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WIRELESS ENGINEER

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CONTENTS

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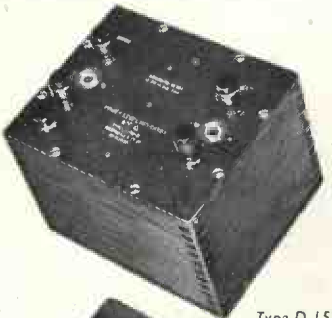
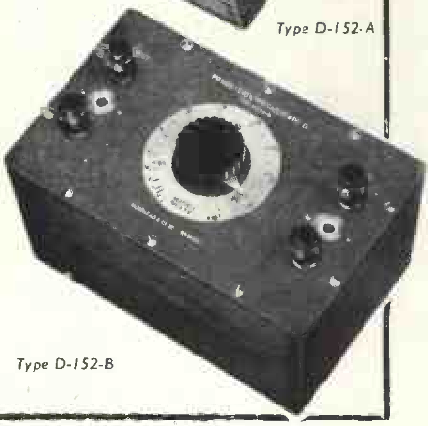


Type D-152-A



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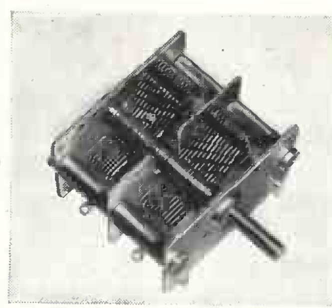

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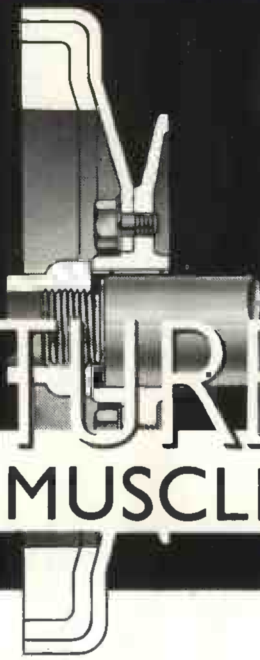

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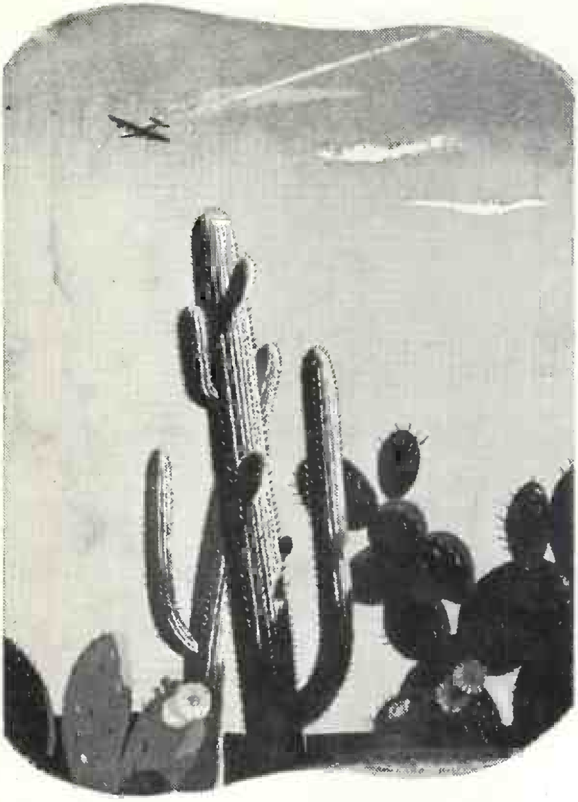

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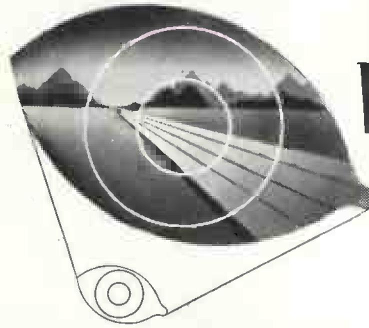

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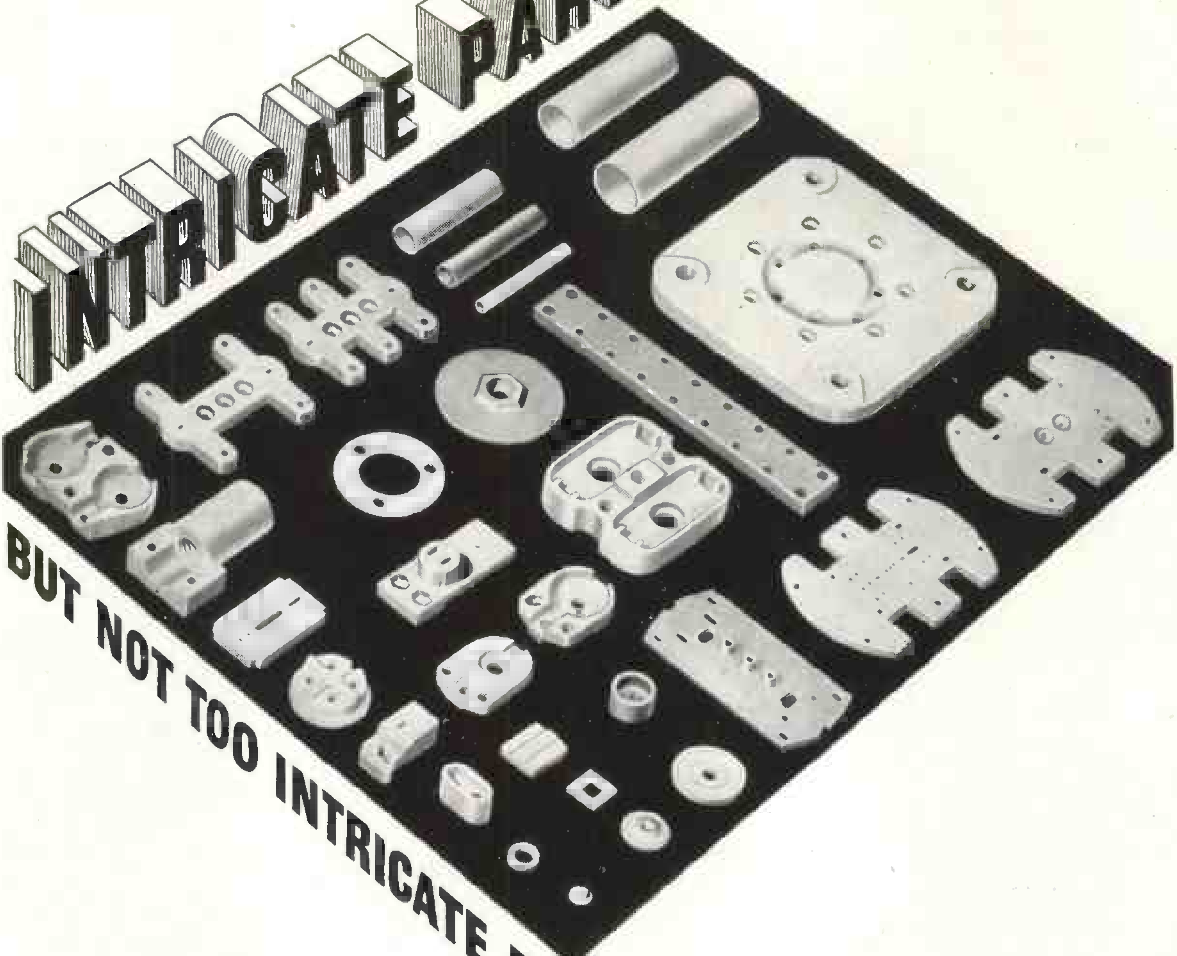

