large capacitor provides an accurate method of measuring noise. The mean rectified current with no applied signal is directly proportional to the R.M.S. noise input, the factor of proportionality being a function of the load resistance multiplied by the diode conductance. When both noise and signal are present, the ratio of the rectified current to R.M.S. noise input is a function of the signal/noise input ratio and the product of load resistance and diode conductance.

For the case of a diode operating on the exponential part of the characteristic, the rectified current is obtained for an input consisting of a mixture of signal and noise. Results are given for various values of signal input voltage and R.M.S. noise input. An indication is given of the type of transition to be expected between the exponential characteristic and the linear characteristic as the mean diode current increases.

LIST OF SYMBOLS.

v_1 = Instantaneous value of input voltage.
v_2 = Instantaneous value of output voltage.
$\sigma^2 = \overline{(v_1 - v_1)^2}$
$\bar{v}_1$ = mean value of input voltage.
$\bar{v}_2$ = mean value of output voltage.
V_1 = cut-off voltage of triode (V_1 a negative voltage).
V_2 = bias on triode.
$V = -V_1 + V_2$
i = instantaneous current through valve.
$\bar{i}$ = mean current through valve.
R = bias resistance for diode.
c = amplitude of sinusoidal carrier.
$p = \bar{v}_2/\sigma$
g = diode conductance.
$r = \bar{v}_2/c$
$q = \dfrac{c}{\sigma} = \dfrac{p}{r}$
$\alpha = \dfrac{q(r-1)}{\sqrt{2}}$
$\beta = \dfrac{q(r+1)}{\sqrt{2}}$
$b_n = \displaystyle\int_\alpha^\beta \phi^n \exp\{-\phi^2\}\, d\phi$
R_n see equations (46).
$\left.\begin{matrix} A \\ b \end{matrix}\right\}$ constants.
$\omega = 2\pi \times$ frequency of sinusoidal input.
a_n see equations (29).
I_n = see equations (31).
θ_n see equation (39).

1. Introduction

IN accurate measurements of noise, the most widely used measuring instrument is the vacuo-thermo-junction, which gives a true measure of the mean square value. The overload capacity of a vacuo-thermo-junction is, however, small, and it would be very convenient in making noise measurements on high gain R.F. amplifiers, to replace the thermo-junction by a thermionic detector.

In the past various experimenters have used the triode as an "anode bend" detector for measuring noise. Others have used a diode detector, since such a detector is generally incorporated in the receiver.

When the triode as an "anode-bend" detector has been used, the usual practice has been to bias the valve so as to obtain a steady anode current of the order of 1 mA in the absence of any signal, and to take the increase in anode current with applied signal voltage as a measure of that voltage. There has been some doubt, however, as to how much error was involved when comparing signal and noise voltage with this detector.

The current/voltage characteristic of a normal diode is approximately linear for currents higher than about 100 microamperes, but for currents smaller than this the characteristic departs from linearity and becomes exponential. When a diode rectifier is used for the measurement of

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* MS. accepted by the Editor, July 1945.

noise or signal to noise ratio, one can assume a linear characteristic for large input voltages, but this assumption is not justified when the input voltage is small.

Since the analysis of the response of an exponential diode to signal plus noise does not present great difficulty, and the numerical work involved is much less than in the case of the linear diode, it was thought worth while to examine the exponential as well as the linear case.

2. Measurement of R.M.S. Noise using Square-Law Triode

We assume that the input voltage v_1 is pure noise; that is that it is derived from random voltage pulses, and that all the circuits involved up to the rectifier are linear. If these assumptions are made, it is shown in recent papers[1] that the distribution of v_1 is Gaussian, so that if $W(v_1)\,dv_1$ is the probability that v_1 lies between v_1 and $v_1 + dv_1$

$$W(v_1) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left\{-\frac{{v_1}^2}{2\sigma^2}\right\} \quad \ldots \quad (1)$$

where $$\sigma^2 = \overline{(v_1 - \bar{v}_1)^2} \quad \ldots \quad \ldots \quad (2)$$

If we take the characteristic of the triode (see Figs. 1 and 2) as

$$\begin{aligned} i &= a\,(v_1 - V_1 + V_2)^2 \\ &= a\,(v_1 + V)^2 \qquad v_1 > -V \\ i &= 0 \qquad\qquad\qquad v_1 < -V \end{aligned} \quad \ldots \quad (3)$$

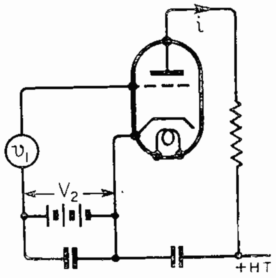

Fig. 1.

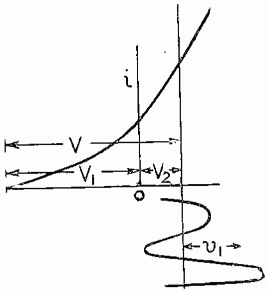

Fig. 2.

where a is a constant, and V is the bias voltage plus the cut-off voltage

$$\bar{i} = a\,\overline{(v_1 + V)^2}$$

$$= \int_{-v}^{\infty} a\,(v_1 + V)^2\,W(v_1)\,dv_1$$

$$= \frac{a}{\sqrt{\pi}} \int_{-v/\sigma\sqrt{2}}^{\infty} (V^2 + 2\sqrt{2}\,V\sigma y + 2\sigma^2 y^2) \exp(-y^2)\,dy \quad \ldots \quad (4)$$

Using the identity

$$\int_x^{\infty} y^2 \exp(-y^2)\,dy = \frac{x}{2}\exp(-x^2) + \tfrac{1}{2}\int_x^{\infty} \exp(-y^2)\,dy \quad \ldots \quad \ldots \quad (5)$$

it is easy to show that

$$\frac{i}{a} = \frac{1}{\sqrt{\pi}}(V^2 + \sigma^2)\int_{-v/\sigma\sqrt{2}}^{\infty} \exp(-y^2)\,dy + \frac{V\sigma}{\sqrt{2\pi}}\exp\left(-\frac{V^2}{2\sigma^2}\right) \quad \ldots \quad (6)$$

Now, if $V_2 = V_1$ that is $V = 0$, this gives

$$i/a = \sigma^2/2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

which is clearly correct, since a square-law triode biassed to cut-off will give half the output of a perfect square-law rectifier such as a thermocouple. In general, however, the output will depend upon V.

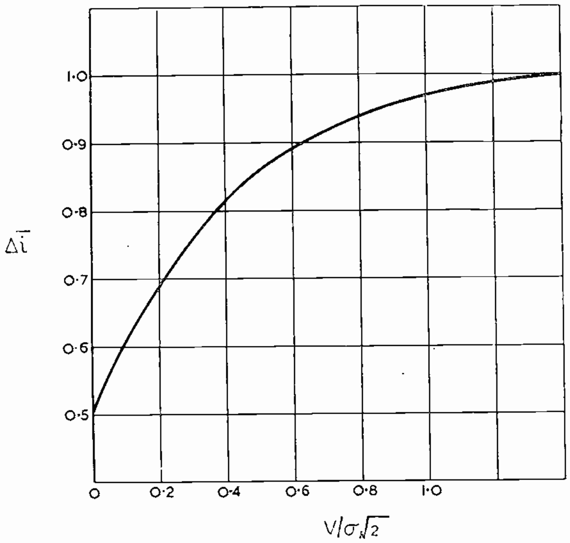

Fig. 3.

If Δi is the increase in the output due to the noise, we have

$$\Delta\bar{i} = \bar{i} - aV^2 \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

whence

$$\frac{\Delta\bar{i}}{a\sigma^2} = \tfrac{1}{2}\left\{1 + \operatorname{erf}\left(\frac{V}{\sigma\sqrt{2}}\right)\right\} - \frac{V^2}{2\sigma^2}\left\{1 - \operatorname{erf}\left(\frac{V}{\sigma\sqrt{2}}\right)\right\} + \frac{1}{\sqrt{\pi}}\left(\frac{V}{\sigma\sqrt{2}}\right)\exp\left(-\frac{V^2}{2\sigma^2}\right) \quad \ldots \quad \ldots \quad (9)$$

$$\text{where } \operatorname{erf}(x) = \frac{2}{\sqrt{\pi}}\int_0^x \exp(-y^2)\,dy \quad .. \quad (10)$$

Fig. 3 shows $\Delta i/a\sigma^2$ plotted against $V/\sigma\sqrt{2}$ from which, if V is known and Δi is measured, σ can be found. It is clear that large errors can be made if (7) is assumed to be true for all values of V.

3. Measurement of R.M.S. Noise using Linear Diode

Consider the usual rectifier circuit shown in Fig. 4 where R is chosen small enough to allow the diode to operate on the substantially linear part of its characteristic and the capacitor is chosen so large that the output voltage v_2 is substantially constant and equal to $\bar{v}_2$.

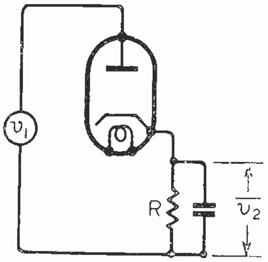

Fig. 4.

Let

$$\left.\begin{aligned} i &= g\,(v_1 - \bar{v}_2) \qquad & v_1 > \bar{v}_2 \\ i &= 0 & v_1 < \bar{v}_2 \end{aligned}\right\} \quad .. \quad (11)$$

Then

$$\bar{i} = \frac{\bar{v}_2}{R} = \int_{\bar{v}_2}^{\infty} g\,(v_1 - \bar{v}_2)\,W(v_1)\,dv_1$$

$$= \frac{g\sigma}{\sqrt{2\pi}}\exp\left(-\frac{\bar{v}_2{}^2}{2\sigma^2}\right) - \frac{g\bar{v}_2}{2} + \frac{g\bar{v}_2}{2}\operatorname{erf}\left(\frac{\bar{v}_2}{\sigma\sqrt{2}}\right) \quad .. \quad .. \quad (12)$$

$$1 + \frac{2}{Rg} = \frac{1}{\sqrt{\pi}}\left(\frac{\sigma\sqrt{2}}{\bar{v}_2}\right)\exp\left(-\frac{\bar{v}_2}{2\sigma^2}\right) + \operatorname{erf}\left(\frac{\bar{v}_2}{\sigma\sqrt{2}}\right) \quad .. \quad .. \quad (13)$$

This is an equation for $\bar{v}_2/\sigma\sqrt{2}$, whose solution is of the form

$$\bar{v}_2/\sigma = f\,(Rg) \quad .. \quad .. \quad .. \quad (14)$$

so that whatever the value of Rg, $\bar{v}_2$ is proportional to σ. That is, for a self-biased linear diode, the mean rectified voltage or current, when the time-constant of the load is large, is strictly proportional to the R.M.S. value of the input noise. For $g = 2$ mA/V and $R = 1{,}000$ ohms.

$$\bar{v}_2 = 0.42\sigma \quad .. \quad .. \quad .. \quad (15)$$

4. Linear Diode Rectification of Noise-Modulated Carrier

4 (a). *The Amplitude Distribution Function.*

Consider the same circuit as Fig. 4, but now with a sinusoidal carrier of frequency $\omega/2\pi$ superimposed on the noise. The problem is to find the output voltage as a function of the carrier amplitude, c, and the R.M.S. noise, σ.

For this purpose we need to know the amplitude probability distribution for a noise modulated carrier. The probability that the noise amplitude, x, lies between x and $x + dx$ is:

$$W_1(x)\,dx = \frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{x^2}{2\sigma^2}\right)dx \quad (16)$$

The probability that the carrier amplitude, y, lies between y and $y + dy$ is easily shown to be:

$$W_2(y)\,dy = \frac{dy}{\pi\,(c^2 - y^2)^{\frac{1}{2}}} \quad .. \quad .. \quad (17)$$

Therefore, the probability that the noise amplitude lies between x and $x + dx$ and that the carrier amplitude lies between y and $y + dy$ is

$$W_1(x)\,W_2(y)\,dx\,dy$$

$$= \frac{1}{\pi\sigma\sqrt{2\pi}}\cdot\frac{1}{(c^2 - y^2)^{\frac{1}{2}}}\exp\left(-\frac{x^2}{2\sigma^2}\right)dx\,dy \quad .. \quad .. \quad (18)$$

where the range of y is from $-c$ to $+c$, and the range of x from $-\infty$ to $+\infty$.

If we now make the transformation

$$\begin{aligned} x + y &= v_1 \\ y &= y \end{aligned}$$

we have

$$\int_{-\infty}^{+\infty} dv_1 \int_{-c}^{+c} W_3(v_1, y)\,dy$$

$$= \frac{1}{\pi\sigma\sqrt{2\pi}}\int_{-\infty}^{+\infty} dv_1 \int_{-c}^{+c} \frac{1}{\sqrt{c^2 - y^2}} \exp\left\{-\frac{1}{2\sigma^2}(v_1 - y)^2\right\}dy \quad (19)$$

where $W_3\,(v_1,\ y)\,dv_1\,dy$ is the probability that the total amplitude lies between v_1 and $v_1 + dv_1$ and that the carrier component lies between y and $y + dy$.

Thus if $W_4\,(v_1)\,dv_1$ is the probability that the amplitude of the noise modulated carrier lies between v_1 and $v_1 + dv_1$ we have:

$$W_4(v_1) = \frac{1}{\pi\sigma\sqrt{2\pi}}\int_{-c}^{+c}\frac{1}{\sqrt{c^2 - y^2}} \exp\left\{-\frac{(v_1 - y)^2}{2\sigma^2}\right\}dy \quad .. \quad (20)$$

The integral on the right of equation (20) considered as a function of v_1 with σ and c as parameters, fulfils the same rôle for a noise modulated carrier as the expression on the right of equation (16) as a function of v_1, with σ as parameter, fulfils for the noise voltage. This method of dealing with a noise modulated carrier may have other useful applications besides those considered in this paper. It should be noticed that the right-hand side of equation (20) is an improper integral, the integrand becoming infinite at the limits. It therefore might require careful handling in some cases, but the uses to which it is put in this paper do not lead to difficulty.

We thought that this method of dealing with combined signal and noise was new, but since this work was done we have found that the same method had been used by Bennett[2], although his analysis is restricted to the case of no bias on the detector.

4 (b). *The Equation for the Output.*

For a linear diode and the circuit of Fig. 4, we have, as before :

$$\left.\begin{aligned} i &= g\,(v_1 - \bar{v}_2) \qquad & v_1 > \bar{v}_2 \\ i &= o & v_1 < \bar{v}_2 \end{aligned}\right\} \quad .. \quad (11)$$

$$\therefore\ \bar{i} = \frac{\bar{v}_2}{R} = \frac{1}{\pi\sigma\sqrt{2\pi}} \int_{\bar{v}_2}^{\infty} g(v_1 - \bar{v}_2)\, dv_1 \int_{-c}^{+c} \frac{1}{\sqrt{c^2 - y^2}} \exp\left\{-\frac{1}{2\sigma^2}(v_1 - y)^2\right\} dy \quad .. \quad (21)$$

Putting $y = cz$ and $v_1 = u\,\bar{v}_2$ this gives

$$\bar{v}_2 = \frac{Rg}{\pi\sigma\sqrt{2\pi}} \int_1^{\infty} (u - 1)\, du \int_{-1}^{+1} \frac{1}{\sqrt{1 - z^2}} \exp\left\{-\frac{1}{2\sigma^2}(u\bar{v}_2 - cz)^2\right\} dz \qquad (22)$$

And now putting

$$\bar{v}_2/\sigma = p\ ;\quad \bar{v}_2/c = r\ ;\quad c/\sigma = q = p/r$$

and for convenience changing the variables of integration we have

$$\int_1^{\infty} (y - 1)\, dy \int_{-1}^{+1} \frac{1}{\sqrt{1 - x^2}} \exp\left\{-\tfrac{1}{2}(yp - qx)\right\} dx = \frac{\pi\sqrt{2\pi}}{Rg\,p} \quad .. \quad .. \quad (23)$$

The solution of this equation is of the form

$$F\,(p, q) = Rg \quad .. \quad .. \quad .. \quad (24)$$

and therefore is the solution of our problem, since for given Rg we obtain p as a function of q or vice versa.

Equation (13) gives one limiting case of this equation, that is when $c = 0$. The other limiting case, when $\sigma = 0$ follows at once from equation (17), giving

$$\bar{v}_2 = \frac{Rg}{\pi} \int_{\bar{v}_2}^{+c} \frac{(x - \bar{v}_2)}{\sqrt{c^2 - x^2}}\, dx \quad .. \quad (25)$$

which leads to

$$r + \frac{Rgr}{2} - \frac{Rgr}{\pi} \sin^{-1} r - \frac{Rg}{\pi}\sqrt{1 - r^2} = 0 \quad .. \quad .. \quad (26)$$

For the particular value of $Rg = 2$, this gives $r = 0.33$, that is

$$\bar{v}_2 = 0.33c \quad .. \quad .. \quad .. \quad (27)$$

4 (c). *The Solution for Small Values of q.*

For small values of q we may expand the integrand in powers of q, the analytical processes of expansion and integration term by term being easily justified.

We have then

$$\frac{\pi\sqrt{2\pi}}{Rgp} = \int_1^{\infty} (y - 1)\, dy \int_{-1}^{+1} \frac{1}{\sqrt{1 - \pi^2}} (1 + q^2 a_2 + q^4 a_4 + \ldots) \exp\left(-\frac{y^2 p^2}{2}\right) dx$$

where $\quad .. \quad .. \quad (28)$

$$\left.\begin{aligned} a_2 &= -\frac{x^2}{2} + \frac{p^2 x^2 y^2}{2} \\ a_4 &= \frac{x^4}{8} - \frac{p^2 x^4 y^2}{4} + \frac{p^4 x^4 y^4}{24} \\ a_6 &= -\frac{x^6}{48} + \frac{p^2 x^6 y^2}{16} - \frac{p^4 x^6 y^4}{48} + \frac{p^6 x^6 y^6}{720} \\ a_8 &= \frac{x^8}{384} - \frac{p^2 x^8 y^2}{96} + \frac{p^4 x^8 y^4}{192} - \frac{p^6 x^8 y^6}{1440} + \frac{p^8 x^8 y^8}{40{,}320} \end{aligned}\right\} (29)$$

etc.

The odd powers of q vanish on integration with respect to x so are not calculated. It follows that

$$\frac{\pi\sqrt{2\pi}}{Rgp} = I_0 + q^2 I_2 + q^4 I_4 + q^6 I_6 + \ldots \quad .. \quad .. \quad (30)$$

where

$$\left.\begin{aligned}
I_0 &= \pi \int_1^\infty (y-1)\exp(-\tfrac{1}{2}p^2y^2)\,dy \\
I_2 &= \frac{\pi}{4}\int_1^\infty (y-1)(-1+p^2y^2)\exp(-\tfrac{1}{2}p^2y^2)\,dy \\
I_4 &= \frac{\pi}{64}\int_1^\infty (y-1)(3-6p^2y^2+p^4y^4)\exp(-\tfrac{1}{2}p^2y^2)\,dy \\
I_6 &= \frac{\pi}{2304}\int_1^\infty (y-1)(-15+45p^2y^2-15p^4y^4+p^6y^6)\exp(-\tfrac{1}{2}p^2y^2)\,dy
\end{aligned}\right\} \quad (31)$$

etc.

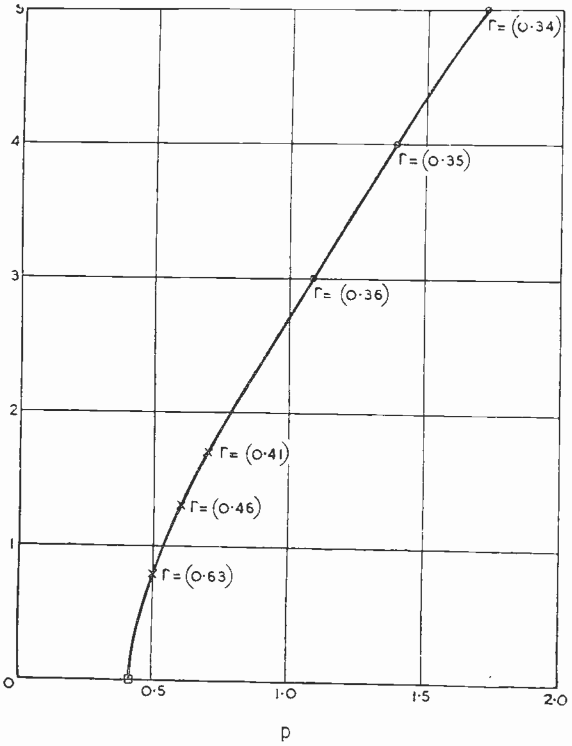

Fig. 5.

Now, if we put

$$l_n = \int_1^\infty y^n \exp(-\tfrac{1}{2}p^2y^2)\,dy \qquad .. \quad (32)$$

and use the identity

$$\int_1^\infty y^{n+2}\exp(-\tfrac{1}{2}p^2y^2)\,dy = \frac{n+1}{p^2}\int_1^\infty y^n \exp(-\tfrac{1}{2}p^2y^2)\,dy + \frac{1}{p^2}\exp\left(-\frac{p^2}{2}\right) \qquad .. \quad .. \quad (33)$$

we find

$$\left.\begin{aligned}
I_0 &= \pi(l_1 - l_0) \\
I_2 &= \frac{\pi}{4}(l_1) \\
I_4 &= \frac{\pi}{16}(p^2l_1 - l_1) \\
I_6 &= \frac{\pi}{2304}(p^4l_1 - 6p^2l_1 + 3l_1) \\
I_8 &= \frac{\pi}{147{,}456}(p^6l_1 - 13p^4l_1 + 45p^2l_1 - 15\,l_1)
\end{aligned}\right\} \quad (34)$$

etc.,

where

$$l_0 = \frac{1}{p}\sqrt{\frac{\pi}{2}}\left\{1 - \operatorname{erf}\left(\frac{p}{\sqrt{2}}\right)\right\} \qquad .. \quad (35)$$

$$l_1 = \frac{1}{p^2}\exp\left(-\frac{p^2}{2}\right) \qquad .. \quad .. \quad (36)$$

$$\operatorname{erf}(x) = \frac{2}{\sqrt{\pi}}\int_0^x \exp\{-\eta^2\}\,d\eta \qquad .. \quad (37)$$

It follows at once that

$$1 + \tfrac{1}{4}q^2 + \theta_4q^4 + \theta_6q^6 + \theta_8q^8 + \ldots = \frac{p\sqrt{2}}{\phi\left(\frac{p}{\sqrt{2}}\right)}\left\{\frac{2}{Rg} + 1 - \operatorname{erf}\left(\frac{p}{\sqrt{2}}\right)\right\} \quad (38)$$

where

$$\left.\begin{aligned}
\theta_4 &= \frac{p^2-1}{64} \\
\theta_6 &= \frac{p^4 - 6p^2 + 3}{2304} \\
\theta_8 &= \frac{p^6 - 15p^4 + 45p^2 - 15}{147{,}456} \\
\phi(x) &= \frac{2}{\sqrt{\pi}}\exp(-x^2)
\end{aligned}\right\} \quad (39)$$

For a given value of p equation (38) becomes a power series in q with constant coefficients. It is easy to obtain sufficiently approximate values of q satisfying this for values of p less than 0.8. The values obtained for $Rg = 2$ are shown in Table I.