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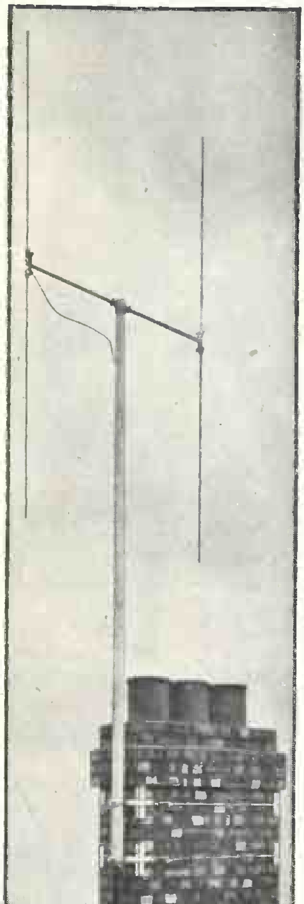

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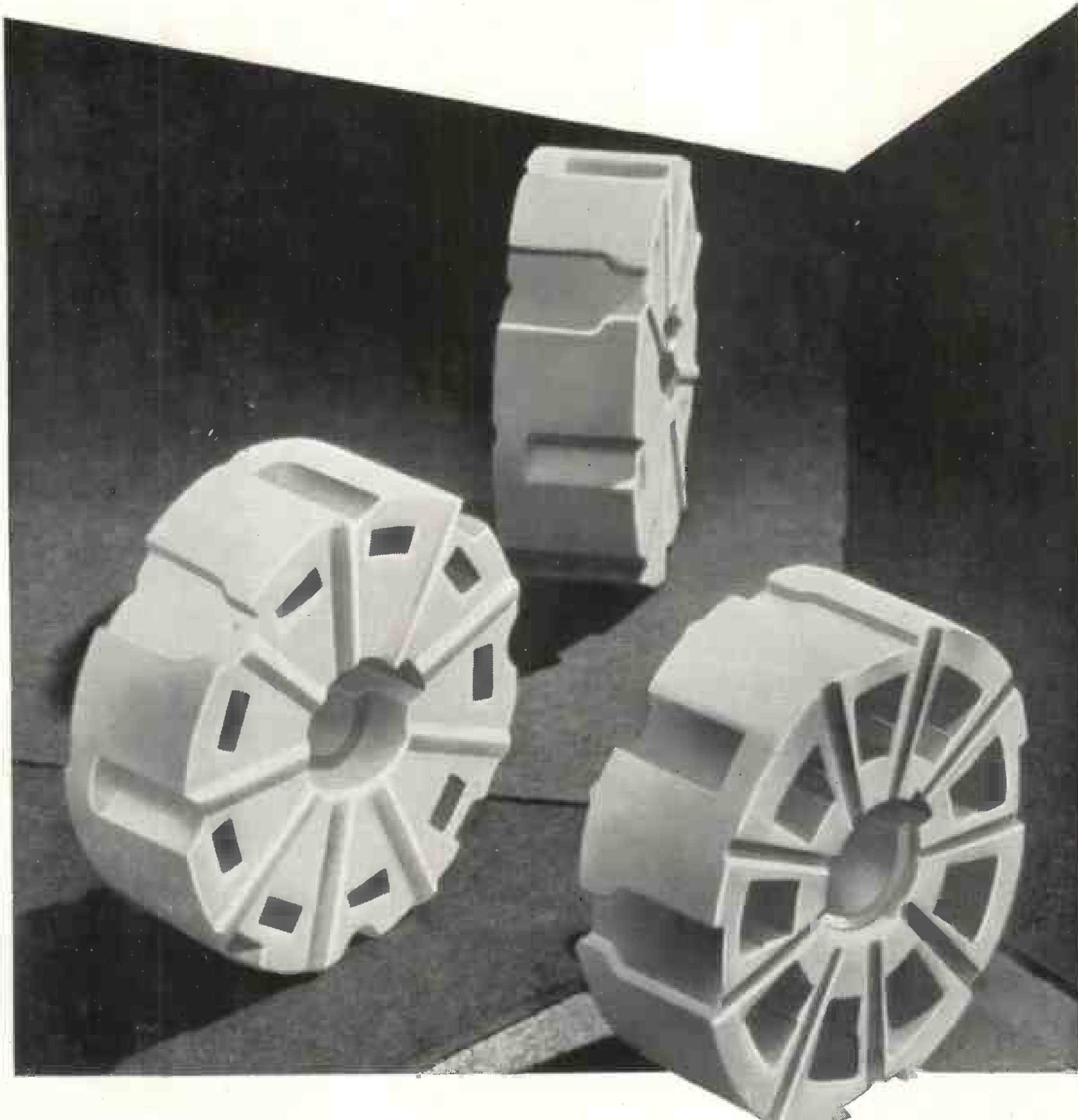

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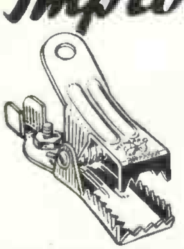

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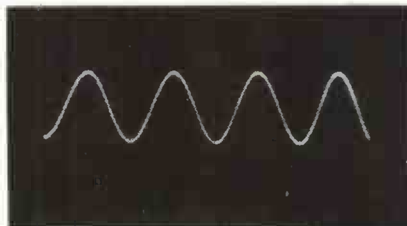

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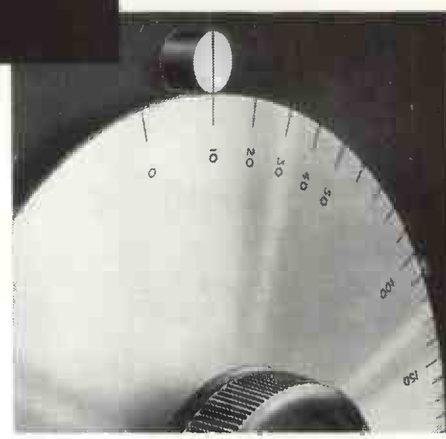