TABLE I.

p	q	r
0.5	0.8	0.625
0.6	1.3	0.460
0.7	1.7	0.412

These values are shown plotted as crosses in Fig. 5. Unfortunately for larger values of p the series in equation (38) converges slowly and although it is easy to obtain other terms in the series the labour of calculating increases rapidly with increasing p. For large values of q it therefore becomes necessary to develop another expansion.

4 (d). *The Solution for Large Values of q.*

As before, we have

$$\frac{\pi\sqrt{2\pi}}{Rgp} = \int_{1}^{\infty}(y-1)\,dy\int_{-1}^{+1}\frac{1}{\sqrt{1-p^2}}\exp\left\{-\frac{q^2}{2}(yr-x)^2\right\}dx \qquad (23)$$

For large values of q, the main contribution to the integral will come from small values of $(yr-x)$. We therefore make the transformation

$$\left.\begin{aligned} ry - x &= s \\ x &= t \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad (40)$$

and seek a solution for small values of s.

We have

$$\begin{aligned}\frac{\pi\sqrt{2\pi}}{Rgp} &= \frac{1}{r^2}\int_{(r-1)}^{(r+1)}(s+t+r)\,ds\int_{r-s}^{+1}\frac{1}{\sqrt{1-t^2}}\exp\left(-\frac{q^2s^2}{2}\right)dt \\ &\quad + \frac{1}{r^2}\int_{(1+r)}^{\infty}(s+t-r)\,ds\int_{-1}^{+1}\frac{1}{\sqrt{1-t^2}}\exp\left(-\frac{q^2s^2}{2}\right)dt \qquad \ldots \quad (41)\end{aligned}$$

whence

$$\left.\begin{aligned}\frac{r^2\pi\sqrt{2\pi}}{Rgp} &= \pi\int_{1+r}^{\infty}(s-r)\exp\left(-\frac{q^2s^2}{2}\right)ds \\ &\quad + \int_{r-1}^{r+1}(s-1)\left\{\frac{\pi}{2}-\sin^{-1}(r-s)\right\}\exp\left(-\frac{q^2s^2}{2}\right)ds \\ &\quad + \int_{r-1}^{+}\sqrt{1-(r-s)^2}\exp\left(-\frac{q^2s^2}{2}\right)ds\end{aligned}\right\} \quad (42)$$

If we put $\dfrac{qs}{\sqrt{2}} = \phi$ and use the expansion

$$\sqrt{1-x^2} + x\sin^{-1}x = 1 + \tfrac{1}{2}x^2 + \frac{1}{24}x^4 + \frac{1}{80}x^6 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (43)$$

we obtain

$$\left.\begin{aligned}\frac{r^2\pi\sqrt{2\pi}}{Rgp} &= \pi\left(\frac{\sqrt{2}}{q}\right)\int_{\beta}^{\infty}\phi\exp(-\phi^2)\,d\phi \\ &\quad - \pi\frac{\sqrt{2}}{q}r\int_{\beta}^{\infty}\exp(-\phi^2)\,d\phi \\ &\quad - b_0\frac{\sqrt{2}}{q}\left(R_0-\frac{\pi r}{2}\right) \\ &\quad + b_1\left(\frac{\sqrt{2}}{q}\right)^2(R_1+\pi/2) \\ &\quad - b_2\left(\frac{\sqrt{2}}{q}\right)^3R_2 + b_3\left(\frac{\sqrt{2}}{q}\right)^4R_3 \\ &\quad - b_4\left(\frac{\sqrt{2}}{q}\right)^5R_4 + \ldots\ldots\end{aligned}\right\} (44)$$

where

$$b_n = \int_{\alpha}^{\beta}\phi^n\exp\{-\phi^2\}\,d\phi;\quad \alpha = \frac{q(r-1)}{\sqrt{2}};$$

$$\beta = \frac{q(r+1)}{\sqrt{2}} \qquad \ldots \quad \ldots \quad (45)$$

and

$$\left.\begin{aligned} R_0 &= 1 + \tfrac{1}{2}r^2 + \tfrac{1}{24}r^4 + \tfrac{1}{80}r^6 \\ R_1 &= r + \tfrac{1}{6}r^3 + \tfrac{3}{40}r^5 + \ldots \\ R_2 &= \tfrac{1}{2} + \tfrac{1}{4}r^2 + \tfrac{3}{16}r^4 + \ldots \\ R_3 &= \tfrac{1}{6}r + \tfrac{1}{4}r^3 + \ldots \end{aligned}\right\} \quad (46)$$

In the expansion of the third integral on the right-hand side of equation (42) we have retained powers of s up to the fourth. It is quite easy to use the higher terms to obtain solutions for smaller values of q, but this approximation is sufficient for our purpose.

We now use the identity

$$b_{n+2} = \frac{n+1}{2}b_n - \tfrac{1}{2}(\beta^{n+1}\exp\{-\beta^2\} - \alpha^{n+1}\exp\{-\alpha^2\}) \quad \ldots \quad \ldots \quad (47)$$

and the approximation (valid for large positive values of y)

$$\int_{y}^{\infty}\exp(-x^2)\,dx = \frac{1}{2y}\left\{1 - \frac{1}{2y^2} + \frac{1.3}{(2y^2)^2} - \ldots\right\}\exp(-y^2) \quad \ldots \quad \ldots \quad (48)$$

It should be noted that for large values of q, r will be less than unity so that α will be negative. It is easily seen that

$$b_0 = \sqrt{\pi} + \left(\frac{1}{2\alpha} - \frac{1}{4\alpha^3}\right) \exp(-\alpha^2) - \left(\frac{1}{2\beta} - \frac{1}{4\beta^3}\right) \exp(-\beta^2) \qquad \ldots \ldots \quad (49)$$

All the terms involving the exponential will be small compared with unity so that the large terms on the right-hand side of equation (44) come from b_0.

We obtain

$$\left.\begin{aligned} &\frac{\sqrt{2\pi}}{r}\left[R_0 + \frac{1}{q^2}R_2 + \frac{3}{q^4}R_4 + \ldots\right] \\ &+ \frac{1}{r}\cdot\frac{1}{q}\exp\left\{-\frac{q^2(r-1)^2}{2}\right\}\left[-\frac{\pi}{2}\frac{1}{(r-1)}\right. \\ &\qquad \left. + \frac{R_0}{(r-1)} - R_1 + R_2(r-1) - \ldots\right] \\ &+ \frac{1}{r}\cdot\frac{1}{q}\exp\left\{-\frac{q^2(r+1)^2}{2}\right\}\left[-\frac{\pi}{2}\cdot\frac{(2r+1)}{2(r+1)}\right. \\ &\qquad \left. - \frac{R_0}{(r+1)} + R_1 - R_2(r+1) + \ldots\right] \\ &= \sqrt{2\pi}\left[\frac{\pi}{Rg} + \frac{\pi}{2}\right] \end{aligned}\right\} (50)$$

The higher order terms on the left-hand side of equation (50) are easy to obtain by retaining additional terms in equation (44) and will be of the form

$$\frac{1}{r}\cdot\frac{1}{q^n}\exp\left\{-\frac{q^2}{2}(r-1)^2\right\}F_n(r, R_0, R_1 \ldots)$$

and

$$\frac{1}{r}\cdot\frac{1}{q^n}\exp\left\{-\frac{q^2}{2}(r+1)^2\right\}G_n(r, R_0, R_1 \ldots) \qquad \ldots \ldots \quad (51)$$

The approximation in equation (50) gives sufficiently accurate results for values of q not less than 3. For given Rg the right-hand side of equation (50) is a constant and the equation is of the form

$$F(r, q) = \text{constant} \qquad \ldots \ldots \quad (52)$$

For given q it is therefore a straightforward process to obtain the corresponding value of r and therefore of p. The results are given in Table II. These values are plotted as circles in Fig. 5. The curve passes through the point $q = 0$, $p = 0.42$ from equation (15). The values of r corresponding to the various values of p and q are plotted along the curve, and for large values of p and q the value of r becomes asymptotically equal to 0.33 from equation (27).

TABLE II.

q	r	p
5	0.34	1.72
4	0.35	1.39
3	0.36	1.09

It is clear from Fig. 5 that if $(\bar{v}_2)_a$ is the output reading due to a noise input of R.M.S. value σ with no signal and $(\bar{v}_2)_b$ is the output due to a noise input with R.M.S. value σ plus a sinusoidal signal with R.M.S. value $c/\sqrt{2}$ equal to σ, then $q = \sqrt{2}$ and $p = 0.63$. Thus

$$(\bar{v}_2)_b/(\bar{v}_2)_a = 1.5$$

and the error involved in assuming that the response of the linear rectifier to signal plus noise is increased by a factor $\sqrt{2}$ over that due to the noise alone (as in the case of a thermo-junction) is about 6 per cent. or 0.5 db.

This figure is of course true only when the input R.M.S. noise is equal to the input R.M.S. signal. For larger ratios of signal/noise input the corresponding error is larger, for example if the input signal power is twice the noise input power the error becomes 0.6 db.

5. Formula for Noise-Modulated Carrier working on Exponential Part of Diode Characteristic

In the circuit of Fig. 1 the capacitor is assumed so large that the voltage $\bar{v}_2$ across R is substantially constant and equal to $\bar{v}_2$. The characteristic of the diode now is taken to be :—

$$i = A \exp\{b(v_1 - \bar{v}_2)\} \qquad \ldots \ldots \quad (53)$$

where

$$\left.\begin{aligned} A &= 10^{-4} \text{ amperes} \\ b &= 10 \text{ (volts)}^{-1} \end{aligned}\right\} \qquad \ldots \ldots \quad (54)$$

This characteristic can be assumed to hold up to about 100 μA. Between some 100 μA and 200 μA there is a gradual change-over from the exponential characteristic to the linear or three-halves power law.

Now, as in Section 4, if the input voltage consists of a sinusoidal signal with amplitude c and frequency $\omega/2\pi$ together with noise whose amplitude distribution is given by

$$W(v_1) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left\{-\frac{{v_1}^2}{2\sigma^2}\right\} \quad .. \quad (55)$$

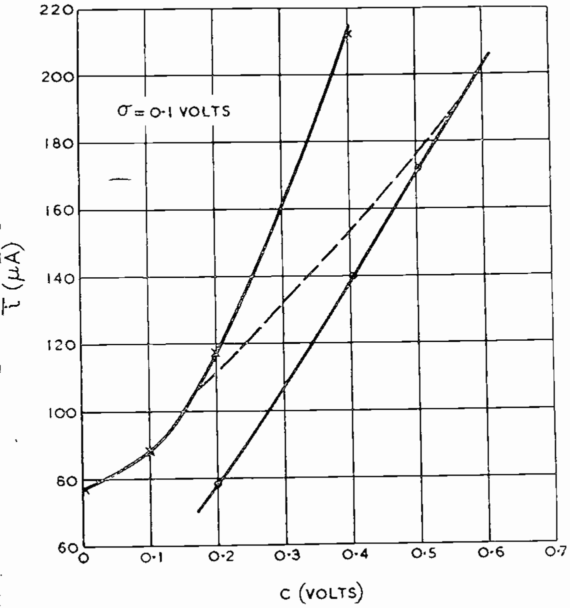

Fig. 6.

we have

$$\bar{\imath} = \frac{1}{\pi\sigma\sqrt{2\pi}} \int_{-\infty}^{+\infty} A \exp\{b(v_1 - \bar{v}_2)\}\, dv_1$$

$$\int_{-1}^{+1} \frac{1}{\sqrt{1 - y^2}} \exp\left\{-\frac{(v_1 - cy)^2}{2\sigma^2}\right\} dy \quad .. \quad .. \quad (56)$$

Here, in view of the fact that we have used $+\infty$ for the upper limit of v_1, we assume that either the exponential characteristic holds for all values of v_1, or that the input voltage is limited in value to the exponential part of the characteristic. Neither assumption is, in fact, true; so long as the input involves noise with the distribution (55), theoretically infinite amplitudes will occur, but so long as the mean diode current is less than that at which the exponential characteristic ceases to be valid, it may be safely assumed that the high amplitude noise peaks occur sufficiently rarely to allow (56) to be a good approximation.

From (56) it follows that :

$$\bar{\imath} = \bar{v}_2/R$$

$$= \frac{1}{\pi\sigma\sqrt{2\pi}} \int_{-\infty}^{+\infty} A \exp\{b(v_1 - \bar{v}_2)\} dv_1 \int_{-1}^{+1} \frac{1}{\sqrt{1 - y^2}} \exp\left\{-\frac{(v_1 - cy)^2}{2\sigma^2}\right\} dy \quad .. \quad .. \quad (57)$$

From which, by reversing the order of integration, we obtain

$$\bar{v}_2 \exp(b - \bar{v}_2) = RA \exp(\tfrac{1}{2}\sigma^2 b^2)\, J(jbc) \quad .. \quad .. \quad (58)$$

with the usual Bessel Function Notation.

5 (a). *The Solution for Small Values of the Load Resistance.*

If R is small, then σ and c must be small in order that the diode may operate on the exponential part of its characteristic.

The results cannot be conveniently plotted in the form of a relation between p and q as was done in Section 4, since the relation between p and q for the exponential case is not independent of σ so that for each value of σ there is a different $p - q$ curve. This method of plotting the results therefore loses its usefulness. In Figs. 6, 7 and 8 are plotted as crosses results from equation (58) with $R = 1000$ ohms connecting $\bar{\imath}$ and c. The curves in these figures with circles are

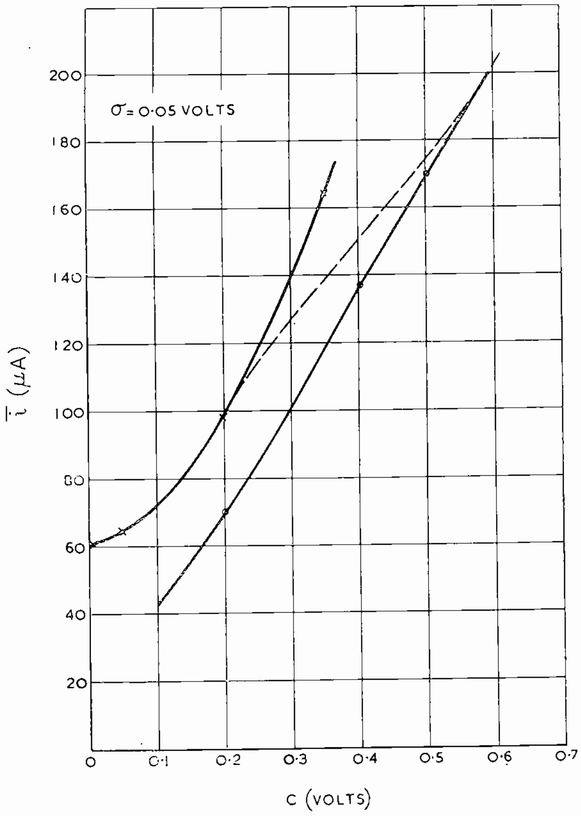

Fig. 7.

the results obtained for the various values of σ assuming the linear diode characteristic and the formulae derived in Section 4. From somewhere below 150 μA on the exponential-diode curve a transition to the linear diode curve takes place, the line joining the latter somewhere above 150 μA. Dotted lines are drawn suggesting a possible transition characteristic, although it is likely that those shown are not sufficiently gradual.

These results show that, with a small load resistance, measurement of noise of small amplitude using the exponential part of the diode characteristic is not practicable. For values of σ between about 0.1 volt and 1 volt the transition part of the characteristic and the linear part are mainly involved and this range requires additional analysis although it is certain that the same difficulties which are mentioned below for smaller values of σ will occur for this range also. Thus if the exponential part of the characteristic is to be used, we are restricted to values of σ less than 0.1 volt. Further, since σ is not known, and in fact is the quantity to be measured, it is necessary to find the range over which the output is dependent on c but substantially independent of σ.

A method often used with the linear diode is to increase c until $\bar{\imath}$ is doubled, and then assume (as in the case of a thermo-junction) that the R.M.S. value of the signal is equal to the R.M.S. value of the noise. That is certainly not the case here as Table III shows.

TABLE III.

σ	$\bar{\imath}$ (μA) ($c = 0$)	c_1	$\frac{c_1}{\sigma}$
0.1	77	0.40	4.0
0.05	60	0.27	5.4
0.01	57	0.28	30.0 (approx.)

In the second column of Table III the value of $\bar{\imath}$ with noise alone is given and in the third column c_1 (the value of c which doubles the current). It is seen that the ratio c_1/σ is by no means constant and for small values of σ the increase is extremely rapid. In addition to this, these values involve the use of the transition part of the characteristic which is not known at all accurately.

The fact that with the exponential characteristic the rectified output current bears little direct relation to the R.M.S. input with a noise modulated signal means that it is necessary to be certain that the noise amplitude is large enough to make the exponential part of the characteristic unimportant when making noise measurements with a diode.

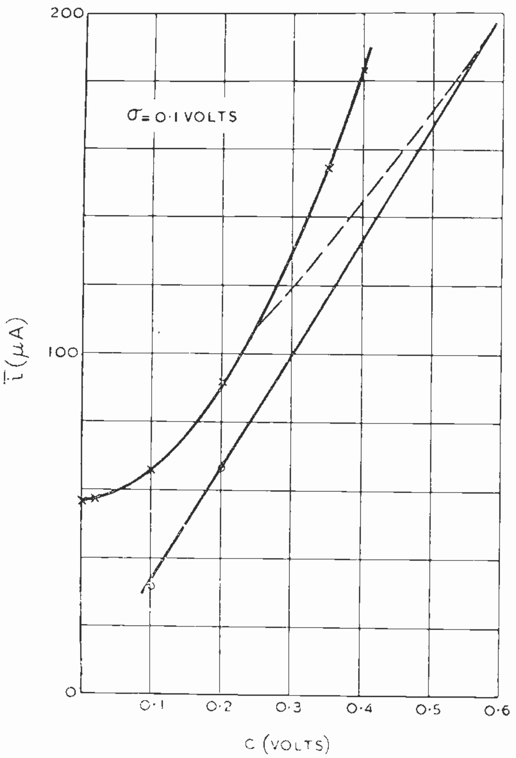

Fig. 8.

5 (b). *The Solution for Large Values of the Load Resistance*

If the load resistance is large compared with the diode impedance, larger values of the input voltage are necessary in order to obtain an appreciable rectified output current. For values of σ and c greater than about 1 volt an approximate analytical solution of Equation (58) can be obtained. Using the asymptotic approximation for $J(jbc)$

$$J(jbc) \doteqdot \frac{\exp(jbc)}{\sqrt{2\pi jbc}} \qquad \ldots \quad \ldots \quad (59)$$

which involves not more than 1 per cent. error if $bc > 10$; we have

$$b\bar{v}_2 \exp(b\bar{v}_2 - \tfrac{1}{2}\sigma^2 b^2 - bc) - \frac{bRA}{\sqrt{2\pi bc}} = 0 \qquad \ldots \quad \ldots \quad (60)$$

Now, if we take for example $R = 10^6$ ohms, since $b\bar{v}_2$ will be $\simeq 50$ and the second term in equation (60) will be of the order of 100, a variation in $b\bar{v}_2 - \frac{1}{2}\sigma^2 b^2 - bc$ of one or two units will always be sufficient to change the sign of the left-hand side of equation (60). But this will be only 1 per cent. or 2 per cent. in the value of $b\bar{v}_2$; so that an approximate solution of equation (60) is

$$b\bar{v}_2 = \tfrac{1}{2}\sigma^2 b^2 + bc \qquad \ldots \qquad \ldots \qquad (61)$$

that is

$$\bar{i} = 5\sigma^2 + c \qquad \ldots \qquad \ldots \qquad \ldots \qquad (62)$$

in microamperes, if $R = 10^6$ ohms.

The results derived in this case seem to be even less applicable to the measurement of noise than is the case for a small R. Curves are shown in Fig. 9 for $\sigma = 4$. Again the crosses refer to the exponential characteristic and the circles to the linear characteristic, the dotted curve being a possible transition from one to the other. A point of interest and one of the reasons why noise measurements cannot easily be made by this method is the large ratio c/σ required before the magnitude of the rectified output current is appreciably altered. This is due to the fact that the large R gives great weight to the effect of the large amplitude noise peaks and for this reason any limitation of amplitude due to saturation in the amplification of the noise will make calculations for large R inaccurate.

5 (c). *Very Small Values of the Load Resistance*

When σ is of the order of 1 mV it might be possible to work with R considerably less than 1,000 ohms. The transition region in this way can be avoided by keeping $\bar{i}$ down to the order of 50 μA and the value of c/σ for a given increase of $\bar{i}$ can be made more nearly independent of σ. The actual values for such a case are not worked out here, but there may in some cases be a practical value in measurements made in this way. Values are readily obtainable from equation (58).

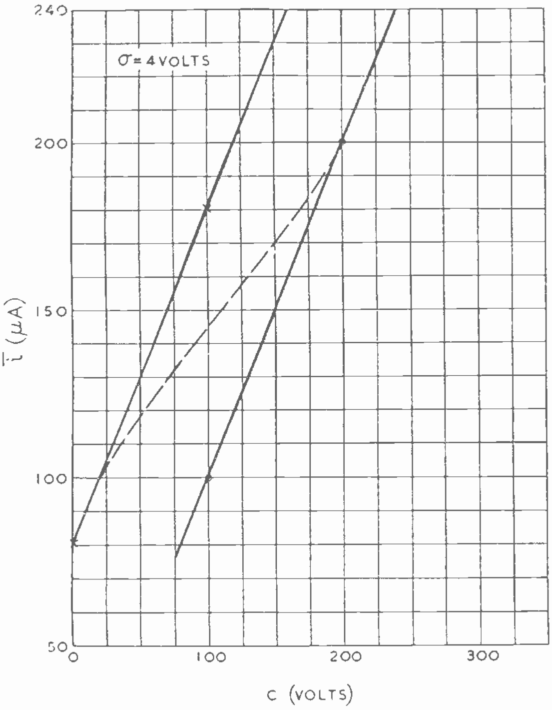

Fig. 9.

In conclusion we wish to tender our acknowledgments to The General Electric Co., Ltd. and The Marconiphone Co., Ltd. on whose behalf the work which has led to this publication was carried out.

REFERENCES

[1] See for example S. O. Rice, *Bell S. Tech. Journ.*, Vol. 23, July, 1944.
[2] W. R. Bennett, *Bell S. Tech. Journ.*, Vol. 23, p. 97, 1944

FILTER DESIGN TABLES BASED ON PREFERRED NUMBERS*

Low-pass Filters

By H. Jefferson, B.A., A.M.I.E.E., A.Inst.P.

IN another paper† the author has discussed the application of preferred numbers to filter design. It was shown in this paper that if the final design was to involve the use of preferred values of capacitance, a logical design method followed when preferred impedance and cut-off frequency were specified. The use of preferred impedance values is also desirable if commercially available resistors are to form the terminations. The tables which follow enable the values of capacitance and inductance to be read off directly for any impedance and cut-off frequency. The errors involved in the use of these tables are those discussed in the previous paper, and are less than the error introduced by normal commercial tolerances. The tables given here cover the design of constant-*k* low-pass filters.

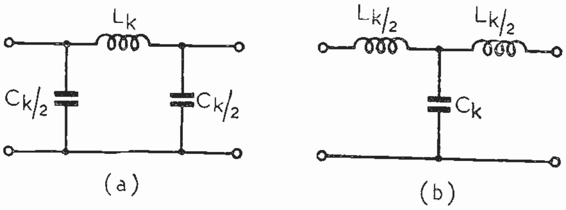

Fig. 1. *π- and T-filter sections.*

The tables give the values of the usual ladder network elements. When only single sections are used, the actual principal element values are those shown in Fig. 1, where L_k and C_k are the values given by the tables, and are approximations to

$$L_k = R/\pi f_c \quad \text{and} \quad C_k = 1/\pi f_c R$$

where R is the design impedance and f_c is the cut-off frequency.

It was shown in the earlier paper that preferred values for $X/2$ exist for all preferred values of X, and for convenience these are listed below.

The tables are in pairs, each pair being used to determine the value of one element of the filter. The first table of each pair is of coarse mesh, in half-decade (logarithmic) steps. From this the order of magnitude of the capacitance or inductance is found by examination of the values which border it. The second table covers only one decade and enables the significant figures to be found.

As an example of the use of the tables, let us consider a low-pass filter of 620 ohms impedance and 5,100 c/s cut-off frequency. From Table I, the capacitance is in the square bounded by 0.33 μF, 0.1 μF, 0.033 μF and 0.1 μF. From Table III the inductance is in the square bounded by 33 mH, 10 mH, 33 mH and 0.1 H. Table II gives the significant figures for the capacitance as 10, so that the actual value of capacitance is 0.10 μF. Table IV gives the significant figures for the inductance as 39, so that the actual inductance value is 39 mH. An exact computation gives $L_k = 38.4$ mH and $C_k = 0.1004\,\mu$F, so that the error is less than 2 per cent. The physical form of a single section is shown in Fig. 2.

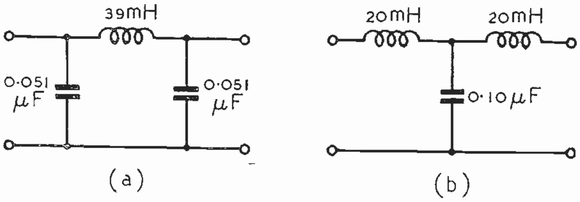

Fig. 2. *The component values of the example discussed in the text are marked on these π- and T-sections.*

PREFERRED VALUES OF $X/2$ FOR PREFERRED VALUES OF X.

X	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	100
$\frac{X}{2}$	5.1	5.6	6.2	6.8	7.5	8.2	9.1	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51

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* MS. accepted by the Editor, July 1945.

† "Preferred Numbers and Filter Design": *Wireless Engineer*, October 1945.

TABLE I

CAPACITANCE C_k OF LOW-PASS FILTER

DESIGN IMPEDANCE (OHMS)

CUT-OFF FREQUENCY	1	3.3	10	33	100	330	1 000	3 300	10 000	33 000	100 000	330 000
1	3.3×10^{5}	1×10^{5}	3.3×10^{4}	1×10^{4}	3.3×10^{3}	1×10^{3}	330	100	33	10	3.3	1.0
3.3	1×10^{5}	3.3×10^{4}	1×10^{4}	3.3×10^{3}	1×10^{3}	330	100	33	10	3.3	1.0	0.33
10	3.3×10^{4}	1×10^{4}	3.3×10^{3}	1×10^{3}	330	100	33	10	3.3	1.0	0.33	0.1
33	1×10^{4}	3.3×10^{3}	1×10^{3}	330	100	33	10	3.3	1.0	0.33	0.1	3.3×10^{-2}
100	3.3×10^{3}	1×10^{3}	330	100	33	10	3.3	1.0	0.33	0.1	3.3×10^{-2}	1×10^{-2}
330	1×10^{3}	330	100	33	10	3.3	1.0	0.33	0.1	3.3×10^{-2}	1×10^{-2}	3.3×10^{-3}
1 000	330	100	33	10	3.3	1.0	0.33	0.1	3.3×10^{-2}	1×10^{-2}	3.3×10^{-3}	1×10^{-3}
3 300	100	33	10	3.3	1.0	0.33	0.1	3.3×10^{-2}	1×10^{-2}	3.3×10^{-3}	1×10^{-3}	330
10 000	33	10	3.3	1.0	0.33	0.1	3.3×10^{-2}	1×10^{-2}	3.3×10^{-3}	1×10^{-3}	330	100
33 000	10	3.3	1.0	0.33	0.1	3.3×10^{-2}	1×10^{-2}	3.3×10^{-3}	1×10^{-3}	330	100	33
100 000	3.3	1.0	0.33	0.1	3.3×10^{-2}	1×10^{-2}	3.3×10^{-3}	1×10^{-3}	330	100	33	10
330 000	1.0	0.33	0.1	3.3×10^{-2}	1×10^{-2}	3.3×10^{-3}	1×10^{-3}	330	100	33	10	3.3
c/s	μF							$\mu\mu$F				
M/cs	$\mu\mu$F							$\mu\mu\mu$F				

TABLE II

SIGNIFICANT FIGURES FOR C_k OF LOW-PASS FILTER

DESIGN IMPEDANCE

CUT-OFF FREQUENCY	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10
10	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33
11	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	65	62	56	51	47	43	39	36	33	30
12	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27
13	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24
15	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22
16	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20
18	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18
20	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16
22	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15
24	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13
27	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12
30	11	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11
33	10	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10
36	91	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91
39	82	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82
43	75	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75
47	68	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68
51	62	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62
56	56	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56
62	51	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51
68	47	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47
75	43	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43
82	39	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39
91	36	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36
10	33	30	27	24	22	20	18	16	15	13	12	11	10	91	82	75	68	62	56	51	47	43	39	36	33

TABLE III

INDUCTANCE L_k OF LOW-PASS FILTER

CUT-OFF FREQUENCY	DESIGN IMPEDANCE (OHMS)											
	1	3.3	10	33	100	330	1000	3300	10 000	33 000	100 000	330 000
1	0.33	1.0	3.3	10	33	100	330	1000	3300	10 000	33 000	100 000
3.3	0.10	0.33	1.0	3.3	10	33	100	330	1000	3300	10 000	33 000
10	33	0.10	0.33	1.0	3.3	10	33	100	330	1000	3300	10 000
33	10	33	0.10	0.33	1.0	3.3	10	33	100	330	1000	3300
100	3.3	10	33	0.10	0.33	1.0	3.3	10	33	100	330	1000
330	1.0	3.3	10	33	0.10	0.33	1.0	3.3	10	33	100	330
1000	0.33	1.0	3.3	10	33	0.10	0.33	1.0	3.3	10	33	100
3300	0.10	0.33	1.0	3.3	10	33	0.10	0.33	1.0	3.3	10	33
10 000	33	0.10	0.33	1.0	3.3	10	33	0.10	0.33	1.0	3.3	10
33 000	10	33	0.10	0.33	1.0	3.3	10	33	0.10	0.33	1.0	3.3
100 000	3.3	10	33	0.10	0.33	1.0	3.3	10	33	0.10	0.33	10
330 000	1.0	3.3	10	33	0.10	0.33	1.0	3.3	10	33	0.10	0.33
c/s	μH				mH						H	
kc/s	μH×10⁻³				μH						mH	
Mc/s	μμH				μH×10⁻³						μH	

TABLE IV

SIGNIFICANT FIGURES FOR L_k OF LOW-PASS FILTER

CUT-OFF FREQUENCY	DESIGN IMPEDANCE																								
	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10
10	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33
11	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30
12	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27
13	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24
15	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22
16	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20
18	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18
20	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16
22	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15
24	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13
27	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12
30	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10	11
33	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	10
36	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91
39	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82
43	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75
47	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68
51	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62
56	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56
62	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51
68	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47
75	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43
82	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39
91	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33	36
10	33	36	39	43	47	51	56	62	68	75	82	91	10	11	12	13	15	16	18	20	22	24	27	30	33

CORRESPONDENCE

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

Diode Input Resistance

To the Editor, "Wireless Engineer."

SIR,—In the October 1941 issue of *Wireless Engineer* you published a paper by D. A. Bell on the "Diode as Rectifier and Frequency-Changer," and I should like to make two comments on it.

Equation (14) for the shunt input resistance can be simplified to

$$\rho_0 = \frac{2\pi R_a}{\alpha - \sin\alpha}$$

using

$$\frac{R}{R_a} = \frac{\pi}{\tan\alpha/2 - \alpha/2}$$

These results for the linear detector had been derived some years previously by F. M. Colebrook.*

The "peculiar kinks" in Figs. 10, 11 and 12 are due to computational errors, since an accurate evaluation of the quantities graphed shows that they vary smoothly over the range of R_a/R from 0.5 to 0.9.

R. E. BURGESS,
Radio Division, N.P.L.

Pulse Modulation

To the Editor, "Wireless Engineer."

SIR,—The article by Roberts and Simmonds in your November issue dealing with the use of modulated pulses in communication systems can be expected to foreshadow the publication of further information regarding this comparatively new technique. Recently disclosed details of the Army's Wireless Set No. 10 reveal that pulse multiplex has already been put to useful effect, and there is now no doubt a wealth of knowledge available in various quarters, which having accumulated during the war years, is likely to be released in technical publications.

With the expectation of further contributions in the near future, and bearing in mind the greater variety of possible modulating systems resultant upon the use of discrete pulses, there is a need and opportunity for early rationalisation of nomenclature so as to avoid a potential source of confusion, which the writer knows all too well is apt to fog clarity of exposition and discussion in this field.

Doubtless several types of pulse modulation will emerge for discussion in the future, but since one may reasonably expect them to be related to the basic types described by Roberts and Simmonds, it is pertinent to examine critically the names with which they have been christened in this paper.

In the main the authors' choice appears to be a judicious one, and no one is likely to quarrel with their usage of the terms "pulse amplitude modulation" or "pulse frequency modulation," but it may be argued there is a case to prefer "pulse length modulation" to "pulse width modulation," since pulse length has a more precise meaning than pulse width when expressed in units of time, as well as being in conformity with current parlance in the U.S.A. and other quarters.

The term "pulse delay modulation" does, however, appear to be open to criticism on the grounds that the pulses convey the information by advancement in mean time of occurrence as well as by delay in mean time of occurrence. It is suggested that pulse phase modulation (PPM) is a more exact description, since the modulation, whether in advance or retard of the normal instant of occurrence is applied as a variation in the phase of occurrence of a recurrent wave form. Furthermore, the term then comes into line with the accepted description of a similar form of modulation when applied to a steady carrier, namely "phase modulation."

The authors draw a distinction between pulse frequency modulation and pulse number modulation. The reason for the distinction is not immediately clear, since the frequency of recurrence of a pulse train means precisely the number of pulses occurring per second, unless perhaps a system is envisaged in which modulation is accomplished by suppression or insertion of pulses in a recurrent pulse train. Such a system would not appear to be able to deal faithfully with a continuously varying modulating waveform.

It is highly probable that further comparisons will be drawn between pulse multiplex systems and carrier multiplex systems, and once again it would be useful if the same terminology could be used in future discussion. In referring to the two systems as "time allocation multiplex" and "frequency allocation multiplex" respectively, the authors have coined two terms which, at the same time as providing a nutshell description of the technique, also draw a basic distinction between them. One feels that these terms could be perpetuated with advantage.

D. COOKE.
Signals Research and Development
Establishment, Ministry of Supply.

The Physical Society's Exhibition

THE 30th Exhibition of Scientific Instruments and Apparatus will be held at the Imperial College of Science and Technology, Imperial Institute Road, South Kensington, London, S.W.7. It will be open for three days, 1st Jan., 2.30–9 p.m.; 2nd Jan., 4–9 p.m., and 3rd Jan., 2.30–9 p.m. Admission is by ticket only. Tickets may be obtained from the Exhibition Secretary, 1, Lowther Gardens, Exhibition Road, London, S.W.7, but members of Institutions and Scientific Societies may obtain them from their Secretaries.

In addition to the Exhibition there will be discourses; on 1st Jan., at 5.30 and 8.15 p.m., "The Optical Industry in the War," by Captain R. Martin, M.Sc.; on 2nd Jan., at the same times, "Radar," by Sir Edward Appleton, K.C.B., F.R.S.; and, on 3rd Jan., at 5.30 and 9 p.m., "Modern Plastics and Cements," by J. C. Swallow, Ph.D., B.Sc.

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* F. M. Colebrook. "The Theory of the Straight-Line Rectifier," *Wireless Engineer*, 1930, Vol. 7, pp. 595–603.

WIRELESS PATENTS

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

570 337.—Design and construction of a moving-coil microphone wherein various spaces surrounding the elements are utilised to secure an improved frequency characteristic.

Standard Telephones and Cables Ltd. and M. L. Gayford. Application date 28th September, 1943.

570 370.—Holder or casing for a piezo-electric pick-up having sufficient flexibility to accommodate crystals of slightly different sizes.

The Brush Development Co. (assignees of H. B. Shapiro). Convention date (U.S.A.) 26th March, 1942.

AERIALS AND AERIAL SYSTEMS

570 568.—Auxiliary reflector for further concentrating the beam in an aerial of the parabolic mirror type.

Cie. Generale de Telegraphie sans Fil. Convention date (France) 15th June, 1940.

570 888.—Kite or balloon aerial which is also adapted to supply lighting current to a suspended morsing or signal lamp.

International Marine Radio Co. Ltd.; H. Thorpe-Woods and D. H. Harrison. Application date 21st June, 1944.

DIRECTIONAL WIRELESS

570 038.—Directional system in which the dipole of a parabolic reflector is energised by a wave-guide feeder.

The General Electric Co. Ltd. and R. J. Clayton. Application date 7th January 1942.

570 201.—Directive system of the overlapping-beam type in which at least two directly-energised aerials are used in co-operation with side reflectors.

Standard Telephones and Cables Ltd. and L. J. Heaton-Armstrong. Application date 12th January, 1942.

570 203.—Phase-shifting devices, particularly for direction-finding, or for radiating a directable beam of energy.

H. Jefferson. Application date 4th February, 1942.

570 204.—Direction-finding system in which the analysis of Morse signals is facilitated by the use of a pair of cathode-ray indicators.

L. J. van Rooyen and W. O. Agar. Application date 4th February, 1942.

570 566.—Preventing errors, due to reflection from the different stratospheric layers, in a direction-finder of the cathode-ray type.

H. Jefferson. Application date 20th January, 1942.

570 986.—Device geared to the rotary coil of a directional aerial for indicating the bearing as a spot of light on a translucent map. (Addition to 551 376.)

J. Thorley. Application date 2nd March, 1943.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

570 008.—Frequency-converting circuit for a superheterodyne receiver in which the I.F. oscillations are maintained at constant intensity, though a variable feed-back is used to increase the selectivity of the set.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 25th September, 1942.

570 092.—Midget receiver designed to be plugged as a unit into any electric lamp-holder or wall socket.

F. M. Hills. Application date 5th November, 1943.

570 224.—Tuning device in which a "logging" scale-indicator is mounted edge on to the main scale, and is geared down to move one division for a complete rotation of the latter.

Marconi's W.T. Co. Ltd., G. L. Grisdale and H. C. Norwood. Application date 9th December, 1943.

570 390.—Wireless receiver in which the frequency sweep of a local oscillator is synchronised with the time base of a cathode-ray tube in order to indicate, at any moment, the number of stations operating within a selected frequency range.

H. Jefferson. Application date 4th February, 1942.

570 391.—Receiver for indicating and identifying the various stations that are transmitting, at any time, within a selected frequency range.

H. Jefferson. Application date 4th February, 1942.

570 392.—Oscillation generator, with a highly-sensitive frequency control, suitable for a receiver designed to indicate, at any moment, the number of short-wave stations operating within a selected frequency range.

D. J. Fewings. Application date 4th February, 1942.

570 466.—Limiting the effect of static and like impulsive "noise" by a method which differentiates between positive and negative peaks of modulation.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 5th October, 1942.

570 474.—Variable tuning device comprising an inductance coil partly covered by a metal cylinder, so that the covered windings simulate a pair of Lecher wires.

"Patelhold" Patentverwertungs & Elektro-Holding A.G. Convention date (Switzerland) 17th December, 1942.

570 478.—Demodulating F.M. signals by using suitably-terminated wave-filters, in combination with a reactance to produce the necessary quadrature-voltage.

R. O. Carter. Application date 23rd December, 1943.

570 636.—Method of precision tuning to centimetre waves by utilizing the harmonics of a stabilised piezo-electric oscillator.

Marconi's W.T. Co. Ltd. and C. P. Beanland. Application date 22nd October, 1943.

570 772.—Receiver primarily designed to receive frequency-modulated signals, but adapted to be switched over to amplitude-modulated or C.W. signals.

The Mullard Radio Valve Co. Ltd. and C. L. Richards. Application date 30th July, 1943.

570 877.—Mass production of wireless sets by spraying or electroplating over a chassis which includes the forms of certain of the component parts and also the connecting leads.

J. A. Sargrove. Application date 30th August, 1943.

571 005.—Variable tuning inductance comprising two movable and one fixed winding, the latter being of opposite polarity to the first two, for giving a linear response over a wide tuning-range.

The British Thomson-Houston Co. Ltd. (communicated by the General Electric Co.). Application date 11th October, 1943.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

571 061.—Stereoscopic television in which right and left eye pictures are respectively focused upon the correspondingly-inclined ridges of a projection screen.

F. W. MacD. Matthews. Application date 20th September, 1943.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

570 094.—Series arrangement of a hard valve and a gas-filled valve to form a switching circuit, particularly for telegraph keying on mark-and-space signals.

Marconi's W.T. Co. Ltd. and L. C. Styles. Application date 10th November, 1943.

570 136.—Coaxial transmission line in which the insulating discs are varied logarithmically, in thickness or spacing, in order to control the frequency characteristic.

The British-Thomson Houston Co. Ltd. Convention date (U.S.A.) 8th March, 1940.

570 279.—Means for measuring the percentage modulation of a signal-carrying wave by passing the latter through two rectifiers in series.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 23rd November, 1942.

570 283.—Combined radio transmitter and receiver in which a single valve serves to control the frequency both of the incoming and outgoing signals.

Communications Patents Ltd. and G. B. Ringham. Application date 1st December, 1943.

570 339.—Terminals or couplings for coaxial transmission lines, in which a graded screw thread is used to ensure a readily-locked joint.

British Insulated Cables Ltd., H. R. F. Carsten and C. H. M. Thorpe. Application date 28th September, 1943.

570 359.—Means for preventing a pair of Lecher wires that are enclosed by a screen from resonating as a coaxial line instead of as a balanced pair of conductors.

Standard Telephones and Cables Ltd. and C. N. Smyth. Application date 21st June, 1940.

570 379.—H.F. cable in which a central conductor, or a pair of spaced conductors, is enclosed in a polythene insulator on which a copper covering is deposited electrolytically.

Callender's Cables and Construction Co. Ltd., Callender-Suchy Developments Ltd., L. G. Brazier, R. McL. Fairfield and C. T. Suchy. Application date 22nd July, 1943.

570 415.—Radio signalling system with automatic dialling wherein the individual conversing frequency of a particular station is used for calling that station.

J. G. Murdoch and Co., Ltd. D. L. Clay and F. L. Hogg. Application date 4th December, 1943.

570 679.—Water-cooled valve in which a steep temperature-gradient is maintained between the anode of the valve and the cooling-liquid, in order to prevent the latter from boiling.

Standard Telephones and Cables Ltd. (assignees of C. V. Little). Convention date (U.S.A.) 5th October, 1942.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

570 488.—System for the secret transmission of speech in which selected frequency-bands are subjected to different attenuation.

"Patel Hold" Patentverwertungs & Elektro-Holding A. G. Convention date (Switzerland) 20th December, 1941.

571 214.—Duplex system of wired-wireless communication over existing telephone or power-supply lines, in which the same carrier-frequency is used both for incoming and outgoing messages.

The British Thomson-Houston Co., Ltd. Convention date (U.S.A.) 11th July, 1942.

571 279.—Generating infra-red rays for signalling purposes by using a self-extinguishing arc and a "glower" or non-ohmic resistance, such as that known under the trade-name "Insulcon."

Stupakoff Ceramic and Manufacturing Co. Convention date (U.S.A.) 19th March, 1942.

571 627.—Modulation system in which the carrier-wave is radiated in pulses of constant amplitude but of varying duration, the pulses being separated by intervals of zero radiation.

Westinghouse Electric International Co. Convention date (U.S.A.) 22nd October, 1942.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

570 213.—Construction and arrangement of the deflecting plates or electrodes in a cathode-ray tube.

O. E. H. Klemperer (commonly known as O. Klemperer). Application date 13th February, 1943.

570 468.—Cathode made in the form of a close-set cage of parallel bars, to give an increased surface of emission when indirectly heated.