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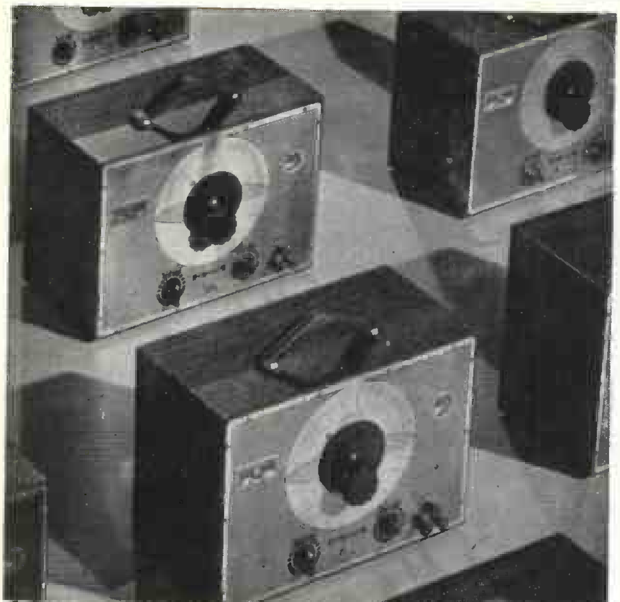

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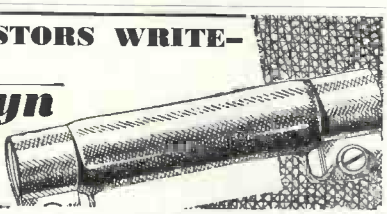

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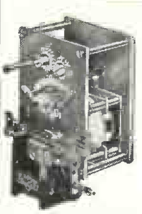

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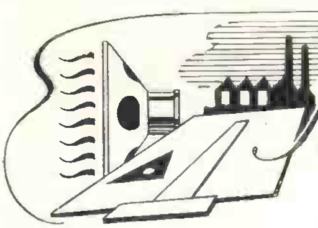

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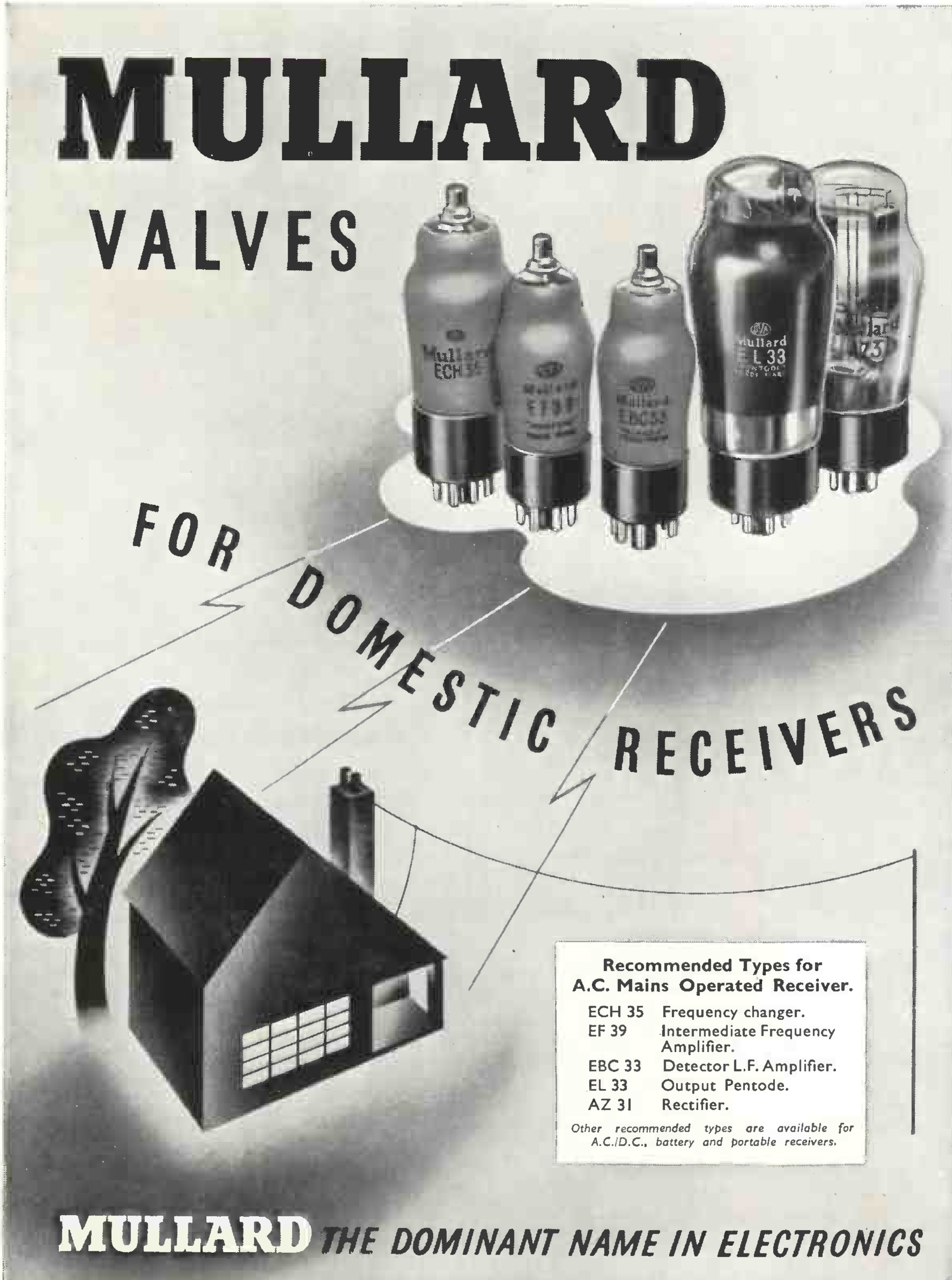

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WIRELESS ENGINEER

Editor HUGH S. POCOCK, M.I.E.E. Technical Editor Prof. G. W. O. HOWE, D.Sc., M.I.E.E.

VOL. XXII NOVEMBER, 1945 No. 266

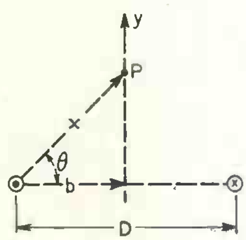
EDITORIAL

The Application of Newton's Third Law to an Electric Circuit

IN last month's Editorial we considered, among other things, a problem to which a considerable amount of attention has been paid in the past, viz., the calculation by various formulæ of the force on any portion of an electric circuit. We saw that whether one used the Biot-Savart or the Ampère formula the same result was obtained for the force on any portion of a complete circuit, and that the idea that the Biot-Savart formula involved a violation of Newton's third law was fallacious. If one considers a rectangle a few inches wide and several miles long carrying a steady current it is true that the mechanical force on the short end conductor is due to the magnetic field in which it is situated and that this magnetic field is produced mainly by the current in the wires in its immediate neighbourhood, but it does not follow that the electro-magnetic reaction is exerted on these wires. The forces on these wires are at right angles to their direction and therefore purely lateral; the reaction to the force on the end conductor can only be exerted on the conductor at the other end of the rectangle, even although it may be several miles away. This is analogous to a long straight pipe full of water; if one end be fitted with a piston and the other end closed, any force exerted on the piston can only be counterbalanced by the reaction at the far end, however long the pipe may be; the pressure on the walls is purely lateral and therefore cannot provide any longitudinal reaction. Just as the force is transmitted from end to end through the medium filling the pipe so the force in the electrical case is transmitted from end to end of the rectangle through the magnetic field which occupies the space around and within the wires. This suggests a simple way of determining the force on the end conductor. In a magnetic field in air there is not only a tensional force of $H^2/8\pi$ dynes per square centimetre in the direction of the field, but also an equal pressure at right-angles to the direction of the field, as if the lines of force were trying to push one another apart. It is by means of this that the longitudinal force is transmitted from one end of the rectangle to the other.

Total Force

If a cross-section of the line be taken at any point not too near the ends, it is a simple matter to calculate the total force, which is the integral of $H^2/8\pi$ over the cross-section, because, since the energy stored in each cubic centimetre is equal to $H^2/8\pi$ ergs, the integral gives also the energy stored in a centimetre length of the line. Now if L be the inductance of the line per centimetre and I the current in absolute units, the energy stored in each centimetre of the line is equal to 0.5 LI^2 ergs. Hence the total longitudinal force is equal to 0.5 LI^2 dynes, and this must be the force on the end conductor whatever its shape. The inductance L per centimetre is equal to $4 \log_e D/r + 1$ where D is the distance between centres and r the radius of the wires. In the example discussed in the October Editorial D/r was equal to 60, for which $L = 17.35$ and the longitudinal force therefore 8.675 I^2 dynes. This assumes that the length of the rectangle is great compared with its width; in the case in which the length was only three times the width the force would be somewhat, but very little, bigger, and it was for this case that Dunton measured the force and found it to be 8.7 I^2.



When the rectangle is very long the application of the Biot-Savart formula is simple. If it be assumed that the end conductor can be replaced by a fine wire just touching the side conductors (Fig.3(a) in Oct.Editorial), the force is $2\int_r^{59r} dx/x = 4.6 \times 1.7709 = 8.14 I^2$, whereas if it be assumed that the fine wire extends from centre to centre (Fig. 3(b) the force is $1 + 2\int_r^{60r} dx/x = 1 + 8.18 = 9.18\, I^2$. The mean of the two results obtained by these simplifying assumptions is thus 8.66 I^2, which is almost exactly the same as the correct value of 8.675 I^2 obtained from the inductance formula, the former being $\log_e 59 + \log_e 60 + 0.5$ and the latter $2 \log_e 60 + 0.5$.

All these values are increased by a little less than one per cent. if instead of being very long the rectangle has a length equal to three times the width.

Although not directly involved in the problem that we set out to discuss, it is interesting to note that the repulsive force between the parallel wires may also be determined from a consideration of the magnetic field stresses. If the figure represent a cross-section of the line, H due to one wire at a distance x from it is equal to $2I/x$, where I is in absolute units. The resultant field at any point P in the median plane due to the two wires will be in the direction y and equal to $4I \cos\theta/x$. The repulsive force at the point will be at right-angles to the field and equal to $H^2/8\pi$ dynes per square centimetre, and the total repulsive force is obtained by integrating this from $\theta = -\pi/2$ to $\theta = +\pi/2$.

$$\text{Now} \quad \int H^2 dy = 16\, I^2 \int \frac{\cos^2\theta}{x^2}\, dy$$

$$= \frac{16\, I^2}{b} \int \cos^2\theta\, d\theta = \frac{16 I^2}{b} \times \frac{\pi}{2}$$

Hence the total repulsive force $= I^2/b = 2\, I^2/D$ dynes per centimetre of length of the line, which is usually obtained much more simply by a direct application of the Biot-Savart formula.

We have discussed this elementary problem in this way in order to show 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.

G. W. O. H.

CARRIER-FREQUENCY AMPLIFIERS*

The Unit Step Response of Amplifiers with Single and Double Circuits

By C. C. Eaglesfield

(The Mullard Radio Valve Company)

SUMMARY.—A comparison between staggered single circuits and double circuits as a means of increasing the speed of carrier-frequency amplifiers. For applications such as television it is concluded that the two methods are equally effective.

CONTENTS

1. Introduction

In a previous article[1] the writer suggested that two figures should be used to summarise the response of a network to a unit step. These figures were named the "speed" and "overshoot." If the response has the same general shape as the curves in Fig. 3, the speed is defined as the maximum slope divided by the final value, and the overshoot is defined as the greatest percentage swing above the final value.

If a network or amplifier gives a step response of a certain speed, it is convenient to call this the speed of the network or amplifier, and the conception can be extended to every link of a chain which conveys intelligence, or to the complete chain.

The speed of each link and of the whole chain must be related to the type of intelligence carried, a requirement which is not exacting for certain links and certain types of intelligence. For example, in the transmission of sound, only the mechanical elements are likely to cause any difficulty. For television, on the other hand, almost every link must be considered carefully; in particular it is difficult to design a receiver combining the necessary amplification, speed, and economy.

It is such amplifiers that are considered here — carrier-frequency amplifiers. Since the number of valves must be restricted it is usual to adjust the amplifier in such a way that an overshoot is produced, a device which usually increases the speed. There are several ways of doing this: the two ways considered here are "staggered" single coupling circuits, and double circuits. By "staggered" circuits is meant circuits tuned to slightly different frequencies. The terms single and double circuit are defined in Sections 2 and 3; they are illustrated by Figs. 1 and 2.

It will be shown that both methods do increase the speed, and a comparison will be made between the two methods. The amount of overshoot that can be tolerated depends on the type of signal to be amplified: if television, then a few per cent, say five to ten. Greater overshoots are unpleasing to the eye. Therefore, to compare two methods of increasing the speed, it is essential that the overshoot be the same for each. To save setting standards of permissible overshoot, the comparison will be made at several different values of overshoot.