Standard Telephones and Cables Ltd. (assignees of P. G. Chevigny). Convention date (U.S.A.) 8th December, 1942.

570 553.—Photo-electric cell wherein the photo-sensitive material is evaporated from the anode

on to the cathode, a movable shield screens the rest of the cell from undesired deposition.

Cinema-Television Ltd., G. A. R. Tomes and W. Blackman. Application date 5th July, 1941.

570 601.—Photo-electric cell with two sensitive electrodes each of which acts alternately as cathode and anode.

The Mullard Radio Valve Co. Ltd. and R. W. Kersey. Application date 6th September, 1943.

570 672.—Electrostatic screening to prevent interaction between the two pairs of deflecting plates in a cathode-ray tube, particularly for ultra-high frequencies.

G. Liebmann. Application date 19th August, 1943.

570 834.—Heat-expansion method of maintaining a pre-determined small clearance between the cathode and grid of a short-wave valve, say a grounded-grid triode.

G. Liebmann and Cathodeon Ltd. Application date 20th November, 1941.

SUBSIDIARY APPARATUS AND MATERIALS

569 700.—Electrode arrangement for a multiple-unit condenser of the rolled or layered type.

J. H. Cozens and The Telegraph Condenser Co., Ltd. Application date 3rd September, 1943.

569 858.—Generating periodic wave-trains at supersonic frequency, and their control for producing a stationary pattern on the screen of a C.R. tube, for detecting flaws in the structure of materials.

United Aircraft Corpn. Convention date (U.S.A.) 29th June, 1942.

569 995.—Screening arrangement for preventing radiation from the sparking plug of an internal combustion engine.

Titeflex Metal Hose Co. Convention date (U.S.A.) 9th October, 1942.

570 087.—Construction of transmission lines used as tuning elements, where it is desirable that the geometrical length should be less than the electrical length.

The General Electric Co. Ltd. and C. R. Dunham. Application date 26th May, 1943.

570 102.—Photo-electric relay, controlled by a gravity-operated screen, and serving to maintain a suspended system in a stable position.

Vickers-Armstrong Ltd., J. C. Clifton and F. W. Rabarts. Application dates 22nd February, 1943, and 18th January, 1944.

570 162.—Grid-controlled rectifier so coupled to an A.C. supply as to maintain a constant-voltage output, irrespective of fluctuations in the supply.

The British Thomson-Houston Co. Ltd., J. Moir and W. S. Graff-Baker. Application date 31st December, 1943.

570 188.—Fixed condenser constructed with inductive elements to serve as a generator of high-frequency impulses.

H. G. Solomon. Application date 9th July, 1943.

570 199.—Photo-electric cell in which a retarding electrode is provided to give the cell a logarithmic increase of sensitivity with rise of anode voltage.

W. Blackman, Cinema-Television Ltd. and G. A. R. Tomes. Application date 20th May, 1941.

570 255.—Screw-down link or terminal, as used on an accumulator, with a spring control for preventing accidental contacts.

Standard Telephones and Cables Ltd. and L. H. Webb. Application date 6th August, 1943.

570 299.—Voltage-stabilising device in which the grid of the main rectifier valve is controlled by a circuit which is shunted across the load and includes a hard valve in series with a glow-discharge tube.

The British Thomson-Houston Co. Ltd. and J. Moir. Application date 6th September, 1943.

570 346.—Method of making and processing the selenium elements used in rectifiers and photo-electric cells.

Standard Telephones and Cables Ltd. (assignees of A. J. Miller and E. P. Sauerborn). Convention date (U.S.A.) 25th November, 1942.

570 347.—Method of making a number of selenium elements in one jig-assembly.

Standard Telephones and Cables Ltd. (assignees of M. F. Skinner). Convention date (U.S.A.) 7th January, 1943.

570 385.—Jigging process for making selenium elements in bulk.

Standard Telephones and Cables Ltd. (assignees of P. R. Kallmeyer). Convention date (U.S.A.) 18th November, 1942.

570 559.—Use of nitro-benzene-sulphuric acid as an electrolyte for accumulators, particularly when the lead plates are sulphated.

Marconi's W.T. Co. Ltd. and C. P. Fagan. Application date 9th September, 1941.

570 717.—Process for coating the glass covers of indicating instruments with fluosilicic acid in order to reduce surface reflection.

Radio Corporation of America. Convention date (U.S.A.) 28th May, 1943.

570 722.—Method of mounting the active elements on a rectifier of the selenium type (addition to 526 482).

Standard Telephones and Cables Ltd. and E. A. Richards. Application date 15th January, 1944.

570 730.—Method of winding the magnetic core of a transformer from a ribbon of sheet steel having the crystal grains of the metal orientated in the direction of rolling.

G. R. Shepherd (communicated by Westinghouse Electric International Co.). Application date 20th January, 1944.

570 773.—Construction and assembly, around the ignition system of an internal combustion engine, of a screen to prevent H.F. radiation.

E. L. W. Byrne (communicated by Titeflex Metal Hose Co.). Application date 24th December, 1943.

571 000.—Robust terminal assembly and support for a ceramic condenser of the tubular or cup-shape type.

F. C. Stephan. Application date 29th September, 1943.

571 101.—Sealing-disc, made in part of synthetic rubber, for a high-voltage capacitor.

R. Trist & Co., Ltd., and D. S. Prince. Application date 27th November, 1943.

571 117.—Unitary assembly of the component parts of a wave-filter circuit.

N. E. Brookes (communicated by Tobe Deutschmann Corp.). Application date 14th December, 1943.

ABSTRACTS AND REFERENCES

Compiled by the Radio Research Board and published by arrangement
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In order to enhance the usefulness of the abstracts, certain changes have been made in their presentation. The subject sections have been increased in number and made more in accordance with the modern trend of development, and they are now arranged in alphabetical order. Universal Decimal Classification numbers have been added to each abstract, and heavy-face type has been adopted for the serial number and title in order to increase their legibility.

ACOUSTICS AND AUDIO FREQUENCIES

534.851 : 621.395.625.2 **1**

On the Playback Loss in the Reproduction of Phonograph Records.—O. Kornei. (*J. Soc. Mot. Pict. Engrs*, Dec. 1941, Vol. 37, No. 6, pp. 569–590.) An analysis of the loss in the upper frequency range in reproducing lateral-cut records due to the elastic properties of the record material for the case of a spherically-pointed stylus. The playback loss (difference between recorded and reproduced level at any point) is independent of record amplitude and may be positive, zero or negative. The translation loss (difference between playback losses at two points) can only be made zero in systems with constant groove velocity; in standard recordings this is impossible, but the stylus mass can be chosen to give a compromise between translation loss and signal/noise ratio.

534.862 **2**

Multiple-Speaker Reproducing Systems for Motion Pictures.—H. I. Reiskind. (*J. Soc. Mot. Pict. Engrs*, Aug. 1941, Vol. 37, No. 2, pp. 154–163.) Systems employing extra loudspeakers outside the screen, while undesirable for dialogue, are advantageous for realistic reproduction of music and sound effects. A commercially practicable arrangement is described, in which a variable-width sprocket-hole control-track on the print is scanned by a simple photo-cell system, amplitude variations of the output of which control the operation and volume of the extra speakers. See also 3.

534.862 **3**

Vitasound [realistic cinema reproduction].—N. Levinson & L. T. Goldsmith. (*J. Soc. Mot. Pict. Engrs*, Aug. 1941, Vol. 37, No. 2, pp. 147–152.) A variable-width control track is printed in the sprocket-hole area of the standard film, and scanned by a separate photocell. This operates a variable-gain sound amplifier over a range of 10 db, and also a loudspeaker switching relay for extending the source of sound to loudspeakers beyond the screen. Both units have self-contained voltage-stabilised power supplies. The operating time of the control equipment is 60 ms, which is fast enough to deal with short duration effects. See also 2.

534.862 **4**

The Stereophonic Sound-Film System—General Theory.—H. Fletcher. (*J. Soc. Mot. Pict. Engrs*, Oct. 1941, Vol. 37, No. 4, pp. 331–352.) The ideal recording reproducing system for a typical hall is discussed. Intensity and frequency range curves are given. The modifications to these caused by room noises are considered in detail. Three-channel recording is used to give good representation of movement on a large stage and allows the use of the central channel for solo work if required. Reasons for variable area rather than variable density recording are given.

A volume range of 80 db has to be compressed to 50 db due to film limitation. Ideal relationships between signal input and compressor gain are deduced from signal/noise considerations to be constant gain for the first 50 db and gain inversely proportional to input for the remaining 30 db. The necessity for a pilot channel to control gain is demonstrated. The single pilot channel controls all three signal channels. Each signal channel is associated with a frequency from a magnetic tone-generator, the amplitude of which is controlled by the level of sound in that channel.

534.862 **5**

Mechanical and Optical Equipment for the Stereophonic Sound-Film System.—E. C. Wente, R. Biddulph, L. A. Elmer & A. B. Anderson.

(*J. Soc. Mot. Pict. Engrs*, Oct. 1941, Vol. 37, No. 4, pp. 353–365.) The same mechanical system is used for recording and reproduction. Special care is taken to ensure uniform film velocity by using a new type of internally-damped roller.

The 3 signal and the pilot channels are recorded simultaneously by light valves. During reproduction the light is guided to the photocells by glass rods.

534.862 **6**

Fantasound [stereophonic system used in " Fantasia "].—W. E. Garity & J. N. A. Hawkins. (*J. Soc. Mot. Pict. Engrs*, Aug. 1941, Vol. 37, No. 2, pp. 127–146.) The system uses three sound tracks and a control track carrying three tones which vary the gains of the three programme channels. A differential junction network is used for giving apparent motion of a sound source across the screen. Ten versions of the system are described in historical order of development. The technique of scoring and dubbing is also described.

534.862 : 621.395.665 **7**

An Improved Mixer Potentiometer.—K. B. Lambert. (*J. Soc. Mot. Pict. Engrs*, Sept. 1941, Vol. 37, No. 3, pp. 283–288, Discussion, pp. 289–291.) A mixer comprising five plug-in units of two mixer controls each. The mixer potentiometer controls move linearly, in parallel grooves, so that all ten can be handled simultaneously by one operator. Incoming channels, attenuated as desired (over a range of 6–105 db) by the potentiometers are combined by special transformers in groups of four, into an output having the same impedance as each (200Ω). The potentiometers are continuously wire-wound, and themselves have approximately constant input and output impedances of 200Ω. Internal crosstalk between channels is less than -110 db.

534.862.3 : 621.395.625.6 **8**

A Light-Valve for the Stereophonic Sound-Film System.—E. C. Wente & R. Biddulph. (*J. Soc. Mot. Pict. Engrs*, Oct. 1941, Vol. 37, No. 4, pp. 397–405.) The theory of light valves for sound recording on film is discussed and a mechanically robust design described. A pair of coplanar duralumin ribbons 0.004 inch apart are supported in a transverse magnetic field of 32 000 Gauss in the air gap between the conical pole pieces of a permanent magnet. The ribbons form a light slit which varies in size in accordance with the current flowing through them. The chief problem is to obtain uniform response over a wide frequency range including the resonant frequency, since a value of this above the working range would involve impracticable ribbon tension and dimensions. In this case the resonant frequency is 8 400 c/s, and the response/frequency characteristic has a broad maximum around 8 000 c/s, 5 db above the response at low frequencies. Uniform overall response in the band 30–14 000 c/s is obtained by suitable electrical networks. Large electromagnetic damping of the ribbons is used to assist in this and also to minimise the effect of free oscillations at the resonant frequency, produced by the ribbons striking each other. The built-in optical system consists of a condensing lens focusing the light source in the plane of the ribbons, and a microscope objective focusing the ribbons on the film.

534.862.3 : 621.395.665.1 **9**

Electrical Equipment for the Stereophonic Sound-Film System.—W. B. Snow & A. R. Soffel. (*J. Soc. Mot. Pict. Engrs*, Oct. 1941, Vol. 37, No. 4, pp. 380–395, Discussion pp. 395–396.) For the recording of symphonic music. Film noise reduced by pre-equalisation rising to 18 db above 8 000 c/s, and automatic compression and expansion of 30 db. Overall " air-to-air " response of system including microphone amplifier and loudspeaker is substantially uniform from 40 to 15 000 c/s. The compandor system has a uniform frequency characteristic and is pilot-operated by a tone channel.

534.862 : 621.396.665.1 **10**

The Stereophonic Sound-Film System—Pre- and Post-Equalization of Compandor Systems.—J. C. Steinberg. (*J. Soc. Mot. Pict. Engrs*, Oct. 1941, Vol. 37, No. 4, pp. 366–379.) Curves give as a function of frequency the reduction in film noise that is required to reproduce the original intensity range. This is greatest at the higher frequencies where 43 db improvement in signal/noise is required. The use of a suitable equaliser reduces this figure to a maximum of 30 db, which is within the range of a compandor, even with a 15 db " enhancement " feature. The practical performance of the compandor is given, with the results of its use in conjunction with equalisers..

621.314.2 **11**

High-Quality Communication and Power Transformers.—Harrison. (*See* 201.)

621.317.353 **12**

A Simple Method of Measuring Distortion in A.F. Oscillators and Amplifiers.—Smith. (*See* 117.)

621.395.47 **13**

Inverted Speech.—A. W. Ladner. (*Marconi Rev.*, Jan./Mar. 1945, Vol. 8, No. 76, pp. 32–35.) Second part of an article dealing with the relationship of inverted speech to ordinary articulatory sounds. Tests are described in which single-syllable words were inverted at 1 500 c/s and recognition by a group of listeners examined. The majority of vowels and consonants become unrecognisable on inversion and the reason for this is illustrated in terms of the energy/frequency spectrum. For first part see 78 of 1945.

621.395.614 **14**

Piezo-Electric Microphones.—W. T. C. (*Wireless World*, Nov. 1945, Vol. 51, No. 11, pp. 345–346.) If mounted in a light-weight container the piezo-electric microphone is very sensitive to noise caused by handling and vibration, and exhibits large resonances. The article shows the design of a heavy metal case in which the performance is greatly improved.

621.395.623 **15**

High-Fidelity Headphones.—L. J. Anderson. (*J. Soc. Mot. Pict. Engrs*, Sept. 1941, Vol. 37, No. 3, pp. 319–323.) The acoustic properties of the moving-coil earpieces are treated in terms of the equivalent electrical circuit. Low-frequency response is improved by the reduction of leakage past the ear-cap as revealed by a smoke test, as well as by adjusting circuit constants. Mechanical requirements are considered and performance curves given.

621.395.623.7 **16**

The Duplex Loudspeaker.—J. B. Lansing. (*J. Soc. Mot. Pict. Engrs*, Sept. 1944, Vol. 43, No. 3, pp. 168–173.) A two-way loudspeaker for 25 W input with a high-frequency horn mounted on the face of the low-frequency diaphragm. Dividing networks are given for cross-over at 1 200 c/s. Gives efficient radiation beyond 15 000 c/s with low intermodulation products. High-frequency horn has an angle of radiation of 60° horizontally and 40° vertically.

621.395.623.8 **17**

Acoustic Feedback Reduction by Increased Directivity in Electric Megaphones.—A. J. Sanial. (*Communications*, Sept. 1945, Vol. 25, No. 9, pp. 62–64.) Acoustic feedback from loudspeaker to microphone is reduced by partially focusing the sound by means of a ring exit surrounded by a slightly divergent outer horn, with an inner plug. Some three times increase in pressure-output over the annular horn has been obtained. A continuation of 3556 of 1945.

621.395.625 : 621 **18**

It Pays to Listen.—(*Sci. Amer.*, July 1945, Vol. 173, No. 1, pp. 18–20.) Imperfections in running machinery can often be detected by a change in the characteristic noise earlier than by any other method. With modern quiet-running machinery the sounds can be amplified and recorded, and compared at any time with a standard recording made when the machinery was running well.

621.395.625.2 + 621.395.625.6 **19**

Western Electric Recording System—U.S. Naval Photographic Science Laboratory.—R. O. Strock & E. A. Dickinson. (*J. Soc. Mot. Pict. Engrs*, Dec. 1944, Vol. 43, No. 6, pp. 379–404.) A general technical description of a commercial recording and re-recording equipment using film and disk. Improved designs for ease of operation and servicing.

621.395.625.2 **20**

Glossary of Disk-Recording Terms.—H. A. Chinn. (*Proc. Inst. Radio Engrs, N.Y.*, Nov. 1945, Vol. 33, No. 11, pp. 760–763.) About 120 terms, all pertaining to constant-rotational-speed disc recording.

621.395.625.2 **21**

Analytic Treatment of Tracking Error and Notes on Optimal Pick-Up Design.—H. G. Baerwald. (*J. Soc. Mot. Pict. Engrs*, Dec. 1941, Vol. 37, No. 6, pp. 591–622.) An analysis of the non-linear distortions due to tracking error in the reproduction of lateral-cut disc recordings. For a sinusoidal signal the analysis is the same as that arising in Bessel's solution of planetary motion. The harmonic distortion for both sinusoidal and complex signals is discussed. The emphasis of the high-frequency components increases the nuisance value of the distortion, which is greater than is commonly assumed.

Pick-up design for minimum tracking distortion over the whole playing range is considered. In straight arms the underhang is adjustable, while in offset arms the offset angle and overhang are adjustable and they are superior to straight arms, enabling tracking distortion to be rendered negligible even under adverse conditions.

621.395.625.6 **22**

A Re-Recording Console, Associated Circuits, and Constant B Equalizers.—W. C. Miller & H. R. Kimball. (*J. Soc. Mot. Pict. Engrs*, Sept. 1944, Vol. 43, No. 3, pp. 187–205.) Metro Goldwyn Mayer studio equipment with constant resistance multi-channel mixing transformers and variable equaliser circuits. Design formulae are given for a bridged-T equaliser network having adjustable resonant frequency with variable loss or gain at that frequency.

621.395.625.6 **23**

A New Mobile [film sound] **Recording Unit for Studio and Location Work.**—J. L. Fields. (*J. Soc. Mot. Pict. Engrs*, July 1944, Vol. 43, No. 1, pp. 51–58.) A battery-operated unit for a medium-sized van. Aisle-type construction permits flexibility in arrangement of apparatus.

621.395.625.6 **24**

Noise-reduction Anticipation Circuits.—J. G. Frayne. (*J. Soc. Mot. Pict. Engrs*, Nov. 1944, Vol. 43, No. 5, pp. 313–320.) The mean illumination in recording a film sound track is controlled by the output from a microphone placed 10 ft. nearer the sound source than the recording microphone. For re-recording a wax record is used with the pick-up advanced in the groove.

621.395.625.6 **25**

An AAF Portable Sound Recording Unit.—F. T. Dyke. (*J. Soc. Mot. Pict. Engrs*, Nov. 1944, Vol. 43, No. 5, pp. 327–333.) An outline of a commercial equipment suitable for a.c. mains or 36 V battery operation, easily carried in a small vehicle.

621.395.667 **26**

"A New Versatile Tone Control Circuit."—D. Winget. (*Wireless World*, June 1945, Vol. 51, No. 6, p. 182.) A modification of the circuit given in 1840 of 1945.

AERIALS AND TRANSMISSION LINES

621.315.212.1 : 621.317.33 **27**

Coaxial Cable Tests.—Ware. (*See* 114.)

621.315.616 : 621.315.212 **28**

Polyethylene-Disk Insulators for Coaxials.—C. Kreisher. (*Bell Lab. Rec.*, Sept. 1945, Vol. 23, No. 9, pp. 321–324.) The replacement of hard rubber disk insulators in coaxial cables by polyethylene has reduced losses to one-twelfth at frequencies of the order of 1 Mc/s. The manufacturing technique has been slightly modified to suit the newer dielectric.

621.316.99 **29**

Grounding Principles and Practice, I.—Fundamental Considerations on Ground Currents.—R. Rüdenberg. (*Elect. Engng*, Jan. 1945, Vol. 64, No. 1, pp. 1–13.) An analysis of the behaviour of earth currents as influenced by soil resistivity, current frequency, and size and shape of the electrodes. Parts II–V of this five-part series appear in the February–May issues of *Elect. Engng*, and deal with power-engineering aspects of the subject of grounding.

621.392 **30**

The Plane-Wave Resolution of Guided Waves.—S. S. Mackeown & J. W. Miles. (*Proc. Inst. Radio

Engrs, N.Y., Nov. 1945, Vol. 33, No. 11, pp. 805–808.) "Wave propagation in cylindrical guides of both rectangular and circular cross section is treated by representing the proper solutions to Maxwell's equation through a plane-wave expansion of the Hertzian vector. In the case of a rectangular wave guide only a finite number of plane waves (two or four) is required to represent a given mode, while for the circular guide an infinite manifold is required. The plane waves are uniform, travelling with the velocity of light in the medium at an angle to the cylindrical axis which is determined by the frequency and the eigen value of the mode under consideration."

621.392 **31**

The Theory of Transmission Lines.—E. N. Dingley, Jr. (*Proc. Inst. Radio Engrs, N.Y.*, Nov. 1945, Vol. 33, No. 11, pp. 810–812.) Discussion on 1748 of 1945.

621.392 **32**

The Tapered Transmission Line.—J. W. Milnor. (*Trans. [mon.] Amer. Inst. elect. Engrs*, June 1945, Vol. 64, No. 6, pp. 345–346.) A tapered section of transmission line acts as a transformer, whereby points in a circuit having different impedances may be connected without mismatch. Design formulae are given for exponential taper, lumped taper, and taper of series impedance only.

621.396.67 **33**

Calculating Antenna Radiation Patterns.—H. L. Krauss: R. W. Cronshey. (*Elect. Engng, N.Y.*, Mar. 1945, Vol. 64, No. 3, pp. 131–132.) A correction to the mathematical solution in 798 of 1945 (Cronshey), which does not invalidate the graphical solution. Also Cronshey's reply.

621.396.676.029.54 **34**

Aerials for use on Aircraft: a Comparison between Fixed and Trailing Types on the 900-metre Waveband.—C. B. Bovill. (*J. Instn elect. Engrs*, Part I, Oct. 1945, Vol. 92, No. 58, pp. 397–398.) Summary of 3294 of 1945.