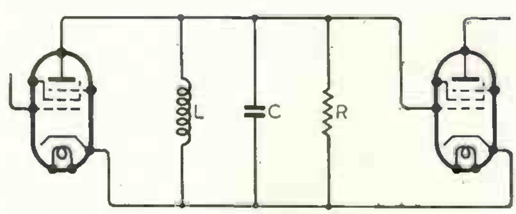


Fig. 1. *Successive valves coupled by single circuits.*

The comparison will be made between two amplifiers of the same gain.

It is implicitly assumed that with either method the capacitance is kept to a minimun in practice, so that the effective capacit-

* MS. accepted by the Editor, May 1945.

ance is the input and output capacitances of the valves plus a small amount of incidental or stray capacitance. The adjustment of tuning is supposed to be done by variation of the inductances. For the comparison the total capacitance per stage is taken the same for each case and for the double circuit it is assumed to be divided equally between the two halves.

Only symmetrical cases are considered, that is to say, where the amplitude frequency characteristic has a frequency about which the characteristic is symmetrical.

The form of test voltage is taken as this central frequency modulated by a unit step; and it is the envelope of the output voltage which is considered the effective output voltage.

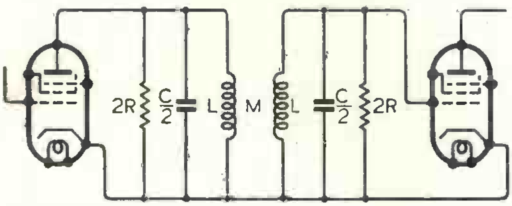


Fig. 2. *Successive valves coupled by double circuits.*

Since the problem is not very simple, approximations are introduced wherever possible; these are based effectively on the assumption that the carrier frequency is increased without limit while everything else is kept constant. This removes the carrier frequency from the results.

The first reason for these simplifications is to make the mathematics easier; a second reason, sufficient in itself, is to reduce the number of parameters.

In Section 2 an expression for the envelope of the output voltage is obtained for an amplifier with n similar valves and similar single circuits; this expression is in the form of a function defined by an operator. In Section 3 the same thing is done for double circuits, and the same function is obtained, but what might be called its order is twice as great. In Section 4 the condition is inserted that the amplifier has the same gain with single or double circuits. In Section 5 an explicit expression is obtained for the function mentioned, and in Section 6 numerical treatment of the function is given. Then in Section 7 the comparison between single and double circuits is made. Section 8 contains some remarks on the steady state characteristic, and Section 9 gives the conclusions drawn.

LIST OF MAIN SYMBOLS

n	=	Number of valves in the chain.
v	=	$(n-1)/2$.
g	=	Mutual conductance of each valve.
p	=	Differential operator d/dt (with reservations).
ω_0	=	Central angular frequency.
ω_1	=	A small increment of angular frequency.
C	=	Total capacitance per valve stage.
R_0	=	Parallel resistance across the single circuits, when all are tuned to ω_0.
a_0	=	Ratio $1/2CR_0$.
R	=	Parallel resistance across the circuits.
a	=	Ratio $1/2CR$.
k	=	Ratio ω_1/a.
V_n	=	Voltage envelope after n valves.
$F(t)$	=	A function of t defined in the text.
$J_v(t)$	=	Bessel function of the first kind of order v and argument t.

2. Single Circuits

The term single circuit is used with the meaning that the coupling impedance between successive valves is a single resonant circuit; Fig. 1 shows the effective arrangement. C and R are the same for each stage, but alternate circuits are adjusted (by appropriate values of L) to resonate to frequencies alternately higher and lower than a centre frequency, that is to say, one set of circuits resonates to one frequency, and the other set to another frequency. The difference between these frequencies and the centre frequency is assumed very small compared to the centre frequency. In addition each circuit is assumed "lightly damped," a condition that will be made explicit presently.

The form of voltage to be injected into the start of the chain is the centre frequency modulated by a unit step. What is required is the envelope of the voltage at the end of the chain.

With the Heaviside notation, which will be used throughout, the input voltage is $\cos \omega_0 t\, \mathbf{1}$, or more conveniently the real part of $e^{j\omega_0 t}\mathbf{1}$; ω_0 being the angular centre frequency.

The admittance of one of the circuits of Fig. 1 is

$$\frac{1}{R} + pC + \frac{1}{pL}$$

The impedance is thus

$$\frac{1}{C}\frac{p}{(p+a)^2+\omega^2}$$

where $a = \dfrac{1}{2RC}$ and $\omega^2 = \dfrac{1}{LC} - a^2$

Assume that a is very small compared to ω, this being the "light damping" condition.

The impedance of two successive circuits in the chain can thus be written :

$$\frac{1}{C}\frac{p}{(p+a)^2+(\omega_0+\omega_1)^2}$$

and $$\frac{1}{C}\frac{p}{(p+a)^2+(\omega_0-\omega_1)^2}$$

Assume that ω_1 is very small compared to ω_0. If "g" is the mutual conductance of each valve, and the circuit impedance is small compared to the valve anode impedance, the gain of the first two valves in the chain is

$$\left(\frac{g}{C}\right)^2\frac{p^2}{[(p+a)^2+(\omega_0+\omega_1)^2]\,[(p+a)^2+(\omega_0-\omega_1)^2]}$$

Thus with an input voltage equal to $e^{j\omega_0 t}\mathbf{1}$ (real part), the voltage at the anode of the second valve is

$$\left(\frac{g}{C}\right)^2\frac{p^2}{[(p+a)^2+(\omega_0+\omega_1)^2]\,[(p+a)^2+(\omega_0-\omega_1)^2]}e^{j\omega_0 t}\mathbf{1} \quad \text{.. .. .. ..} \quad (1)$$

The real part to be taken.

The exponential can be "shifted" outside the operator by writing $(p+j\omega_0)$ in the place of p. This is Heaviside's Shifting Theorem. The voltage then becomes :—

$$e^{j\omega_0 t}\left(\frac{g}{C}\right)^2\frac{(p+j\omega_0)^2}{[(p+a+j\omega_0)^2+(\omega_0+\omega_1)^2]\,[(p+a+j\omega_0)^2+(\omega_0-\omega_1)^2]}\mathbf{1}$$

$$=e^{j\omega_0 t}\left(\frac{g}{C}\right)^2\frac{(p+j\omega_0)^2}{[p+a+j(2\omega_0+\omega_1)]\,[p+a-j\omega_1]\,[p+a+j(2\omega_0-\omega_1)]\,[p+a+j\omega_1]}\mathbf{1}$$

$$=e^{j\omega_0 t}\left(\frac{g}{C}\right)^2\frac{(p+j\omega_0)^2}{[p+a+j(2\omega_0+\omega_1)]\,[p+a+j(2\omega_0-\omega_1)]}\;\frac{1}{(p+a)^2+\omega_1^2}\mathbf{1}$$