621.396.676.029.62 **35**

A Very-High-Frequency Aircraft Antenna for the Reception of 109-megacycle Localizer Signals.—B. E. Montgomery. (*Proc. Inst. Radio Engrs, N.Y.*, Nov. 1945, Vol. 33, No. 11, pp. 767–772.) A U-shaped antenna for the frequency band 108.3–110.3 Mc/s is described. The antenna was covered with 3/4 inch of polystyrene to reduce effect of water. Removal of cover changes tuning by 3 Mc/s, causing 9 db reduction in pick-up. The pick-up was uniform to 6 db in all directions, and not more than 10 db below a standard dipole. The aerodynamic drag was 5 lb at 200 m.p.h.

621.396.677 **36**

The Design of Directional Aerial Arrays.—V. J. Cooper & E. Green. (*Marconi Rev.*, Jan./Mar. 1945, Vol. 8, No. 76, pp. 12–23.) Concluding part of article dealing with a method of designing aerial arrays to give predetermined polar curves of field strength. For previous part see 67 of 1945.

CIRCUITS

621.3.011 **37**

The Extended Employment of Thèvenin's Theorem.—A. Lee & D. K. C. MacDonald. (*Wireless Engr*, Nov. 1945, Vol. 22, No. 266, pp. 534–537.) Some mathematical examples to show how the theorem can be applied to problems containing transient phenomena.

621.3.011.2 : 621.3.012.3 **38**

Conversion from Series to Parallel Impedance.—G. J. Wheeler. (*Electronics*, Oct. 1945, Vol. 18, No. 10, p. 254.) Shows how a graph consisting of a series of circles, tangential to one axis of a rectangular coordinate system, and with centres on the other axis, can be used to convert series impedances into equivalent parallel impedance combinations. The graph is reproduced.

621.31.12 : 621.383 **39**

A Phototube Amplifier.—J. F. Scully. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 168..184.) Describes a new type of amplifier for the control of industrial equipment by the output of a phototube. Coupling capacitors are eliminated by driving the screen-grid instead of the normal control-grid of the output tube.

621.314.3 **40**

Methods of Applying Negative Feedback—a Reference Chart.—(*Electronic Engng*, Nov. 1945, Vol. 17, No. 213, pp. 770–771.) Seven circuit diagrams show methods of obtaining negative feedback by current and by voltage.

621.314.3 **41**

The Cathode Follower.—"Cathode Ray." (*Wireless World*, Nov. 1945, Vol. 51, No. 11, pp. 322–325.)

621.314.3 **42**

Some Considerations concerning the Internal Impedance of the Cathode Follower.—H. Goldberg. (*Proc. Inst. Radio Engrs, N.Y.*, Nov. 1945, Vol. 33, No. 11, pp. 778–782.) Analysis of the cathode follower with R in parallel with C for a load. Step-function and sine-wave inputs are considered. The internal impedance is $1/(G_m + G_p)$, where G_m is the grid-plate transconductance and G_p the plate conductance, when the valve is conductive. For step-function input voltages decreasing with time, the conditions for which the tube is conductive are severe. The conductive range is increased by decreasing R, decreasing G_m, or increasing the plate voltage.

621.314.3 **43**

Negative Voltage Feedback.—G. Builder. (*Proc. Instn Radio Engrs, Aust.*, Aug. 1945, Vol. 6, No. 2, pp. 3–6.) Defining the voltage gain of an amplifier as the complex ratio of output to input voltages of the amplifier, and the amplification factor as $(dE_a/dE_g)$for $I_{a\,\text{const.}}$, where E_a is the voltage of the output electrode, E_g is the voltage of the input electrode and I_a is the current to the output electrode, equations are derived for the gain and the output impedance of an amplifier with negative feed-back. These equations are applicable to multi-stage amplifiers with complex loads and may be used in designing feed-back circuits where the fed-back voltage is a definite fraction of the output voltage and contains no other voltages.

621.314.3 : 578.088.7 : 621.396.822 **44**

Biological Amplifiers.—D. H. Parnum. (*Wireless World*, Nov. 1945, Vol. 51, No. 11, p. 342.) Letter discussing noise in biological amplifiers. Flicker effect increases as frequency is reduced and is immensely greater in coated cathode valves. Writer suggests the use of tungsten filament valves in the first stage of biological amplifiers.

621.314.3 : 578.088.7 **45**

Biological Amplifiers—1.—D. H. Parnum. (*Wireless World*, Nov. 1945, Vol. 51, No. 11, pp. 337–340.) The order of magnitude of voltages encountered in biological work varies from 50 μV to 2 mV at frequencies between 0 and 10 kc/s. The chief difficulties are interference (50 c/s unwanted pick-up), and interaction between several amplifiers connected to one subject. These are both overcome by the use of balanced input stages, push-pull following stages and negative feed-back. Circuit diagrams are shown, and one in particular does not require good insulation to earth, which is very difficult to achieve with human subjects.

621.314.3 : 623.6 **46**

Some Fundamental Considerations in Military Amplifier Design.—Chertok. (*See* 204.)

621.316.313 **47**

Dual A-C Network Calculator.—W. W. Parker. *Elect. Engng, N.Y.*, May 1945, Vol. 64, No. 5, pp. 182–183.) The calculator network is set up to imulate the electric power system under investi- ation, and the loads and generator inputs are djusted to the appropriate values for the specific roblem under consideration. The network is then etered, and the readings of volts, watts, and eactive volt-amperes obtained, which give the nformation required for the system. The calcu- tor is flexible and time-saving: two independent roblems can be solved simultaneously.

21.316.721.078.3 **48**

Analysis of Current-Stabilizer Circuits.—W. R. ill, Jr. (*Proc. Inst. Radio Engrs, N.Y.*, Nov. 945, Vol. 33, No. 11, pp. 785–792.) "The per- rmance of any current stabilizer can be predicted terms of two parameters defined as the stabili- tion transconductance, g_s, and the output con- uctance, g_o. Together with the equivalent circuits Figs. 2 and 3 these two factors permit the calcu- tion of the stabilizer performance in conjunction ith any load circuit and direct-current supply. undamental stabilizer circuits based on the generative and mu-bridge principles are developed d analyzed for the two parameters defined. For mple circuits, the analysis suggests the use of ntodes to obtain best stabilization. Superior rformance can be obtained by the mu-balance cuit described. This circuit provides an output rrent substantially independent of any input- ltage or load-circuit change."

1.317.372 : 621.319.4 **49**

Determining Q of Capacitors.—E. L. Pepperberg. *lectronics*, Sept. 1945, Vol. 18, No. 9, pp. 146, 8.) A chart is given, with a simple calculating cedure whereby the Q of any capacitor may sily be determined from measurement with an dinary laboratory Q meter.

1.318.572 **50**

Electronic Counting.—M. Weber. (*Communica- ns*, Aug. 1945, Vol. 25, No. 8, pp. 42..98.) A scription of a circuit for counting pulses or iding a frequency. Two condensers and two diodes are connected in such a way that each pulse increases the charge on one of the condensers (see 3961 of 1940). When the potential difference between the condenser terminals reaches a predetermined value a triode blocking-oscillator circuit is triggered, resulting in the production of an output pulse and in the discharge of the condenser. Irregularly-spaced pulses of the same peak amplitude but with different width or shape can be counted, and pulses of irregular amplitude can be counted if a voltage-limiter circuit is used before the counter. A maximum of ten input pulses per output pulse is recommended.

621.318.7 + 621.392.52 **51**

Crystal Filters, Part IV.—R. L. Corke. (*P.O. elect. Engrs' J.*, Oct. 1945, Vol. 38, Part 3, pp. 76–81.) Examples are given of a simple filter with narrow band-pass (0.3%), a lattice filter with wider band-pass (0.6%), and a bridged-T filter suitable for the i.f. section of a receiver. A channel filter of 3 kc/s band-pass and a through-group filter passing frequencies from 60 to 108 kc/s are described. For previous parts see 2930 and 3497 of 1945.

621.318.72 **52**

Abacs for Filter Design.—T. Roddam. (*Wireless World*, Nov. 1945, Vol. 51, No. 11, pp. 332–334.) Two full-page charts from which the values of inductance and capacitance required to design low-pass constant-k,-π or-T section filters can be obtained. The first of a series.

621.385.012.8 **53**

Valve Vectors.—R. G. Wood: D. A. Bell. (*Wireless Engr*, Nov. 1945, Vol. 22, No. 266, pp. 532–533.) Continuation of correspondence on sign conventions. See also 3272 and 3504 of 1945.

621.392 : 621.3.011.2 **54**

Stabilized Negative Impedances—Part III.—E. L. Ginzton. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 140–144.) Applications of negative impedances are described. Elimination of distortion in a diode rectifier can be effected by insertion of a negative resistance shunted across the diode load, the value of this negative resistance being equal to the difference between the impedance offered by the diode output at the modulation frequency and that offered to a d.c. potential difference. Means are also described for eliminating the series resistance of capacitors, producing very large capacitance for power-supply filtering, increasing the Q of tuned circuits, and regulating power supplies. For previous parts see 3268 and 3842 of 1945.

621.392.5/.6 **55**

The Application of the Characteristic Equation of a Matrix to the Evaluation of the Range of Frequencies for which Currents are passed through Networks with Four or More Terminals without Attenuation.—H. V. Lowry. (*Phil. Mag.*, April 1945, Vol. 36, No. 255, pp. 255–264.)

621.392.52 **56**

Effect of Coil Q on Filter Performance.—P. Selgin. (*Communications*, Sept. 1945, Vol. 25, No. 9, pp. 46..106.) Two full-page universal charts from which values of filter components can be obtained. A worked example illustrates the method. See also 3499 of 1945.

621.395.625.6 57

A Re-Recording Console, Associated Circuits, and Constant B Equalizers.—Miller & Kimball. (*See* 22.)

621.395.625.6 58

Noise-Reduction Anticipation Circuits.—Frayne. (*See* 24.)

621.395.645.211 : 621.395.645.33 59

The Resistance-Coupled Amplifier.—L. G. Cowles. (*Trans. [mon.] Amer. Inst. elect. Engrs*, June Supplement 1945, Vol. 64, pp. 359–365.) "The routine problems of resistance-coupled amplifier design have been simplified and reduced to a set of graphs and convenient conversion charts.

". . . the coupling circuit can be replaced by a pair of equivalent resistance-capacitance circuits so that it is easy to calculate an amplifier's phase and amplitude-frequency characteristics. The design of a coupling circuit to give a specified band width and an acceptable loss has been simplified by the construction of curves of constant band width and peak-frequency loss.

". . . a method and charts are presented for determining without the use of static characteristic curves a suitable operating point, electrode voltages, and plate or screen resistors for any vacuum tube operated class A. As the method given results in the tube being operated with proportionally reduced electrode voltages, its dynamic constants can be extrapolated from values furnished by the manufacturer. Charts facilitating the extrapolation are given.

"A simple transconductance meter for measuring the mutual conductance and circuit transconductance of a tube operated with an external plate resistor is described . . . The gain of the tube and the equivalent plate-circuit resistance can be calculated easily from these two measurements. The dynamic constants μ and r_p can be obtained also with an accuracy sufficient for most practical purposes.

"The methods outlined . . . have proved to be thoroughly practical and reliable in work on a wide variety of resistance-coupled amplifiers."

621.395.665 60

Resistive Attenuators, Pads and Networks: Part VIII.—P. B. Wright. (*Communications*, Sept. 1945, Vol. 25, No. 9, pp. 68..80.) An analysis of the series-parallel-connected and of the parallel-series-connected multiple-bridge and lattice-network fader and mixer systems. For previous parts see 2178, 3501 and 3821 of 1945.

621.395.667 61

"A New Versatile Tone Control Circuit."—D. Winget. (*Wireless World*, June 1945, Vol. 51, No. 6, p. 182.) A modification of the circuit given in 1840 of 1945.

621.396.615.17 : 621.318.572 62

Timing Action of the Blocking Oscillator.—E. Last. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 184..204.) A very full and detailed description of the blocking (or squegging) oscillator, as applied to timing and trigger circuits, and of the means of controlling the characteristics of the output. A two-page article.

621.396.616 63

Transmission Lines as Tuning Elements.—H. E. Newell, Jr. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 150, 152.) Describes the theory, construction, and use of a graph for designing a tuning element consisting of a section of transmission line shunted by a capacitor. Values of one or two unknown circuit parameters may be found when values of two or three others are known.

621.396.619 : 621.396.615.17 64

Square-Wave [pulse] **Modulator for Signal Generator.**—W. R. Piggott. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 260..268.) Summary of 1536 of 1945.

621.396.66 65

Automatic Fader.—D. Hunter. (*Electronics*, Oct. 1945, Vol. 18, No. 10, p. 119.) A description, in very technical language, of a device which automatically fades a broadcast programme in or out, completely or partially, at predetermined rates, without the use of motors. The fading time is adjustable from 1 to 15 seconds, by variation of a time-delayed bias on an amplifier. It operates from "the nemo and announce tally lights plus an installed fade key and tally".

621.396.662.2.029.62 66

Coil Design for V.H.F.—A. H. Meyerson. (*Communications*, Sept. 1945, Vol. 25, No. 9, pp. 50..84.) The results of experiments to determine the best coil shape for use at 60–120 Mc/s are given graphically and in tabular form. Coils constructed of round wire, tube, strip, and in disc form were measured and the disc form was found to have the best stability while maintaining a good Q. Single-turn coils of round copper tube had the highest Q, which varied somewhat with tube diameter, but at the highest frequencies the variations between tube and disc type were not significant.

621.397.62 67

Restorer-Circuit Operation.—E. Last. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 132–133.) A restorer circuit is a device which shifts the abscissa of an input voltage wave of any form. In a negative restorer a square wave input from 0 to $+ E$ volts will appear as an identical wave from $- E$ to 0 volts; in a positive restorer a wave input from $+ E/2$ to $- E/2$ may be made to appear as a wave from 0 to $+ E$ volts. Biased restoration from $- (E + E_b)$ to $- E_b$ is also possible. The circuits for such devices are described.

621.397.645.31 68

Carrier-Frequency Amplifiers: the Unit Step Response of Amplifiers with Single and Double Circuits.—C. C. Eaglesfield. (*Wireless Engr*, Nov. 1945, Vol. 22, No. 266, pp. 523–532.) A mathematical comparison, using Heaviside's operational method, between two amplifiers, one having staggered single circuits and the other double circuits, with a view to finding which has the greater "speed". For the sake of comparison the two amplifiers have the same "overshoot" (see 2283 of 1945). For applications such as in television the two methods are equally effective.

621.3.01/.02 69

Elementary Electric Circuit Theory [Book Review].—R. H. Frazier. McGraw-Hill, N.Y., 1945, 414 pp., \$4.00. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 428..430.) "... intended as a text for electrical engineers who have completed fundamental physics and mathematical courses." "A broad viewpoint of lumped constant circuits ... written for a first course in circuits."

GENERAL PHYSICS

538.3 70

The Application of Newton's Third Law to an Electric Circuit.—G.W.O.H. (*Wireless Engr*, Nov. 1945, Vol. 22, No. 266, pp. 521–522.) The Biot-Savart formula is not a violation of Newton's third law. Analysis of a long, narrow, rectangular loop carrying a steady current illustrates "the fallacy of endowing with separate physical reality the forces on current elements due to other current elements and then discussing whether or not they violate Newton's third law".

538.3 : 531.51 71

A Classical Theory of Electromagnetism and Gravitation.—H. C. Corben. (*Nature, Lond.*, 29th Sept. 1945, Vol. 156, No. 3961, pp. 388–389.)

621.38 72

Electronics.—S. R. Cook. (*Sci. Mon., N.Y.*, Aug. 1945, Vol. 61, No. 2, p. 163.) A letter questioning some of the ideas expressed in 3752 of 1945 (Mills).

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.165 + 537.591 73

The Composition of the Soft Component of the Cosmic Rays at an Altitude of 3250 m above Sea Level.—A. Alichanow & A. Alichanian. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 2, pp. 73–86.) Cosmic ray measurements by means of counters and ionisation chambers showed a systematic difference between the data obtained by the two methods. "This is due to the presence in the soft component of particles with ionization power exceeding that of the relativistic particles 2.5 to 3.5 times. It is shown that these particles constitute about 20% of the intensity of mesotrons and that they are not connected genetically with the electrons, quanta, or mesotrons and that they are produced by an independent component. . ."

523.165 + 537.591 74

Equilibrium Spectrum of the Soft Component of High Energy Cosmic Rays.—A. Migdal. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 2, pp. 87–92.) Numerical calculations for energies several times greater than critical energy.

523.165 : 523.7 : 525.2 75

On Currents of Fast Charged Particles induced by Revolving Magnetized Cosmic Bodies.—J. P. Terlezky. (*C.R. Acad. Sci. U.R.S.S.*, 20th April 1945, Vol. 47, No. 2, pp. 101–102.) An electric field is induced around the earth and sun owing to the non-coincidence of their magnetic axes and axes of rotation. This field will accelerate charged particles. The maximum energy attainable in the earth's field due to this cause is 3.10^4eV, and in the sun's field, 2.10^8eV. Similar phenomena associated with other stars may induce currents of particles with energies of the order of that of cosmic ray particles.

523.7 : 621.396.822 76

Radio Waves from the Sun.—G. C. Southworth. (*Nature, Lond.*, 1st Sept. 1945, Vol. 156, No. 3957, pp. 273–274.) Review of 3252 of 1945 in relation to the work of Jansky (948 of 1938 and earlier work) and Reber (336 of 1943 and earlier work, and 1028 of 1945).

523.755 : 551.51.053.5 77

Problems of the Solar Corona.—M. Waldmeier. (*Naturwissenschaften*, Feb./Mar. 1944, Vol. 32, Nos. 5/13, pp. 51–57.) Includes an account of the origin in the corona of the intense ultra-violet radiation that probably causes the ionosphere.

523.78 : 621.396.11 78

"Mass Attack" on Secrets of Radio Waves.—(*See* 165.)

537.591 79

What are Cosmic Rays? [Book Review].—P. Auger. Univ. of Chicago Press, 1945, 128 pp., \$2.00. (*Sci. Mon., N.Y.*, Aug. 1945, Vol. 61, No. 2, p. 158.) "... very short and very well written," but necessarily incomplete.

LOCATION AND AIDS TO NAVIGATION

621.396.11 : 538.566.2 80

Experimental Investigation of the Structure of an Electromagnetic Field over the Inhomogeneous Earth's Surface.—Alpert & Gorozhankin. (*See* 101.)

621.396.6 : 629.13 81

The Marconi General Purpose Aircraft Wireless Equipment.—Scott. (*See* 238.)

621.396.677 82

The Design of Directional Aerial Arrays.—Cooper & Green. (*See* 36.)

621.396.9 83

Radar Warfare.—D.G.F. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 92–97.) A general descriptive article illustrated by twelve photographs. It includes the CH early warning stations and plotting centres, GCI and AI (ground control of interception and airborne interception), PPI (plan position indicator) with examples of "shadow pictures", and some account of the radar gun-control systems.

621.396.9 84

Radar in the United States Army.—R. B. Colton. (*Proc. Inst. Radio Engrs., N.Y.*, Nov. 1945, Vol. 33, No. 11, pp. 740–752.) "The evolution of radar technique is traced and the radar-development program of the United States Army Signal Corps at the Signal Corps Laboratories, Fort Monmouth, New Jersey, described from its inception to America's entry in the War. Two radars developed by the Signal Corps Laboratories during this period, SCR-268 and SCR-270, are described in detail."

Original tests on SCR-268 showed the range to be 40 000 yd with an average distance error of 700 yd, an azimuthal error of 4°, and an elevational error of $2\frac{1}{2}$°. The final design operated at a frequency of 205 Mc/s with a pulse rate of 4 100 per sec. The duration of the pulse was $5\ \mu s$, and the peak power 50 kW.

SCR-270, designed for long-range warning, had a power of 100 kW at a carrier frequency of 110 Mc/s. The pulse rate was 625 per sec and the duration 15 to 40 μs. The array rotated 5 revs per min. The range was 120 miles for bombers and 75 miles for fighters. The distance error was 2 miles and the direction error 4°. A plan-position indicator was introduced. See also 87.

621.396.9 **85**

Fundamentals of Radar—2. —(*Wireless World*, Nov. 1945, Vol. 51, No. 11, pp. 326–329.) The Air Interception (AI) system working on $1\frac{1}{2}$ metres and at centimetre wavelengths is described, the former using fixed aerials with broad polar diagrams, the latter using a narrow beam, scanning spirally. The theoretical relations between transmitted power, range and wavelength are discussed. For part 1 see 3903 of 1945.

621.396.9 **86**

Radar in War and in Peace.—R. Watson-Watt. (*Nature, Lond.*, 15th Sept. 1945, Vol. 156, No. 3959, pp. 319–324.) An historical review of the war-time and pre-war development of radar, and a discussion of peace-time applications.

621.396.9 **87**

The SCR-268 Radar.—D. G. F. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 100–109.) The transmitting and receiving arrays are mounted on a pedestal and are manually controlled. The transmitting array consists of 16 crossed-dipoles and 16 reflectors with an open transmission line; the azimuth receiving array consists of a " bill board " 6 dipoles wide and 4 dipoles high with reflectors; the elevation array consists of a similar " bill board " 2 dipoles wide and 6 dipoles high. The transmitting beam is 10° wide between the 3 db points; the azimuth and elevation arrays have a directivity of 12° and 9° respectively, and lobe switching is provided, giving an accuracy of ± 1°. The range accuracy is ±200 yards. The keying unit includes a 4 098 c/s electron-coupled Hartley oscillator using a 6SJ7 valve. By means of sharpening, flattening, and over-driven amplifier circuits, short pulses are produced which are successively amplified by a 6F6 stage, two 6L6 valves in parallel, and a 304 TL triode. A peak pulse of 3 500 volts is thereby applied to the modulator unit, which includes eight 304 TL valves in parallel. The transmitter includes sixteen 100TS valves in a ring circuit. The essential features are pulse repetition frequency 4 098 per sec, pulse width 6 μs, peak power 75 kW, radio frequency 205 Mc/s, receiver power sensitivity 10^{-13} W, maximum range 22 miles, total weight 37 tons, total power required 15 kVA. A-scope presentation is utilised with " split image " display. See also 84.

621.396.9 **88**

Radar and the Bell System.—(*Bell Lab. Rec.*, Sept. 1945, Vol. 23, No. 9, pp. 325–328.) A short account of radar applications in various theatres of war with special reference to the part played by the Bell System Laboratories.

621.396.9 : 623.454.25 **89**

Proximity Fuse.—(*Wireless World*, Nov. 1945, Vol. 51, No. 11, p. 331.) A complete transmitter and receiver with aerial, batteries and fuse-operating mechanism, is built into the nose of an anti-aircraft shell. The transmitter sends out a cone of c.w. radiation which is reflected by the target and arrives back at the receiver at a different frequency due to relative motion of the shell and target (Doppler effect). The beat note formed is amplified and used to trigger the fuse.