Now let $\omega_0\rightarrow\infty$

then $$\frac{(p+j\omega_0)^2}{[p+a+j(2\omega_0+\omega_1)]\,[p+a+j(2\omega_0-\omega_1)]}\rightarrow\tfrac{1}{4}$$

and the voltage $\rightarrow$

$$e^{j\omega_0 t}\left(\frac{g}{2C}\right)^2\frac{1}{(p+a)^2+\omega_1^2}\mathbf{1}$$

of which the real part

$$=\cos\omega_0 t\left(\frac{g}{2C}\right)^2\frac{1}{(p+a)^2+\omega_1^2}\mathbf{1}$$

so that the envelope for two valves (V_2) is

$$V_2=\left(\frac{g}{2C}\right)^2\frac{1}{(p+a)^2+\omega_1^2}\mathbf{1}$$

$$=(gR)^2\frac{1}{1+k^2}\;\frac{(1+k^2)a^2}{(p+a)^2+k^2a^2}\mathbf{1}$$

since $=\dfrac{1}{2C}=Ra$; k is written for ω_1/a

For n valves, n an even number, the procedure is exactly the same, and the envelope can be written down :—

$$V_n=(gR)^n\frac{1}{(1+k^2)^{n/2}}\left[\frac{a^2(1+k^2)}{(p+a)^2+k^2a^2}\right]^{n/2}\mathbf{1}$$

$$=(gR)^n\frac{1}{(1+k^2)^{n/2}}F_{n,k}(at) \quad \text{.. .. ..} \quad (2)$$

where $F_{n,k}(at)$ has been written for the solution of the operator in square brackets. The treatment of this function will be deferred until Section 5. Inspection of the operator suggests the following things about it : since if ap is written for p, a is removed, it is a function of at, as stated ; since for $p=\infty$ the operator $=0$, the function is zero for $t=0$; and since for $p=0$, the operator $=1$, the function $=1$ for $t=\infty$

that is, $F(0)=0$ and $F(\infty)=1$.

It may be that the direct operational method of simplifying the operator as given here, by letting $\omega_0\rightarrow\infty$, will not convince some readers. However, the result given can be established rigorously by means of contour integration. For this statement I am much indebted to Mr. D. P. Dalzell.

3. Double Circuits

The term double circuits is used with the meaning that the network connecting successive valves in the chain is made up of two identical resonant circuits coupled by a common reactance, the reactance being made capacitive or inductive according to its position so that for small values of the coupling reactance the composite circuit has a single resonance, and for values of the coupling reactance greater than a critical value the composite circuit has a double resonance. There are several well-known arrangements that behave in this way; to fix ideas the circuit of Fig. 2 will be used, but the same result would be reached if any of the other networks were used.

In Fig. 2 C is the same as the C of Fig. 1, that is, the total capacitance is the same for the two arrangements. L and R are different in value from those in Fig. 1, but to save subscripts the same symbols are used. This method of treating inferior parameters is thought to be less confusing than a mass of subscripts.

The thing to be done in this section is to obtain an expression for the envelope of the output voltage from a chain of valves in the same way as was done in Section 2, but now with the coupling circuits of Fig. 2. Similar assumptions will be made.

The stage gain is gZ, where Z can be obtained quite easily in terms of L, R, C, M. The result is found to be

$$Z = \frac{Mp}{\left[(L-M)\frac{C}{2}\left(p^2+\frac{p}{RC}\right)+1\right]\left[(L+M)\frac{C}{2}\left(p^2+\frac{p}{RC}\right)+1\right]}$$

Now write $a = \frac{1}{2RC}$

$$(\omega_0+\omega_1)^2 = \frac{2}{(L-M)C} - a^2 \qquad (\omega_0-\omega_1)^2 = \frac{2}{(L+M)C} - a^2$$

so that $$Z = \frac{4M}{(L^2-M^2)C^2}\,\frac{p}{[(p+a)^2+(\omega_0-\omega_1)^2]\,[(p+a)^2+(\omega_0+\omega_1)^2]}$$

The assumption that both ω_1 and a are much less than ω_0 requires that M be much less than L.

Hence $$\omega_0 = \sqrt{\frac{2}{LC}} \quad \text{and} \quad \omega_1 = \tfrac{1}{2}\frac{M}{L}\sqrt{\frac{2}{LC}} = \tfrac{1}{2}\frac{M}{L}\omega_0$$

Z now becomes $$Z = 4\frac{\omega_1\omega_0}{C}\,\frac{p}{[(p+a)^2+(\omega_0-\omega_1)^2]\,[(p+a)^2+(\omega_0+\omega_1)^2]}$$

Proceeding as in Section 2, the output voltage from the first valve:—

$$= 4\frac{g\omega_1\omega_0}{C}\,\frac{p}{[(p+a)^2+(\omega_0-\omega_1)^2]\,[(p+a)^2+(\omega_0+\omega_1)^2]}\,e^{j\omega_0 t}\,\mathbf{1}$$

This equation is very similar to equation (1) in Section 2, and a similar treatment reduces it to

$$je^{j\omega_0 t}\,g\frac{\omega_1}{C}\,\frac{1}{(p+a)^2+\omega_1^2}\,\mathbf{1}$$

so that the envelope after one valve is

$$V_1 = g\frac{\omega_1}{C}\,\frac{1}{(p+a)^2+\omega_1^2}\,\mathbf{1}$$

$$= \frac{g}{2Ca}\,\frac{2\omega_1 a}{a^2+\omega_1^2}\,\frac{a^2+\omega_1^2}{(p+a)^2+\omega_1^2}\,\mathbf{1}$$

$$= gR\,\frac{2k}{1+k^2}\,\frac{a^2(1+k^2)}{(p+a)^2+k^2a^2}\,\mathbf{1}$$

where $\omega_1 = ka$.

And finally, after n valves,

$$V_n = (gR)^n\left(\frac{2k}{1+k^2}\right)^n F_{2n,k}(at) \quad \ldots \quad (3)$$

Comparing equations (2) and (3) it will be seen that they differ only in the coefficient and in the order of F.

4. Equalisation of Gain

It is proposed to compare the several ways of connecting the n valves of a chain with the condition that the steady state gain is the same in all cases, that is that the value of the output envelope for $t = \infty$ is the same in all cases. Since $F(\infty) = 1$ it is only necessary to compare the coefficients in equations (2) and (3).

It is convenient to take as a standard the case of single circuits all resonant to the same frequency. Suppose a_0, R_0 refer to this case;

a_1 refers to staggered single circuits and a_2 refers to double circuits. The total capacitance C is assumed the same for all three cases.

By putting $k = 0$ in equation (2), and $F = 1$, the steady state voltage for single circuits on tune is obtained :—

$$V_n = (gR_0)^n = \left(\frac{g}{2Ca_0}\right)^n$$

Similarly for single circuits staggered, by equation (2) :—

$$V_n = \left(\frac{g}{2Ca_1}\right)^n \cdot \left(\frac{1}{1+k^2}\right)^{n/2}$$

For double circuits, by equation (3) :—

$$V_n = \left(\frac{g}{2Ca_2}\right)^n \cdot \left(\frac{2k}{1+k^2}\right)^n$$

For V_n to be the same in all three cases :—

$$a_1 = \frac{a_0}{\sqrt{1+k^2}}$$

$$a_2 = a_0 \frac{2k}{1+k^2}$$

The equations for the envelopes in the three cases therefore become

$$\left.\begin{aligned} V_n &= (gR_0)^n \,.\, F_{n,0}(a_0 t) \\ &\text{(Single circuits on tune)} \\ V_n &= (gR_0)^n \,.\, F_{n,k}\left(\frac{a_0 t}{\sqrt{1+k^2}}\right) \\ &\text{(Single circuits, staggered)} \\ V_n &= (gR_0)^n \,.\, F_{2n,k}\left(\frac{2ka_0 t}{1+k^2}\right) \\ &\text{(Double circuits)} \end{aligned}\right\} \quad \ldots \quad (4)$$

5. Explicit form of $F_{n,k}(t)$

The expression for the envelope has been left in the form of an undetermined operator

$$F_{n,k}(t) = \left[\frac{1+k^2}{(p+1)^2+k^2}\right]^{n/2} 1 \quad \ldots \quad (5)$$

where n is an even integer, and k is real. This can be simplified by "shifting" an exponential from the operator :—

$$F_{n,k}(t) = \frac{1}{p} \cdot p \left[\frac{1+k^2}{(p+1)^2+k^2}\right]^{n/2} 1$$

$$= \frac{1}{p} \cdot e^{-t} \cdot p \left[\frac{1+k^2}{p^2+k^2}\right]^{n/2} 1$$

$$= (1+k^2)^{n/2} \cdot \frac{1}{p} \cdot e^{-t} \cdot \frac{p}{[p^2+k^2]^{n/2}} 1$$

The operator on the right is a standard form, and will be found in most textbooks. See, for example, McLachlan,[2] Appendix 11, equation 35 :—

$$\frac{p}{(p^2+1)^{v+\frac{1}{2}}} 1 = \frac{\sqrt{\pi}}{2^v \Gamma(v+\frac{1}{2})} t^v J_v(t)$$

Thus writing $n/2 = v + \frac{1}{2}$; $F_{n,k}(t)$ is obtained as

$$F_{n,k}(t) = A \int_0^t e^{-t} t^v J_v(kt)\, dt \quad \ldots \quad (6)$$

$$\text{Where } A = \frac{\sqrt{2\pi k}}{\Gamma(n/2)} \left(\frac{1+k^2}{2k}\right)^{n/2}$$

In the above $J_v(t)$ is the Bessel function of the first kind and order v. Since n is an even integer $(n-1)/2$ is half an integer, so that $J_v(t)$ can be expressed as the sum of a finite number of elementary functions; but no appreciable simplification of equation (6) seems to be possible.

Two particular cases will now be considered. The first is when $k = 0$. Either from equation (6), or more easily direct from equation (5),

$$F_{n,0}(t) = \frac{1}{(n-1)!} \int_0^t e^{-t} \cdot t^{n-1} \,.\, dt \quad \ldots \quad (7)$$

$F_{n,0}(t)$ will be recognised as the incomplete gamma function, which has been tabulated up to $n = 50$ by Karl Pearson[3].

$$F'_{n,0}(t) = \frac{1}{(n-1)!} \,.\, e^{-t} \,.\, t^{n-1}$$

$$\left.\begin{aligned} \text{and } \left[F'_{n,0}(t)\right]_{\max} &= \frac{e^{-(n-1)}(n-1)^{n-1}}{(n-1)!} \\ &\sim \frac{1}{\sqrt{2\pi(n-1)}} \end{aligned}\right\} \quad (8)$$

for n large, by Stirling's formula for $n!$. Since $F(\infty) = 1$, equation (8) is an expression for the speed, as defined in the introduction. For this case there is no overshoot.

The second case is when $n = 2$. From equation (5)

$$F_{2,k}(t) = \frac{1+k^2}{(p+1)^2+k^2} 1$$

$$= \frac{1+k^2}{k} \int_0^t e^{-t} \sin kt\, dt$$

$$= 1 - e^{-t}\left(\cos kt + \frac{1}{k}\sin kt\right) \quad (9)$$

The slope is given by

$$F'_{2,k}(t) = \frac{1+k^2}{k} e^{-t} \sin kt$$

which is a maximum for $\tan kt = k$

The maximum slope is thus

$$\left[F'_{2,k}(t)\right]_{max} = \sqrt{1+k^2}\, e^{-\frac{1}{k}\tan^{-1}k} \quad (10)$$

The slope is zero for $\sin kt = 0$

$$t = \frac{\pi}{k}, \text{ etc.}$$

$$\text{Thus } \left[F_{2,k}\right]_{max} - 1 = e^{-\pi/k} \quad .. \quad .. \quad (11)$$

Equations (10) and (11) are explicit expressions for the speed and overshoot. Equation (11) shows that for $n = 2$ the overshoot is finite when $k > 0$; that this is so in the general case is shown by equation (6), which contains the oscillatory term $J_v(kt)$.

6. Numerical Treatment of $F_{n,k}(t)$

In Section 5 explicit expressions were found for the speed and overshoot of $F_{n,k}(t)$ for the particular cases of $k = 0$ or $n = 2$. For the general case explicit expressions cannot be found, and to proceed further it is necessary to change from algebra to arithmetic.

For given numerical values of n and k it is possible to obtain F numerically from equation (6), since J_v is tabulated[4] for half-integral values of v; but tables only appear to be available for integral values of the argument.

A numerical method of solution of such operators has been described by Bedford and Fredendall[5]; it has the advantage that it can be used even when an explicit solution of the operator is not available. In effect the method consists in replacing the unit step by a recurrent square waveform of unit amplitude. The square waveform can be represented by the Fourier series

$$\frac{1}{2} + \frac{2}{\pi}\left(\sin \omega t + \frac{1}{3}\sin 3\omega t + \frac{1}{5}\sin 5\omega t + \ldots\right).$$

This series converges to the value 0 for t lying between $-\pi/\omega$ and 0, and to the value 1 for t lying between 0 and $+\pi/\omega$. Thus as $\omega \to 0$ the series tends to a unit step.