MATERIALS AND SUBSIDIARY TECHNIQUES

538.221 : 621.317.41.029.5 **90**

Permeability of Iron at Radio Frequencies.—A. W. Smith, F. P. Dickey & S. W. Foor. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 268..280.) Summary of 1603 of 1945.

594.514.1 : 537.228.1 : 621.39 **91**

Piezo Electric Quartz Crystals.—J. L. Creighton. (*P.O. elect. Engrs' J.*, Oct. 1945, Vol. 38, Part 3, pp. 65–69.) The relationship between the atomic grouping and the piezo-electric effect. Methods of applying piezo-electric crystals to telecommunications. Methods of minimizing the variation with temperature of crystal oscillators.

594.514.1 : 537.531 : 621.396.611.21 **92**

X-rays Alter Wavelength, Change Color of Gems.—(*See* 126.)

620.193.7 **93**

Cathodic Protection.—L. H. Woodman. (*Sci. Amer.*, July 1945, Vol. 173, No. 1, pp. 44–46.) Corrosion of underground metallic structures by the action of galvanic currents may be prevented by connecting to them large masses of magnesium. These have a higher potential than the structure, which becomes a cathode and is not corroded.

620.193.7(213) : 621.315.5 : 621.315.6 **94**

Electrolytic Corrosion—Methods of Evaluating Insulating Materials used in Tropical Service.—Thompson & Mathes. (*See* 256.)

621-752 : 621.38/.39 **95**

Vibration Control for Electronic Products.—F.H. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 134–139.) A review of the many types of specialised units designed to provide isolation from vibration and shock. Many types of rubber mountings are described and illustrated, and the degree of vibration absorption in each case is stated.

621-752 : 678 **96**

Vibration Insulation and Structural Rubber.—J. A. Connon. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, June 1945, Vol. 64, No. 6, pp. 324–328.) A compilation of information on the fundamentals of mechanical vibrations and the properties of structural rubber, related especially to the protection of delicate equipments.

621.3.032.53 **97**

Glass-to-Metal Seal Design.—W. J. Scott. (*Electronic Engng*, Nov. 1945, Vol. 17, No. 213, pp. 764–767.) Factors which need consideration are wetting, stress, expansion, elasticity, plasticity, and shaping to avoid local stress concentrations. Excerpt from a comprehensive paper to appear in *J. sci. Instrum.*

621.315.616 : 546.287 **98**

The Application of Silicone Resins to Insulation for Electric Machinery.—J. DeKiep, L. R. Hill & G. L. Moses. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, Mar. 1945, Vol. 64, No. 3, pp. 94–98.)

Tests on silicone resins, silicone treated materials, and wire-wound apparatus treated with silicone varnish show a considerable improvement in the thermal endurance of the insulation. While further tests are required, it is suggested that this class of insulation should be differentiated from class B and C insulation, with appropriate temperature limits, so that designers may make use of its advantages. For discussion see *Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, June Supplement 1945, Vol. 64, pp. 460–462.

621.315.616 : 546.287 **99**

Organo-Silicon Compounds for Insulating Electric Machines.—T. A. Kauppi & G. L. Moses. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, Mar. 1945, Vol. 64, No. 3, pp. 90–93.) The physical and chemical properties of the silicone compounds are described. The use of these resins in place of the organic resins used as bonds, impregnants and surface treatments, gives a great improvement in the thermal stability of the insulation, the most important single factor in insulation life. For discussion see *Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, June Supplement 1945, Vol. 64, pp. 457–458.

621.315.616 : 679.5 **100**

Notes on Plastics.—J. Taylor. (*Electrician*, 16th Nov. 1945, Vol. 135, No. 3520, pp. 541–542.) The dielectric constant and power factor at high frequencies of polystyrene are both low. Its mechanical properties do not change much with temperature up to 70° C; a chlorinated compound, polydichlorstyrene, is stable up to 112° C. Polystyrene is light, water-resistant, and unaffected by weak acids, strong alkalis and many organic solvents. It has a high refractive index and good light transmission properties so is used for special lenses in light condensers and signal lamps. Styrene can be made to co-polymerise with other polymers, such as butadiene, to produce synthetic rubbers for use as wire and cable coverings.

621.315.617.3 **101**

Control of Electrical-Insulating Varnishes.—D. L. Gibson & C. H. Braithwaite. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, July 1945, Vol. 64, No. 7, pp. 520–524.) Varnishes used in the manufacture of radio equipment do not have reproducible properties unless frequent checks are made of chemical and physical properties. A suitable routine involves daily measurements of viscosity and density, and periodic chemical examination, with adequate filtration of the varnish.

621.317.35 **102**

Graphical Analysis of Complex Waves.—L. S. Cole. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 142–145.) A simple account of the Fourier analysis of a complex wave-form, giving the detail and formulae for 6-, 8-, and 12-point schedules.

621.318.22 **103**

Industry's Permanent Pull.—(*Sci. Amer.*, July 1945, Vol. 173, No. 1, pp. 36 . . 49.) Properties and uses of some modern materials used for permanent magnets.

621.385.832 **104**

Characteristics of Luminescent Materials for Cathode Ray Tubes.—(*J. Televis. Soc.*, June 1945, Vol. 4, No. 6, pp. 143–144.) Summary of a discussion by the Radio Section I.E.E., led by C. G. A. Hill.

621.386.1 : 620.179] (091) **105**

The Growth of Industrial Radiology.—L. Mullins. (*Electronic Engng*, Nov. 1945, Vol. 17, No. 213, pp. 760–763.) Within a year of the discovery of X-rays their use for industrial purposes had commenced. Advances in photographic film, and in the design of tubes have helped the subsequent growth of radiology, which was greatly accelerated during the two world wars.

MATHEMATICS

51 **106**

An Extension of the Limits of Applicability of the Small Parameter Method [for solving non-linear oscillation problems].—S. M. Rytov. (*C.R. Acad. Sci. U.R.S.S.*, 30th April 1945, Vol. 47, No. 3, pp. 181–184.)

517.512.2 : 621.317.35 **107**

Note on the Fourier Series for Several Pulse Forms.—Lattin. (*See* 116.)

531.2 **108**

The Stress Distribution in a Long Circular Cylinder when a Discontinuous Pressure is applied to the Curved Surface.—C. J. Tranter & J. W. Craggs. (*Phil. Mag.*, April 1945, Vol. 36, No. 255, pp. 241–250.)

534.131 **109**

The Oscillations of an Isotropic Elastic Sphere.—G. I. Petrashen. (*C.R. Acad. Sci. U.R.S.S.*, 30th April 1945, Vol. 47, No. 3, pp. 172–176.)

621.392.5/.6 **110**

The Application of the Characteristic Equation of a Matrix to the Evaluation of the Range of Frequencies for which Currents are passed through Networks with Four or More Terminals without Attenuation.—H. V. Lowry. (*Phil. Mag.*, April 1945, Vol. 36, No. 255, pp. 255–264.)

621.396.615.17 **111**

Theory of Synchronization of Relaxation Auto-Oscillatory Systems.—K. Theodorchik. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 2, pp. 139–143.) The general theory is worked out by König's iteration method and conditions of stable synchronisation are found by plotting some of the functions as in Lamerey's method. It is shown that the Nth order synchronisation bands can never overlap.

51 : 621.39 **112**

Applied Mathematics for Radio and Communication Engineers [Book Review].—C. E. Smith. McGraw-Hill, N.Y., 231 pp., $3.50. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 422..426.) A " refresher course for home study . . ."

518.2 **113**

Sechsstellige Trigonometrische Tafel [Book Review].—H. Brandenburg. Lorentz, Leipzig, reproduced by Edwards, Michigan, 304 pp., $5.00. (*Phil. Mag.*, Apr. 1945, Vol. 36, No. 255, p. 296.) With a list of errata by L. J. Comrie.

MEASUREMENTS AND TEST GEAR

621.317.33 : 621.315.212.1 **114**

Coaxial Cable Tests.—P. H. Ware. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 130–134.) An elementary description of the measurement of cable characteristics at relatively low radio frequencies by the open and shorted method, using series or parallel substitution in closed resonant circuits and observing the change of reading of a variable air capacitor and the change in the width of the resonance curve; or by similar substitution in a radio-frequency bridge. The relevant formulae and some typical examples are included.

621.317.35 **115**

Graphical Analysis of Complex Waves.—Cole. (*See* 102.)

621.317.35 : 517.512.2. **116**

Note on the Fourier Series for Several Pulse Forms.—W. J. Lattin. (*Proc. Inst. Radio Engrs, N.Y.*, Nov. 1945, Vol. 33, No. 11, pp. 783–784.) "Fourier-series expressions for symmetrical rectangular, triangular, and trapezoidal pulses are derived in a form from which general curves of the magnitudes of the harmonic-amplitude coefficients may be plotted. From these curves it is possible to obtain the values of the amplitude coefficients of the harmonics for any ratio of pulse duration t to cycle period T."

621.317.353 **117**

A Simple Method of Measuring Distortion in A.F. Oscillators and Amplifiers.—L. W. Smith. (*R.S.G.B. Bull.*, Nov. 1945, Vol. 21, No. 5, pp. 71–72.) The output of the amplifier is connected through a potentiometer to a bridge circuit which can be adjusted to balance out the fundamental frequency, using a high-gain amplifier with a visual indicator in the output as a detector. With the fundamental present, the same reading in the detector is obtained by adjusting the potentiometer; the two potentiometer readings give the ratio of the harmonics to the full wave.

621.317.382 **118**

Power Measurements at Very High Frequencies.—W. Maron. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 216–217.) Measurement in the range 20–40 W at 100 Mc/s by means of a 60 W 110 V lamp (resistance about 70 ohms), the brightness of which is measured by a photocell. The lamp is calibrated by low-frequency a.c.

621.317.41.029.5 : 538.221 **119**

Permeability of Iron at Radio Frequencies.—A. W. Smith, F. P. Dickey & S. W. Foor. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 268..280.)—Summary of 1603 of 1945.

621.317.7 **120**

Industrial Test Equipment Design.—T. Powell. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 135–137). A paper based on notes made during the training and supervision of a crew of repair-force men in a large ship-yard, where test gear was roughly handled. It details vulnerable features and emphasises the need for better dust and water proofing.

621.317.726 : 621.3.015.33 **121**

Transient Peak Voltmeter.—C. Ryerson & M. Aronson. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 110–111.) The amplitude of a single short pulse is determined by amplifying the transient voltage, then charging a capacitor through a diode, the holding-on action of which permits the charge to be maintained long enough for measurement by means of a balanced-bridge d.c. voltmeter equipped with a 0–200μA indicating instrument. The device has four ranges, 1, 5, 10 and 20 V full scale, and is a.c.-mains operated.

621.317.73 **122**

Reactor Measurements.—H. L. Daniels. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 146–148.) Describes a complete source and valve-voltmeter network for the measurement of the characteristics of air- or iron-cored inductors so that these characteristics are not affected by the rest of the circuit. The valve source, from which a.c. and d.c. can be derived simultaneously is arranged, by the use of current feed-back, to have an exceedingly high output impedance (2.5–90 megohms, depending on the selected current range, 0.3–50 mA) and the valve voltmeter is buffered by a cathode-follower circuit. Details of the method of measurement are given.

621.317.73.083.4.085.3 **123**

Bridge Null-Indicator.—E. W. Herold. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 128–129.) A sensitive tuned null indicator for a 1 000 c/s bridge, providing discrimination against harmonics, off-balance phase indication, visual balance indication, and over-load protection derived from delayed automatic gain-control. An input of 10 μV is sufficient to give an observable deflection on either the meter or the cathode-ray indicators.

621.317.738 : 621.385.032.2 **124**

Production Tester for Small Values of Capacitance.—L. Y. Hanopol. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 160..180.) The instrument consists of a constant-voltage source, a measuring network, and a high-impedance detector. A frequency of 465 kc/s is used, and the detector consists of a high-gain, three-stage, band-pass amplifier. An accuracy of 3 per cent. is claimed over the range 0.005 to 200 μμF. A two-page article.

621.319.4 : 621.317.372 **125**

Determining Q of Capacitors.—Pepperberg. (*See* 49.)

621.396.611.21 : 537.531 : 594.514.1 **126**

X-rays Alter Wavelength, Change Color of Gems.—(*Elect. Engng, N.Y.*, July 1945, Vol. 64, No. 7, p. 250.) A short note mentioning, *inter alia*, the use of X-ray irradiation for rapidly adjusting the frequency of a quartz crystal to a desired value.

621.396.615.12 **127**

Design of Stable Heterodyne Oscillators.—Moore. (*See* 241.)

621.396.615.17 : 621.317.755] .089.6 **128**

Time-Base Calibration.—W. W. Ludman. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 117–119.) Time-displacement linearity of oscilloscope sweep is measured at tenth-microsecond intervals by the use of a crystal-controlled multivibrator chain. The circuit described provides a sweep-triggering pulse and a constant-amplitude continuous calibrating signal.

621.396.619 : 621.396.015.17 129
Square-Wave [pulse] **Modulator for Signal Generator.**—W. R. Piggott. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 260..268.) Summary of 1536 of 1945.

621.396.67 : 621.317.384.029.56/.58 130
A Proposed Standard Dummy Antenna for Testing Aircraft-Radio Transmitters.—Stewart. (*See* 243.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

351.811 : 621.38 131
Automatic Control of Vehicular Traffic.—(*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 150..154.) Brief description of an automatic vehicle controller developed by the Northern Electric Co., Montreal. The detector, which is buried in the ground at each approach to an intersection, comprises two magnetised parallel steel bars with coil assemblies mounted so that passage of a vehicle induces a small voltage. The voltage is amplified and operates relays which control the dispatching system of lights.

535.336.2.05 : 621.389 132
Electronics of the Mass Spectrometer.—J. A. Hipple, D. J. Grove & W. M. Hickam. (*Elect. Engng, N.Y.*, April 1945, Vol. 64, No. 4, pp. 141–145.) Deals with the technique of making an automatic self-recording mass-spectrograph. A motor-driven potentiometer varies the magnetic field, and the ion current is measured by a Speedomax recorder energised through a d.c. amplifier. Automatic provision is made for increasing scanning speed when the ion current drops below a predetermined level. Two automatic devices are incorporated which enable recording to be carried out over a wide range of ion currents. A " mass-marker " calibration circuit is provided.

61 : 621.396.6 133
Medical Probe.—R. E. Ricketts. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 300..312.) A preliminary description of a portable u.s.w. transreceiver which can be used to indicate irregularities of bone and organs under the skin, and the size and placement of large organs, by utilising the effect of differences in the permittivities of tissue.

620.179.14 : 621.38 134
Crack Detector for Production Testing.—J. H. Jupe. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 114–115.) Description of a compact electronic instrument designed by Salford Electrical Instruments Ltd. The specimen is in the magnetic field of an oscillator. The induced eddy currents affect the frequency to an extent dependent on the presence of surface cracks. The instrument can indicate cracks from 0.000 5 to 0.25 inch deep.

621 : 621.395.625 135
It Pays to Listen [Detection of faults in machinery by change in characteristic noise]. (*See* 18.)

621.3.083.7 136
A Modulated-Frequency System of Telemetering.—H. E. Renfro & A. P. Peterson. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, Feb. 1945, Vol. 64, No. 2, pp. 45–47.) Two variable capacitors, having a common rotor fixed to the spindle of the primary instrument, are incorporated in the transmitter, and so arranged that the capacitance of one increases as the capacitance of the other decreases. The plates are shaped so that the edge exposure, and therefore the electrostatic torque on the rotor due to edge effect, is dependent only on the potential difference between the rotor and the stators, and is independent of the angular position of the rotor. With the same potential difference applied across each capacitor the torque is neutralised and the calibration of the primary instrument is therefore not invalidated by electrostatic torque on the rotor. The capacitors vary the frequency of two temperature-compensated oscillator circuits, between 50–49.5 kc/s, and 60–60.5 kc/s, respectively. The difference frequency is fed through a low-pass filter to an amplifier that is transformer coupled to the line to the receiver at the control station. The receiver consists of a high-frequency amplifier, a local oscillator of fixed frequency 9.9 kc/s, that gives a difference frequency of 100–1 100 c/s with the incoming signal. This is passed through a low-pass filter to an amplifier feeding a frequency meter incorporating the final indicating instrument. Six complete sets of this system have been in continuous operation for several years.

621.3.083.7 : 654.942 137
Electronics Aids Waterway Development.—E. H. Woodman. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 120–128.) A description of devices used by the U.S. War Dept. Engineering Corps. For the measurement of wave heights in breakwater and harbour studies, a vertical set of contacts is arranged so that the water short-circuits some of them. The contacts are connected to a resistance potentiometer and the current produced when constant potential difference is applied depends on the number immersed. For hydrostatic pressure measurement a cell has been developed with a diaphragm which, on flexing, changes the reactance of an iron-cored inductance, and for strain measurement, resistance-wire strain gauges are used. Associated electronic equipment is described. Some of the devices have been used for recording the deflection of road and pavement surfaces.

621.314.3 : 578.088.7 138
Biological Amplifiers.—Parnum. (*See* 45.)

621.314.3 : 578.088.7 : 621.396.822 139
Biological Amplifiers.—Parnum. (*See* 44.)

621.315.1/.5 : 621.317.3.082.78 140
Wire Splice Detector.—F. S. Hird. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 98–99.) Steel wire under test is magnetised longitudinally by passing it through a strong magnetic field. It is subsequently passed through a detector coil in which voltages are generated by the motion of the magnetic poles produced at the discontinuities. The sensitivity is such that a single-strand splice in a 14-strand cable can be detected.

621.316.313 141
Dual A-C Network Calculator.—Parker. (*See* 47.)

621.317.787.2 : 621.316.5.064.2 142
An Interval Timer for [switching-] **Arc Duration.**—J. S. Quill. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, May 1945, Vol. 64, No. 5, pp. 237–240.) Voltage appearing across the opening contacts under test starts the timing, and current disappearing from the circuit finishes it. During the

interval a capacitor charges linearly, the final voltage across it gives a measure of the arc time.

621.318.572 **143**

Electronic Counting.—Weber. (*See* 50.)

621.362 : 621.3.036.64 **144**

Electronic Control of Furnace Temperatures.—(*Elect. Engng, N. Y.*, Aug. 1945, Vol. 64, No. 8, p. 289.) See 4124 of 1945.

621.365.5 + 621.365.9 + 621.369 **145**

The Place of Radiant, Dielectric and Eddy-Current Heating in the Process Heating Field.—L. J. C. Connell, O. W. Humphreys and J. L. Rycroft. (*J. Instn elect. Engrs*, Part II, Oct. 1945, Vol. 92, No. 29, pp. 385–399. Discussion, pp. 399–402.) The paper outlines the various methods of heating available and points out the particular features of each. General formulae are given for heating and temperature distribution where possible. Tables indicate methods technically suitable and preferable for heating insulators or conductors under various conditions of rate of rise of temperature and heat penetration. Methods involving heat transfer from an external source include contact heating, natural and forced convective heating, and radiant heating using lamps or exposed resistors.

Several industrial applications are treated in detail. These include the setting of adhesives, drying of surface finishes, treatment of plastics, drying, and surface hardening of metals. Long bibliography.

621.365.5 + 621.365.92 **146**

High-Frequency Heating of Conductors and Non-Conductors.—R. M. Baker & C. J. Madsen. (*Elect. Engng, N. Y.*, Feb. 1945, Vol. 64, No. 2, pp. 50–57.) The simple theory of induction and dielectric heating is given, with its applications to various industrial processes, such as brazing, soldering, curing, case-hardening and heat-treating. Induction heating is inherently non-uniform, dielectric heating, provided the material is homogeneous, gives almost perfect uniformity in heating throughout. High-frequency heating is usually more expensive than more conventional methods, both in cost of equipment and in running costs, but it is more adaptable; it increases the speed of the process, advantageous when rapid heating is required, as in surface hardening and in continuous processes, and it is clean and compact. It can be used on materials such as iron, steel, brass, copper, wood, plastics, paper, nylon and other synthetics, rubber, and food. Electronic sources of high-frequency heat are more costly than rotating machine generators, but electronic sources permit the use of higher frequencies, an advantage in many applications, although, for a given size of material, there is an upper limit to the frequency because stationary wave patterns may be formed with consequent non-uniformity of heating.

621.365.52 **147**

Induction Heating of Moving Magnetic Strip.—R. M. Baker. (*Trans. [mon.] Amer. Inst. elect. Engrs*, April 1945, Vol. 64, No. 4, pp. 184–189.) Derivation of equations for power-factor efficiency and density of heating under all conditions. General curves illustrate the limitations of strip thickness, frequency, and density of heating. Factors controlling the choice of frequency are discussed: "At strip speeds of 1 000 feet per minute and a temperature rise of 250°C, strips thicker than 0.04 cm can be heated satisfactorily at 9 600 c/s."

621.365.52 **148**

Design of Induction-Heating Coils for Cylindrical Nonmagnetic Loads.—J. T. Vaughan & J. W. Williamson. (*Trans. [mon.] Amer. Inst. elect. Engrs*, Aug. 1945, Vol. 64, No. 8, pp. 587–592.) "Equations are presented for the calculation of the required number of coil turns to match a given power source for [single layer] solenoidal coils with coaxial cylindrical loads of non-magnetic materials in electromagnetic induction circuits. The equations apply to both solid and hollow loads. A correction factor is established for coil shortness providing the coil length is equal to or greater than the coil diameter. Also given are equations for power distribution and impedance values. The accuracy of the calculations is substantiated by experimental results."

621.365.92 **149**

A Survey of Dielectric Heating.—M. J. Maiers. (*Elect. Engng*, June 1945, Vol. 64, No. 6, pp. 210–211.)—Developments in the use of alternating electric fields (3–30 Mc/s) for heating non-conducting materials. The destruction of weevils in grain, the manufacture of plywood and other fabricated wooden articles, the dehydration of hygroscopic materials, and the cooking of food. The greatest advantage over other methods of heating is the development of heat throughout the body of the substance instead of at its surface only.

621.365.92 **150**

The Role of Frequency in Industrial Dielectric Heating.—G. W. Scott, Jr. (*Trans. [mon.] Amer. Inst. elect. Engrs*, Aug. 1945, Vol. 64, No. 8, pp. 558–562.) None of the variables in the heating equation is completely independent of frequency. As the frequency is increased the overall heating efficiency is reduced by the effect of stray capacitance the useful load capacitance decreases and the useful length of material which can be dealt with is reduced because of troubles due to standing waves. Increasing the frequency may reduce the duration of the heating cycle, but increased production rate may not be economical unless accompanied by increased volume of production. For large-scale industrial heating involving load capacitances up to 500$\mu\mu$F, and output powers as high as 100 kW, the frequency band 10–30 Mc/s will prove most useful.

621.365.92 : 679.5 **151**

Better Plastics Heating.—(*Sci. Amer.*, July 1945, Vol. 173, No. 1, pp. 22–24.) An account of high-frequency heating.

621.38 **152**

Electronics—An Industry Comes of Age.—D. D. Knowles. (*Elect. Engng, N. Y.*, Mar. 1945, Vol. 64, No. 3, pp. 106–108.) Radio, and the use in all aircraft and on all ships of detection devices developed during the war, will probably remain for some time the greatest field for the application of electronics, but others are being developed rapidly. Induction and dielectric heating increase the speed and efficiency of many processes. The use of power transmission lines to carry information saves money and material. Electrical power can be converted into any form, and switched quickly and accurately. Other applications are in specialised instruments such as the electron microscope and the mass spectrometer.

621.38 : 6 **153**
Electronic Applications in [U.S.] **Industry.**—Sommer. (*See* 213).

621.396.9 : 623.454.25 **154**
Proximity Fuse.—(*See* 89.)

629.13 : 621.38 **155**
Aviation's Electronic Requirements.—D. W. Rentzel. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. f288..300.) The requirements, for which performance desiderata are detailed, include an obstacle indicator, radio altimeter, automatic position reporter, and a means of sending written communications to aircraft.

629.13 : 621.38 **156**
Fingertip Control for Formation Flying.—D. G. Taylor & G. Volkenant. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 98–101.) Description of a pistol-grip control, which, by means of two mutually perpendicular potential dividers, introduces signals into the auto-pilot bridge circuits, thus enabling the advantages of the auto-pilot controls to be combined with effortless manual control in formation flying.

629.13 : 621.38 **157**
Flying Electronics.—V. Zeluff. (*Sci. Amer.*, June 1945, Vol. 172, No. 6, pp. 348–350.) Many electronic devices are now available for improving the safety and consistency of aviation. In commercial and private aviation these will be used for navigation, communication, accurate indication of fuel supply, warning of ice formation, landing, and collision warning.

629.13 : 621.38 **158**
Control in the Air.—(*Sci. Amer.*, July 1945, Vol. 173, No. 1, pp. 26–28.) Methods of operating flying controls, and of controlling the engine and other features of an aircraft by the use of electronic devices.

669 : 621.38 **159**
Metals by Electronics.—V. Zeluff. (*Sci. Amer.*, April 1945, Vol. 172, No. 4, pp. 210–212.) Many processes in the production of metals have been speeded up and improved by the use of electronic devices. Photoelectric cells have been used to control tipping at the mines, to regulate shearing and other processes in the mills and to detect holes in sheet metal. Photoelectric pyrometers control high temperature processes, and mercury arc rectifiers supply d.c. power to large industrial plants.

PROPAGATION OF WAVES

538.566 : 621.396.11 **160**
Diffraction of Radio Waves by Surface of Earth.—V. A. Fock. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 2, p. 150.) Summary of a paper before the Acad. Sci., U.S.S.R. A theoretical investigation assuming a homogeneous earth surface, taking account of diffraction, but neglecting ionosphere. An approximation to the exact value of the vertical field component is obtained as a function of the height of the source, the distance of the receiver, the radius and dielectric property of the earth. Well-known formulae can be obtained by reduction of the expression given. Methods are given for the numerical evaluation of the series and integrals used.

538.566.2 : 621.396.11 **161**
Experimental Investigation of the Structure of an Electromagnetic Field over the Inhomogeneous Earth's Surface.—J. Alpert & B. Gorozhankin. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 2, pp. 115–122.) The phase structure of the field over a stretch of sea near a hilly coast is investigated by a radio interferometer and a direction finder. The results are plotted as contours of equal phase velocity and show variations of as much as 0.5% in some directions at distances up to 5λ from the radiator. At distances of the order of 8λ, for all directions, the phase velocity approximates to *c*. The direction-finding errors are of different sign according to the angle of the shore line, whereas most workers have indicated that the sign of the coastal error must always be negative.

621.316.99 **162**
Grounding Principles and Practice, I.—Fundamental Considerations on Ground Currents.—Rüdenberg. (*See* 29.)

621.392 **163**
The Plane-Wave Resolution of Guided Waves.—Mackeown & Miles. (*See* 30.)

621.396.029.63/.64 **164**
Microwave Techniques.—Jenks. (*See* 185.)

621.396.11 : 523.78 **165**
"Mass Attack" on Secrets of Radio Waves.—(*Proc. Instn Radio Engrs, Aust.*, Aug. 1945, Vol. 6, No. 2, pp. 9–10.) The effects of the recent solar eclipse on the ionisation of the atmosphere were studied by observing the variation of received signal strength of long, medium and short wave transmissions over paths that passed through, or close to, the track of totality, by vertical incidence measurements of the heights of the ionised layers, by direction-finding measurements, and by radar.

RECEPTION

621.314.3 + 621.383 + 621.396.62 **166**
The State of Development and Physical Limit [of sensitivity] **of Communication Devices, Radiation Converters and Radiation Storage Devices.**—O. Schäfer. (*Naturwissenschaften*, Feb./Mar. 1944, Vol. 32, Nos. 5/13, pp. 62–68.) A comparison of the physical and practical limits of sensitivity of a number of devices for converting energy from one form to another.

The limiting sensitivity of the dark-adapted retina can be such as to enable detection of about one quantum per second per light-sensitive element. This corresponds to perception of a point light source giving a power flux at the pupil of about 10^{-16} W/cm^2, though some writers give a smaller figure. The ear can detect a continuous note at 2 000 c/s with a power flux of 10^{-16} W/cm^2. This limit is about 10 db worse than the physical limit due to thermal agitation of the air molecules against the eardrum.

The sensitivity of the condenser microphone is theoretically such as to enable the detection of impact of individual air molecules, but the practical limit of the sensitivity of microphones is set by the noise in the amplifiers with which they are associated. To overcome resistance noise alone in an amplifier, a microphone needs to deliver $4kT\Delta f$, corresponding to 10^{-16} W with $\Delta f = 10^4$ c/s, a sensitivity about the same as that of the unaided ear. Reduction of Δf to 1 c/s changes this figure to 10^{-20} W, but then the sound must last for at least one second because of the build-up time of the sharply-tuned resonator, and the mean frequency must not vary by more than $\frac{1}{2}$ c/s. This is an example of the increase of sensitivity by the use of an energy-storage device. Shot effect and other sources of receiver noise reduce the sensitivity further.

The limit of sensitivity of radio receivers depends on the noise in the amplifiers, and on cosmic and atmospheric noise. The aerial, considered alone, reaches its natural limit, as cosmic and atmospheric noise are easily detectable. In the wavelength ranges where these noises are small, telegraph signals containing about 10^{-19} Joule can be detected. At λ 10m this corresponds to a field with power flux about 10^{-23}W/cm^2, which is far smaller than the flux detectable by any other instrument or unaided sense organ. This performance is due to the aerial's property of collecting energy from an area of the wave-front equal to about $0.03\lambda^2$.

A modern alkali vacuum photocell yields about one electron per 100 incident light quanta, so that 10^3 quanta/sec is detectable assuming an adjustment time of 10 sec. With a cell requiring an exposure of 1 sec, the detectable energy flux is about 10^{-14} W/cm^2, *i.e.*, 100 times more than is needed for the eye. In low-pressure gas-filled cells in which multiplication of the current is produced by ionisation, the sensitivity is increased to about equal to that of the eye (10^{-16} W/cm^2). The light-counter can detect about 10 quanta/sec with an adjustment time of 10^{-2} sec. In storage cameras such as the iconoscope increased exposure would greatly increase sensitivity, but a limit is set by amplifier noise and by imperfection of the device itself. A television equipment is about 10^3 less sensitive than the eye. An image converter (*Bildwandler*), in which an image at an invisible wave-length (*e.g.*, infra-red) is converted to a visible image, requires 10^{11} quanta/sec per sensitive element.

A sensitised photographic emulsion has a physical limit of about one absorbed quantum per grain, but the spontaneous reduction on development of a number of the unexposed grains causes a practical limit worse by 10^2 or 10^3. For a panchromatic emulsion exposed for 1 sec through a lens corresponding to that of the eye, 10^3 times more light is needed to produce a detectable image than is needed to stimulate the eye.

621.396.029.63/.64 **167**

Microwave Techniques.—Jenks. (*See* 185.)

621.396.3 : 621.396.812.3 **168**

High-Speed Radio-Telegraphy.—Robinson : Roddam. (*See* 188.)

621.396.611.21 : 621.396.621.54 : 621.396.619.081.41 **169**

Crystal Tuned F.M. Receivers.—W. Maron. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 138–141.) The full realisation of f.m. possibilities requires a very high degree of local oscillator stability (±0.01%). The article states the case for quartz-crystal control of the local oscillator, using separate crystals for each station to be received. It gives a detailed description of an experimental receiver built to receive any of eight f.m. stations in the band 42–50 Mc/s. The crystals were of about 5 Mc/s fundamental frequency, and the fifth harmonic was used for control. Stations were selected by an 8-position switch.

621.396.611.21 : 621.396.621.54.029.6 **170**

Crystal Oscillators in F.M. and Television [receivers].—S. X. Shore. (*Communications*, Sept. 1945, Vol. 25, No. 9, pp. 54..88.) A description of some crystal plate cuts and their application in v.h.f. receivers is given and illustrated with circuit diagrams. In general, crystals are best suited to fixed-frequency working and so could be easily incorporated in press-button tuning systems. Variable-frequency crystals allowing of tuning over several hundred kc/s can be made, but are expensive and have a lower stability with temperature. Crystals can be cut so as to be easily excited to vibrate in harmonic modes. The AT cut is easier to excite than the BT cut, but with both, the frequency is limited to about 50 Mc/s by the shunt capacitance of the crystal. Continuation of 3826 of 1945.

621.396.615.12 **171**

Design of Stable Heterodyne Oscillators.—Moore. (*See* 241.)

621.396.619.018.41 : 621.396.82 **172**

Interference in F.M. Receivers.—R. N. Johnson. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 129–131.) Calculations on interference assuming an idealised frequency-modulation receiver are shown to be valid when applied to a representative commercial receiver. The type of interference considered is that which results from two signals having the same average frequency, one being considered as the desired signal, and the other as the interfering signal.

621.396.62 **173**

Radio Receiver Specifications including a Method of Specifying Performance.—A. S. McNicol. (*R.S.G.B. Bull.*, Nov. 1945, Vol. 21, No. 5, pp. 66–68.) Receiver specifications should be simplified so that the relative merit of any two receivers can be easily ascertained. A "Communications Index" could be used, based on a figure for each characteristic of the receiver, such as selectivity, sensitivity, noise equivalent, image ratio and tuning drift. Suggestions for determining these figures are given.

621.396.62 : 623.6 **174**

Army Set R107.—E. Forster. (*Wireless World*, Nov. 1945, Vol. 51, No. 11, pp. 343–344.) Comments on 3286 of 1945 by the designer of the set. On c.w. a signal of 1 μV will be heard 20 db above noise level at 3 kc/s bandwidth, and 0.4 μV for the same signal/noise ratio when the a.f. note filter is in use.

621.396.621.53 **175**

Long-Wave Converter.—H. B. Dent. (*Wireless World*, Nov. 1945, Vol. 51, No. 11, pp. 341–342.) A circuit diagram of a converter using a single triode-hexode valve, suitable for reception at 1 500 m when the receiver is tuned to 500 m.

621.396.822 **176**

Receiver Sensitivities and Noise at the Input Stage.—M. Morgan. (*Marconi Rev.*, Jan. 1945, Vol. 8, No. 76, pp. 24–31.) The noise has three components, due to the r.f. valve itself, the matching device between valve and aerial, and the aerial. It is most convenient to consider all noise sources in terms of their equivalent thermal-noise resistance because then for several sources simple addition of equivalent resistances enables the net noise to be determined. Simple equations are given for computing the value of each noise component, and typical examples for particular valves are given. Expressions are also derived for receiver sensitivity in terms of " detune " ratios.

621.396.822 : 523.7 **177**

Radio Waves from the Sun.—Southworth. (*See* 76.)

621.397.62 **178**

Separating Sound from Vision in Television Reception.—Sturley. (*See* 233.)

STATIONS AND COMMUNICATION SYSTEMS

621.314.65 : 621.396.71 **179**

High-Voltage Steel-Tank Mercury-Arc Rectifier Equipments for Radio Transmitters.—Read. (*See* 05).

621.314.65 : 621.396.71 **180**

The Application of High-Voltage Steel-Tank Mercury-Arc Rectifiers in Broadcast Transmitters —Bevan. (*See* 206).

21.39 **181**

Electrical Communication.—J. Mills. (*Sci. Mon.*, *N.Y.*, Aug. 1945, Vol. 61, No. 2, pp. 138–142.) A general descriptive account of processes entailed n electrical communication systems, generation, modulation, amplification, transmission, selection, nd demodulation, and some of the problems ssociated therewith.

21.39 : 623.6 **182**

[U.S.] **Army Ground Communication Equipment.** —R. B. Colton. (*Elect. Engng*, *N.Y.*, May 1945, Vol. 64, No. 5, pp. 173–179). Army equipment may be divided into fixed type and combat type. In base areas line telephony is primary, construction ecoming lighter and more temporary as the combat rea is approached. In the combat area radio ommunication is often the only possibility. Communication systems are organised in conformity with the military command, *e.g.* battalion communications. Various types of equipment are escribed.

21.391.1 **183**

Multichannel Communication Systems: Pre-minary Investigation of Systems based upon odulated Pulses.—F. F. Roberts & J. C. Simmonds. *Wireless Engr*, Nov. 1945, Vol. 22, No. 266, p. 538–549.) A discussion of the principles underlying communication systems involving pulse chnique, using either a line or radio transmission nk. Pulses of energy from each channel in turn re transmitted along the link, the pulse repetition equency of each channel being at least twice that of the highest frequency contained in the signals. The pulse chains may be generated either mechanically or electronically, synchronisation being effected by a regular increase in amplitude, or reversal of polarity of one of the pulses. Several methods of modulation are available :—

(*a*) Amplitude—using double grid or triode valves.

(*b*) Pulse width—using a saturated triode: this has the advantage that non-linear distortion does not affect operation.

(*c*) Delay—this involves varying the time-relationship of the pulses in the given channel, using a phase-shifting circuit, or otherwise.

A mathematical analysis of each is given, together with a discussion of the required transmitter stability. Demodulation is accomplished by means of low-pass filters, charge and discharge of capacitors, or by using double-grid tubes. The usefulness of the radio link is restricted due to cross-talk between channels, but with a line link this can be reduced to tolerable proportions.

The first of two articles.

621.395.44 **184**

The Unit Bay 1B Coaxial Cable Transmission System.—R. A. Brockbank & C. F. Floyd. (*P.O. elect. Engrs' J.*, Oct. 1945, Vol. 38, Part 3, pp. 82–87.) Continuation of 3660 of 1945 describing the more important panels of the Unit Bay.

621.396.029.63/.64 **185**

Microwave Techniques.—F. A. Jenks. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 120–127.) A survey of propagation features and of terminal equipment design. Radiation and range formulae are given and illustrated, for non-directive and directive systems. It is shown, for example, that with parabolic reflectors, a tenth of a watt at 10 cm wavelength could give a range of over 4 000 miles. There is a brief description of the application of crystal control to transmitters and of automatic frequency control, by reference to a stabilised source or to a resonant cavity, for transmission and reception.

621.396.24 **186**

Microwave Communications Chain may replace Present Radio Beam System for Aircraft.—(*Telegr. Teleph. Age*, Oct. 1945, Vol. 63, No. 10, pp. 9..35.) Enthusiastic support for the proposed (U.S.) nation-wide Raytheon microwave relay system to work in seven broad bands between 1 900 and 2 600 Mc/s. Stations would be built on mountain tops to cover up to 500 miles, and facilities for television, f.m. *etc.*, provided. See also 3378 of 1945.

621.396.24 : 621.397.26 **187**

V.H.F. Multiple-Relay Television Network.—F. J. Bingley. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 102–108.) Description of a six-station chain through which video programmes originating in Washington are broadcast in the Philadelphia area, on frequencies in the 210–236 Mc/s band. Relay stations are on four hill-top sites giving 100ft clearance over all intervening terrain. The receiving and transmitting antennae are located near to each other but in positions of zero coupling, and operate on different carrier frequencies. In each relay station a synchronising expander unit is used to counteract the compression of the synchronising signal by the non-linear characteristic of the relay transmitters in the synchronising region.

621.396.3 : 621.396.812.3 **188**

High-Speed Radio-Telegraphy.—J. Robinson : T. Roddam. (*Wireless World*, Nov. 1945, Vol. 51, No. 11, p. 343.) Correspondence on the Romac system, following 3676 of 1945, on the intelligibility of the signals in conditions of fading.

621.396.44 : 621.315.052.63 **189**

Power-Line Carrier Channels.—M. J. Brown. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, May 1945, Vol. 64, No. 5, pp. 246–250.) The use of a power cable for carrier-frequency communication requires the consideration of factors not involved if the cable is designed for power alone. The characteristic impedance must be known for satisfactory design of the coupling to it of the communications equipment. The attenuation can be calculated from formulae giving the increase in resistance due to skin effect at the carrier frequency used, but measurement shows that losses may be up to five times the calculated value, particularly where stranded conductors are installed, so an empirical formula is given. Losses also occur in the couplings to the line, in the units necessary to by-pass apparatus (*e.g.* circuit-breakers) in the line, and in the traps isolating spur lines from the carrier-frequency current. With well designed equipment these losses should be small.

621.396.44 : 621.396.619 : 621.315.052.63 **190**

A Comparison of the Amplitude-Modulation, Frequency-Modulation, and Single-Side-Band Systems for Power-Line Carrier Transmission.—R. C. Cheek. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, May 1945, Vol. 64, No. 5, pp. 215–220.) The three systems are considered with reference to their ability to meet problems of attenuation, interfering noise, and required band-width. Frequency modulation only gives an improvement in signal/noise ratio at the expense of an increased band-width. With unity deviation the gain in signal/noise ratio obtained by using frequency modulation instead of amplitude modulation is 4.8 db with a 1.5 increase in band-width. The single-side-band system only requires half the band-width needed for amplitude modulation, and the gain in signal/noise ratio is 9 db when the same power is used. The communication system as a whole can be made more flexible when single-side-band is used. Amplitude-modulated systems can be readily converted to single-side-band by the addition of the necessary units. For discussion see *Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, June Supplement 1945, Vol. 64, pp. 450–452.

621.396.6 : 621.396.619.018.41 **191**

Airline V.H.F. F.M. Systems.—T. W. Hall. (*Communications*, Sept. 1945, Vol. 25, No. 9, pp. 39..91.) A description of the Trans-Canada communication system between the mainland and Vancouver Island (48 miles). The transmitting frequencies are 95.5 and 73.5 Mc/s, the deviation ±15 kc/s, and the transmitter power 50 W.

621.396.66 **192**

Automatic Fader.—Hunter. (*See* 65.)

621.396.712 **193**

Canada's International Short-Wave Plant.—H. M. Smith. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 112–116.) The new C.B.C. installation at Sackville, New Brunswick. This site was selected to be outside the magnetically-disturbed zone. Three antenna systems have been installed beamed on Europe, South America and Australia and, by reversal, on Central America and New Zealand, Eastern Asia, and South Africa. Each system comprises several arrays for 6, 9, 11, 15, and 17 Mc/s, of the driven curtain type, with non-driven reflectors. Each curtain consists of two side-by-side vertical stacks of four horizontal elements. Two 50 kW transmitters are used, and the service started in 1944.

621.396.712 : 621.396.61 **194**

2UE Broadcasting Station.—Stevenson. (*See* 240.)

621.396.8 **195**

Slow-Speed Relaying.—W. Stockman. (*Wireless World*, June 1945, Vol. 51, No. 6, p. 175.) A proposal for reducing noise interference with communications. Record the signal, *e.g.* on steel tape, transmit from the recording at about one-fifth the natural speed, record again at the receiving station, and afterwards reproduce this recording at the natural speed. By this process modulation frequencies would be reduced during transmission, so that narrower-band equipment could be used, with consequent reduction in noise level and in the effect of selective fading.

621.396.97 + 621.397 **196**

Developments in Radio and Television.—Baker. (*See* 222.)

621.396.97 : 356.251.11 **197**

Britain's Monitoring [of enemy broadcasts] **Service.** (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 211–212.)

SUBSIDIARY APPARATUS

537.531 : 62 **198**

Discussion on " A Survey of X-rays in Engineering and Industry."—V. E. Pullin. (*J. Instn elect. Engrs*, Part I, Oct. 1945, Vol. 92, No. 58, pp. 390–395.) Discussion of 3431 of 1945.

537.531(091) **199**

The Discovery of X-rays.—J. A. Crowther. (*Electronic Engng*, Nov. 1945, Vol. 17, No. 213, pp. 755–758.)

621.526 : 621.391 **200**

The Servo Problem as a Transmission Problem.—E. B. Ferrell. (*Proc. Inst. Radio Engrs, N.Y.*, Nov. 1945, Vol. 33, No. 11, pp. 763 - 767.) The analogy between the action of a servo and an amplifier is drawn. Many mechanical problems can be dealt with using electrical circuit analysis as described by Nyquist (1932 abstracts p. 279) and Bode (4231 of 1940).

621.314.2 **201**

High-Quality Communication and Power Transformers.—E. B. Harrison. (*J. Soc. Mot. Pict. Engrs*, Sept. 1944, Vol. 43, No. 3, pp. 155–167.) Low external fields are obtained from power transformers using astatically-balanced solenoids and narrow cores. The laminations have air gaps staggered in adjacent pairs to increase permeability. The large coil surface exposed allows twice the heat to be dissipated for half the usual chassis space with 3% drop in efficiency. Power chokes have air gaps between astatic coils, for low leakage. Harmonics are eliminated by arranging clamps and bolts so that little magnetic flux passes through them. Audio chokes following this design have Qs of 70 at 1 000 c/s.

The design is given of push-pull audio transformers for wide frequency range, with excellent balance and light weight. The output transformer uses many turns to keep flux density low, and a long magnetic path to obtain correct inductance. The high-impedance primary is sectionalised to reduce distributed capacity, the leakage reactance being reduced by surrounding the core with a copper eddy-current shield. Astatic coils reduce hum pick-up 30 db. A method of vacuum impregnation is described. A screened input transformer is described attenuating external fields 90 db.

621.314.2 : 536.2 **202**

Formulas for Calculating Temperature Distribution in Transformer Cores and Other Electric Apparatus of Rectangular Cross Section.—T. J. Higgins. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, April 1945, Vol. 64, No. 4, pp. 190–194.) Formulae are derived for the temperature distribution, the naximum temperature, and the average temperaure in transformer cores and other electrical pparatus of rectangular cross section and of such eneral shape that the temperature distribution is ssentially two dimensional. The theory is applied o a numerical example and checks well with xperimental data. For discussion see *Trans.* [*mon.*] *mer. Inst. elect. Engrs*, June Supplement 1945, ol. 64, pp. 493–494.

21.314.2.08 **203**

Note on the Measurement of Transformer Turns-atio.—P. M. Honnell. (*Proc. Inst. Radio Engrs*, *Y.*, Nov. 1945, Vol. 33, No. 11, pp. 808–809.) This note shows that in many important cases he turns-ratio of iron-core transformers is given y the simple relation $N_1/N_2 = \sqrt{X_{sc1}/X_{sc2}}$, in hich X_{sc1} and X_{sc2} are the reactive components f the short-circuit primary and secondary impedace of the windings concerned."

21.314.3 : 623.6 **204**

Some Fundamental Considerations in Military mplifier Design.—S. L. Chertok. (*J. Soc. Mot. ict. Engrs*, July 1944, Vol. 43, No. 1, pp. 10–18.) utlines the requirements for shock-proof equipent operating under extreme conditions of temrature and humidity. Indicates the arrangement d design of components and the treatment of aterials. Resistance to salt-spray and splashoofing tests are described. Electrolytic capacirs and resistors are major problems. Comonents are mounted on terminal boards for easy rvicing.

1.314.65 : 621.396.71 **205**

High-Voltage Steel-Tank Mercury-Arc Rectifier uipments for Radio Transmitters.—J. C. Read. *Instn elect. Engrs*, Part II, Oct. 1945, Vol. 92, . 29, pp. 453–468. Discussion, pp. 490–494.) detailed account of the design and development equipments supplying 30–700 kW at 10–20 kV c. In all the cases dealt with arc suppression by id control is used. The effect of the circuit on me of the factors affecting backfire at high ltages is briefly discussed. For application see 6.

621.314.65 : 621.396.71 **206**

The Application of High-Voltage Steel-Tank Mercury-Arc Rectifiers to Broadcast Transmitters.—P. A. T. Bevan. (*J. Instn elect. Engrs*, Part II, Oct. 1945, Vol. 92, No. 29, pp. 469–489. Discussion, pp. 490–494.) Review of B.B.C. practice, including a description of a recent type of pumpless air-cooled equipment. Analytical and design data for various types of rectifier connection used in practice, smoothing circuits, and grid-control features.

621.315.3 (23.03) **207**

Simulated-High-Altitude Testing of Aircraft Ignition Cables and Connectors.—H. H. Race & A. M. Ross, Jr. (*Trans.* [*mon.*] *Amer. Inst. elect. Engrs*, Jan. 1945, Vol. 64, No. 1, pp. 20–25.) Ignition systems requiring from 9–12.7 kV peak must have an arc-over voltage in excess of this for efficient operation of the sparking plugs. Other sources of failure are corona cutting of the cable insulation, water-vapour condensation, and thermal deterioration of the cable insulation. An electronic interrupter to simulate the magneto has been used to investigate the behaviour of various types of cable and connector assemblies when subjected to cycles of low pressure and high temperature. It was found that neoprene-sheathed cable was considerably better than lacquered-braid cable, and that sealing of the connector by a grommet was essential.

621.315.62 : 519.283 **208**

Statistical Methods applied to Insulator Development and Manufacture.—Taylor. (*See* 255.)

621.316.578.1 : 621.385.832 **209**

Controlling Activation Schedules at Exhaust.—M. Silverman. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 180..192.) A timer used for obtaining uniformity in the production of cathode-ray tubes.

621.317.7 **210**

Industrial Test Equipment Design.—Powell. (*See* 120.)

621.317.755 **211**

Midget CRO for Maintenance Technicians.—(*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 202..206.) Can operate from mains or 12V battery, with 15W consumption. $1\frac{1}{2}$ inch diameter screen, brilliance and focusing controls, provision for intensity modulation. Plate sensitivity 4V/mm. Linear time base 20 c/s to 25 kc/s, with internal or external synchronisation. Single-stage amplifier with maximum gain 400 from 50 c/s to 10 kc/s.

621.319.42 (213) **212**

Glass-Sealed Capacitors.—V. J. Simson. (*Electronic Engng*, Nov. 1945, Vol. 17, No. 213, p. 780.) Normal types of tubular capacitor fail under tropical conditions or on long sea voyages; the glass-sealed type do not. The copper end cap requires special design to ensure that it yields slightly before breaking stresses are reached in the glass. Brief account of tests and results.

621.38 : 6 **213**

Electronic Applications in [U.S.] Industry.—W. Sommer. (*Electronic Engng*, Nov. 1945, Vol. 17, No. 213, pp. 777–779.) Nineteen thousand questionnaires were sent to subscribers to fourteen selected technical journals. An average of 21 electronic devices are used by each of the 796 firms that replied. The replies are analysed.

621.383.5 **214**

The Electromotive Force of the Selenium Barrier-Layer Photo-Cell.—R. A. Houstoun & A. F. Howatson. (*Phil. Mag.*, April 1945, Vol. 36, No. 255, pp. 279–287.) A selenium barrier-layer photo-cell may be regarded as having a constant e.m.f. which sends a current through a resistance inversely proportional to the intensity of illumination. (See 3641 of 1942 and back references.) This e.m.f. has been more accurately determined, and its variation with colour investigated. The e.m.f. usually increased from blue to red, contrary to the authors' expectations, and the effect is not explained. The effect of an applied (polarising) e.m.f. was investigated, and gave increased resistivity. The combined effect of light and polarising voltage is represented by an empirical formula with a theoretical basis over a limited range. The gain in sensitivity from the polarising voltage does not justify the extra trouble in operation.

621.386 **215**

A Modern X-ray Tube Factory.—A. G. Long. (*Electronic Engng*, Nov. 1945, Vol. 17, No. 213, pp. 772–774.) Materials must conform closely to specification, metals, for example, being spectrographically examined before acceptance as usable. High precision is required in electrode assembly. Special ventilation is provided in the glassworking section. Almost surgical cleanliness is maintained throughout, and handling reduced to a minimum during construction.

621.394.625.11 **216**

Construction of a Morse Recorder.—C. B. Pretty. (*R.S.G.B. Bull.*, Nov. 1945, Vol. 21, No. 5, pp. 72, 76.)

621.395.625.3.015.3 **217**

Frequency-Modulated Magnetic-Tape Transient Recorder.—H. B. Shaper. (*Proc. Inst. Radio Engrs, N.Y.*, Nov. 1945, Vol. 33, No. 11, pp. 753–760.) The transient is recorded on a loop of steel tape driven by a synchronous motor so that the tape makes one revolution every 0.1 sec. A carrier frequency of 10 kc/s is continuously recorded on the tape and then removed on passing the obliterating head. When a signal arrives it modulates the carrier, but also fires a thyratron that quenches the obliterator. 0.1 sec later a second thyratron quenches the carrier, leaving a completed record which is then picked up, amplified and demodulated, and then applied to an oscilloscope with a 10 c/s time-base to give a steady image on the screen. The recorder has a frequency range of 0.02 to 1 000 c/s with some response at 2 000 c/s.

621.315.5 + 621.318.4] (021) **218**

Electric Coils and Conductors [Book Review].—H. B. Dwight. McGraw-Hill, N.Y., 351 pp., $5.00. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 418..422.) Comprehensive reference work on the design of inductors, transformers and conductors.

TELEVISION AND PHOTOTELEGRAPHY

621.314.3 + 621.383 + 621.396.62 **219**

The State of Development and Physical Limit [of sensitivity] **of Communication Devices, Radiation Converters and Radiation Storage Devices.**— Schäfer (*See* 166.)

621.383.5 **220**

The Electromotive Force of the Selenium Barrier-Layer Photo-Cell.—Houstoun & Howatson. (*See* 214.)

621.396.24 : 621.397.26 **221**

V.H.F. Multiple-Relay Television Network.—Bingley. (*See* 187.)

621.397 + 621.396.97 **222**

Developments in Radio and Television.—W. R. G. Baker. (*Elect. Engng, N.Y.*, April 1945, Vol. 64, No. 4, pp. 152–155.) The problems to be faced in providing sound and television broadcast facilities throughout the United States are discussed in relation to recent technical advances. Reference is made to the potentialities of f.m. broadcasting for providing small communities with a satisfactory service. Stress is laid on the importance of "capture effect" in reducing the width of the frequency band necessary to give such a service.

621.397 **223**

Television Broadcasting Practice in America—1927 to 1944.—D. G. Fink. (*J. Televis. Soc.*, March 1945, Vol. 4, No. 5, pp. 112–118.) Long summary of 3955 of 1945.

621.397 : 654.17 **224**

The Television Committee's Report.—(*J. Televis. Soc.*, March 1945, Vol. 4, No. 5, pp. 98–99.) Summary of and extracts from the Hankey report. See also 3002 of 1945.

621.397 : 654.17 **225**

"Television Committee's Report."—R. W. Hallows. (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 207–208.) A reply to 3001 of 1945 and 228 of January criticising 2254 of 1945.

621.397.26 **226**

Scrambled Television.—(*J. Televis. Soc.*, June 1945, Vol. 4, No. 6, pp. 135, 142.) The summary of a patent which makes it possible for a television programme to be picked up by subscribers only. Regularly spaced frame synchronising signals are used for the frame scan, but irregularly spaced ones for the line scan, both at the transmitter and the receiver. Only the former are transmitted, the latter being supplied at the receiver.

621.397.3 **227**

Remarks on Colour Television.—(*J. Televis. Soc.*, Mar. 1945, Vol. 4, No. 5, p. 123.) Summary of Dr. P. C. Goldmark's evidence before the F.C.C.

621.397.5 **228**

Television "Fallacies".—C. W. Sheffield. (*Wireless World*, June 1945, Vol. 51, No. 6, p. 181.) Letter criticising 2254 of 1945.

621.397.5 **229**

Studio Technique in Television.—D. C. Birkinshaw & D. R. Campbell. (*J. Televis. Soc.*, June 1945, Vol. 4, No. 6, pp. 136–142.) Abridged version of 3961 of 1945.

621.397.5 **230**

A New Television System.—Pye, Ltd. (*Electrician*, 16th Nov. 1945, Vol. 135, No. 3520, p. 540.) Sound and television are broadcast on the same frequency by transmitting the sound during the vision "fly-back" time when no vision signals are transmitted. With the present television definition

10 125 sound pulses are transmitted per second. This system reduces the cost of the transmitter and the receiver, the possibility of interference between sound and vision in the receiver is eliminated, automatic volume control can be used to ensure a steady picture, and colour television and stereophonic sound should be easier to achieve. See also *Nature, Lond.*, 10th Nov. 1945, Vol. 156, No. 3967, p. 565.

621.397.62 **231**

The Television Receiver Sound Channel.—(*J. Televis. Soc.*, March 1945, Vol. 4, No. 5, p. 122.) Summary of discussion at meeting of Radio Section I.E.E. on 19th Dec. 1944.

621.397.62 **232**

Better Television.—(*Sci. Amer.*, June 1945, Vol. 172, No. 6, pp. 362–363.) Improvements in projection, incorporating plastic mirrors and lenses, have made possible the reproduction, at reasonable cost, of pictures which are brighter, clearer and larger than those available on pre-war sets. Other improvements are a high-voltage cathode ray tube and circuits to discriminate against noise.

621.397.62 **233**

Separating Sound from Vision in Television Reception.—K. R. Sturley. (*J. Televis. Soc.*, March 1945, Vol. 4, No. 5, pp. 100–111.) A description of the problems, and "an examination . . . of the design of the i.f. stages of a superheterodyne receiver for accepting one of several vestigial sideband television transmissions, which may be adjacent one to the other". Also, "a survey, illustrated by numerical examples, of the methods of preventing interference with the vision programme from its associated, and an adjacent, sound signal. The absorber type of filter, also used as a pick-up circuit for the associated sound programme, is treated in detail, as is the parallel resonant circuit-capacitance voltage divider, the series resonant and series-parallel resonant shunt filter. Reference is made to the possibilities of a resonant coupling in the i.f. transformer, and of cathode feedback."

621.397.62 **234**

Restorer-Circuit Operation.—Last. (*See* 67.)

654.17 **235**

The Social Function of Television.—W. H. Cazaly. (*J. Televis. Soc.*, June 1945, Vol. 4, No. 6, pp. 130–134.) Two important aspects of television are simultaneity of perception with occurrence, and the consequent psychological influence. The former can be exploited with advantage by industry, but also by unscrupulous politicians, and the latter provides satisfaction to the herd instinct by allowing wider participation in events. Television can play a big part in the drift towards co-prosperity if correctly controlled, but if not it can become "a greater curse than any that has inflicted mankind".

TRANSMISSION

621.395.44 **236**

Wide-Band Program-Transmission Circuits.—E. W. Baker. (*Elect. Engng, N.Y.*, Mar. 1945, Vol. 64, No. 3, pp. 99–103.) To utilise the high-fidelity characteristics of frequency modulation, wide-frequency-band circuits are necessary between studio and transmitter, and between network stations. The existing programme networks usually have 5 kc/s band widths, but networks with band widths of 15 kc/s or more can be supplied if required.

621.396.029.63/.64 **237**

Microwave Techniques.—Jenks. (*See* 185.)

621.396.6 : 629.13 **238**

The Marconi General Purpose Aircraft Wireless Equipment.—J. L. Scott. (*Marconi Rev.*, Jan./Mar. 1945, Vol. 8, No. 76, pp. 1–11.) The T1154/R1155 equipment is designed to provide transmission by c.w., m.c.w. and r.t. over the frequency ranges 0.2 to 0.5 and 3 to 10 Mc/s, reception over the ranges 0.075 to 0.5, 0.6 to 1.5, and 3 to 18.5 Mc/s, and direction finding over the ranges 0.6 to 1.5, and 3 to 18.5 Mc/s.

The transmitter weighing 45 lb comprises a master oscillator driving a power amplifier giving an output of 80 W on c.w. and 35 W on m.c.w. or r.t. The receiver weighing 26 lb gives an output of 50 mW with an input of about 10 μV, uses an intermediate frequency of 560 kc/s, and has a band width of 5 kc/s. The d.f. equipment includes a visual indicator consisting of a twin-needle instrument; intersection of the needles is controlled by rotation of the loop, the bearing on the loop scale being observed when the needle intersection occurs on the scale centre. Homing is carried out by locking the loop athwartships, permitting the pilot to direct the course so as to bring the needle intersection to the scale centre.

621.396.61 **239**

Stepping Up Transmitter Power from 500 W to 1 kW.—L. A. Reilly. (*Communications*, Sept. 1945, Vol. 25, No. 9, pp. 42..90.) How the power of the WSPR transmitter was increased from 500 W to 1 kW without interrupting the service. An entirely new 1 750 V power supply was needed and a complete circuit diagram of this and of the whole transmitter is given.

621.396.61 : 621.396.712 **240**

2UE Broadcasting Station.—M. H. Stevenson. (*Proc. Instn Radio Engrs, Aust.*, July 1945, Vol. 6, No. 1, pp. 3–11.) Detailed description of a 1 000 W a.m. transmitter in Sydney, N.S.W. Wavelength not stated. The aerial is a self-supporting quarter-wave radiator with a ground system of 120 radial wires each half a wavelength long.

621.396.615.12 **241**

Design of Stable Heterodyne Oscillators.—J. B. Moore. (*Electronics*, Oct. 1945, Vol. 18, No. 10, pp. 116–118.) A compensation for temperature effects to better than 10 parts in a million per degree centigrade is claimed, by balancing the negative coefficient of the inductor against a positive coefficient given by a specially-designed variable capacitor, having rotor plates of copper-plated invar and a stator with plates and separators of different metals, and ceramic end plates. Residual changes due to stray and fixed capacitances are balanced by small compensating solid-dielectric capacitors. The stabilisation is apparently relative to fairly slow drifts of ambient temperature. The oscillator has a 2 to 1 tuning range about 24 Mc/s.

621.396.615.17 **242**

Theory of Synchronization of Relaxation Auto-Oscillatory Systems.—Theodorchik. (*See* 111.)

621.396.67 : 621.317.384.029.56/.58 **243**

A Proposed Standard Dummy Antenna for Testing Aircraft-Radio Transmitters.—C. Stewart, Jr. (*Proc. Inst. Radio Engrs, N.Y.*, Nov. 1945, Vol. 33, No. 11, pp. 772–777.) The antenna consists of 35ft of coiled coaxial cable with copper cooling fins between turns, and terminating with an r.f. milliammeter or diode. Characteristics simulate those of aircraft antennae for the range 2–30 Mc/s. Maximum power dissipation 125 W.

VALVES AND THERMIONICS

537.583 : 621.3.032.216 **244**

Pulse Emission Characteristics of Oxide Cathodes.—R. L. Sproull. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 270..278.) Summary of 2642 of 1945.

621.385 + 621.386](091) **245**

Electronics and Development of Electronic Tubes.—I. E. Mouromtseff. (*J. Franklin Inst.*, Sept. 1945, Vol. 240, No. 3, pp. 171–192.) An historical survey of the development of various types of electron tubes from the earliest discharge tube, and their applications to industry. Electron Beam Tubes: the Lenard, Roentgen and cathode ray tubes were developed directly from Crookes' discharge tube. Mercury Vapour Tubes: includes a detailed description of a modern mercury arc rectifier (ignitron) and its method of working. High Frequency Tubes: development of high-power tubes for radio and industrial applications. Ultra High Frequency Tubes: description of typical u.h.f. tubes (Types 880 and 530) and applications of dielectric heating to industry. Super High Frequency Tubes: brief description of the development of the magnetron and velocity-modulated tubes, and their possible future applications. An extensive historical bibliography is given.

621.385 **246**

Valve Colour Code?—K. E. Marcus. (*Wireless World*, June 1945, Vol. 51, No. 6, pp. 181–182.) Proposed use of six colours to indicate heater voltage and current.

621.385 **247**

Recent Electron-Tube Developments.—S. B. Ingram. (*Elect. Engng, N.Y.*, Jan. 1945, Vol. 64, No. 1, pp. 22–24.) Special valves developed for carrier-system long-distance telephones, which require valves with high transconductance, low input and output capacitance, and long life with low filament consumption; and for radio-telephone systems where small transit time, duplicate anode and grid leads, and short electrode leads are needed. Thyratrons, with a mixture of mercury vapour and a rare gas, are used in regulated rectifiers for battery chargers. Cold-cathode gas-filled valves, giving many years of trouble-free service, find many applications in telephone systems.

621.385 **248**

Postwar Electron Tube Business.—W. C. White. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 92–97.) It is estimated that about ten million pounds worth of tubes of all types were manufactured annually between 1935 and 1939, and that for the immediate post-war period the annual demand is likely to be about twenty million pounds worth.

621.385.012.8 **249**

"Valve Vectors."—D. H. Parnum: K. R. Sturley. (*Wireless World*, July 1945, Vol. 51, No. 7, pp. 209–210.) Parnum criticises 2179 of 1945, and Sturley replies.

621.385.832 **250**

Characteristics of Luminescent Materials for Cathode Ray Tubes.—(*J. Televis. Soc.*, June 1945, Vol. 4, No. 6, pp. 143–144.) Summary of a discussion by the Radio Section I.E.E., led by C. G. A. Hill.

621.385.832 : 621.316.578.1 **251**

Controlling Activation Schedules at Exhaust.—M. Silverman. (*Electronics*, Sept. 1945, Vol. 18, No. 9, pp. 180..192.) A timer used for obtaining uniformity in the production of cathode-ray tubes.

621.38 **252**

Theory and Applications of Electron Tubes [Book Review].—H. J. Reich. McGraw-Hill, N.Y. & London, 2nd edn. 1944, pp. 716, $5. (*Elect. Engng, N.Y.*, May 1945, Vol. 64, No. 5, p. 205.)

621.38 **253**

An Introduction to Electronics [Book Review].—R. G. Hudson. Macmillan, N.Y., 1945, 97 pp., $3.00. (*Sci. Mon., N.Y.*, Aug. 1945, Vol. 61, No. 2, p. 158.) ". . . for the lay reader."

MISCELLANEOUS

001.891 : 6 **254**

Research—Creator of Employment.—A. W. Hull. (*Elect. Engng, N.Y.*, Jan. 1945, Vol. 64, No. 1, pp. 25–27.) Properly directed research, by developing new products and more efficient processes, promotes progress, combats unemployment, and raises the general standard of living.

519.283 : 621.315.62 **255**

Statistical Methods Applied to Insulator Development and Manufacture.—J. J. Taylor. (*Trans. [mon.] Amer. Inst. elect. Engrs*, July 1945, Vol. 64, No. 7, pp. 495–498.) Quality control in high-voltage insulator manufacture, and the use of associated scientific data for estimation and prediction purposes.

620.193.7(213) : 621.315.5 : 621.315.6 **256**

Electrolytic Corrosion—Methods of Evaluating Insulating Materials used in Tropical Service.—B. H. Thompson & K. N. Mathes. (*Trans. [mon.] Amer. Inst. elect. Engrs*, June 1945, Vol. 64, No. 6, pp. 295–299.) Laboratory tests are made with 100% relative humidity and dew at 35°C. The insulating material in sheet form is rolled round glass rods, and two coils one inch apart, each of three turns of copper wire, are wound on to it, 120 volts d.c. are applied between the coils for periods of up to 7 days, and corrosion is detected by periodic visual examination. Alternatively the current between the electrodes is measured. Typical results for a number of materials are given. An appendix deals with the factors influencing electrolytic corrosion. For discussion see *Trans. [mon.] Amer. Inst. elect. Engrs*, June Supplement 1945, Vol. 64, pp. 443–444.