Thus we get :—

$$f(p)\left[\frac{1}{2} + \frac{2}{\pi}\left(\sin \omega t + \frac{1}{3}\sin 3\omega t + \ldots\right)\right] \to f(p)\,\mathbf{1}$$

$$\text{as } \omega \to 0$$

But $f(p) \,.\, e^{j\omega t} = f(j\omega) \,.\, e^{j\omega t}$

or $f(p) \,.\, \sin \omega t =$ imaginary part of $f(j\omega) \,.\, e^{j\omega t}$

and $f(p) \,.$ constant $=$ constant $.\, f(0)$.

Therefore $\frac{1}{2} f(0)$ + imaginary part of

$$\frac{2}{\pi}\left[f(j\omega)e^{j\omega t} + \frac{1}{3} f(3j\omega) e^{3j\omega t} + \ldots\right]$$

$$\to f(p)\,\mathbf{1} \quad \text{as} \quad \omega \to 0 \quad .. \quad (12)$$

The above is more an indication that equation (12) is reasonable than a rigorous proof of it.

The advantage of equation (12) for numerical work is that with many operators an adequate approximation can be obtained with a finite value of ω which gives rapid convergence. The operator of equation (5) is of such a type, and the method will now be applied to that operator.

$$f(p) = \left[\frac{1+k^2}{(p+1)^2 + k^2}\right]^{n/2}$$

$$f(0) = 1$$

$$f(j\omega) = \left[\frac{1+k^2}{(1+j\omega)^2 + k^2}\right]^{n/2}$$

$$= \left[\frac{(1+k^2)^2}{[1+k^2-\omega^2]^2 + 4\omega^2}\right]^{n/4} e^{jn\theta/2}$$

$$\text{where} \quad \tan\theta = \frac{-2\omega}{1+k^2-\omega^2}$$

Now make the substitution $\omega = m\sqrt{1+k^2}$

Then the imaginary part of $f(j\omega)e^{j\omega t}$

$$= \left[\frac{1}{1 + 2\frac{1-k^2}{1+k^2}m^2 + m^4}\right]^{n/4} \sin(\omega t + n\theta/2)$$

$$\text{where } \tan\theta = -\frac{2}{\sqrt{1+k^2}}\,\frac{m}{1-m^2}$$

The expansion of equation (12) becomes

$$\left.\begin{array}{l}\frac{1}{2} + P_1 \sin \omega t + P_3 \sin 3\omega t + \ldots \\ \quad + Q_1 \cos \omega t + Q_3 \cos 3\omega t + \ldots\end{array}\right\} \quad (13)$$

where

$$\left.\begin{array}{l}\begin{array}{c}P_r \\ Q_r\end{array} = \frac{2}{\pi r}\left[\frac{1}{1 + 2\frac{1-k^2}{1+k^2}(rm)^2 + (rm)^4}\right]^{n/4} \begin{array}{c}\cos \\ \sin\end{array} n\,\theta/2 \\ \tan\theta = -\frac{2}{\sqrt{1+k^2}}\,\frac{rm}{1-(rm)^2} \\ \omega = m\sqrt{1+k^2}\end{array}\right\} \quad .. \quad .. \quad (14)$$

A suitable value of m has to be chosen, large enough to make equation (13) reasonably convergent, but small enough to give a sufficiently correct result: the test being that (13) should be zero for t zero or negative, or what amounts to the same thing, constant for the last part of the first half-cycle. For this case a suitable value of m was found to be

$$0.1/\sqrt{n/8}$$

Calculations were simplified by the construction of a table of sin rx, cos rx; x being at intervals of $2\pi/100$ and r ranging from 1 to 20. Thus when for numerical values of n, k, m the coefficients had been calculated, the synthesis was a simple matter, consisting merely of adding a set of products each of two previously determined numbers. A separate synthesis had to be made for each value of t, chosen to make ωt fit the intervals of the table. The coefficients were calculated to four decimal places, the intention being to obtain results correct to three decimal places. It was found sufficient to continue as far as the nineteenth harmonic.

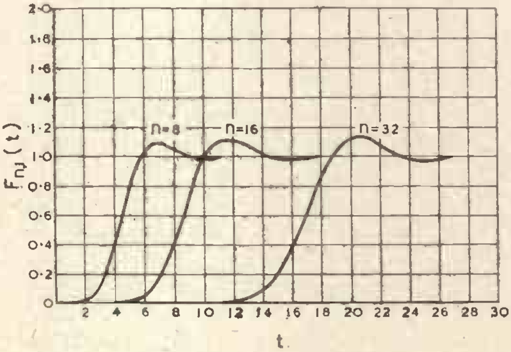


Fig. 3. *The function $F_{n,k}(t)$ for $k = 1$ and $n = 8, 16, 32$.*

TABLE I

The function $F_{n,k}(t)$ for $k = 1$, and $n = 8$, 16, 32.

$\frac{2}{\pi}\frac{t}{\sqrt{n}}$	$n = 8$	$n = 16$	$n = 32$
0	0.000	0.000	0.000
0.1	0.000	0.000	0.000
0.2	0.000	0.000	0.000
0.3	0.001	0.000	0.000
0.4	0.007	0.000	0.000
0.5	0.027	0.000	0.000
0.6	0.073	0.000	0.000
0.7	0.154	0.002	0.000
0.8	0.272	0.010	0.000
0.9	0.421	0.030	0.000
1.0	0.585	0.076	0.000
1.1	0.743	0.158	0.001
1.2	0.879	0.284	0.002
1.3	0.981	0.448	0.006
1.4	1.047	0.632	0.018
1.5	1.078	0.810	0.048
1.6	1.083	0.957	0.111
1.7	1.072	1.055	0.221
1.8	1.052	1.100	0.383
1.9	1.032	1.103	0.585
2.0	1.014	1.079	0.795
2.1	1.002	1.046	0.974
2.2	0.995	1.016	1.089
2.3	0.992	0.996	1.129
2.4	0.992	0.987	1.110
2.5	0.994	0.986	1.062
2.6	0.996	0.990	1.014
2.7	0.998	0.995	0.984
2.8	0.999	0.999	0.976
2.9	1.000	1.001	0.983
3.0	1.001	1.002	0.993
3.1	1.001	1.001	1.001
3.2	1.000	1.001	1.004
3.3	1.000	1.000	1.003
3.4	1.000	1.000	1.001

In general only sufficient syntheses were made to establish the speed and overshoot. Having straddled the overshoot, for instance, a more accurate value was obtained by interpolation. Complete syntheses were made for $n = 8, 16, 32$ and $k = 1$, and these are given in Table I and exhibited in Fig. 3. The remainder of the information obtained is given in Table II, which gives the speed and overshoot for arbitrary values of k. For the purpose in hand this is not in the most convenient form, as it is required to make comparisons at definite values of overshoot.

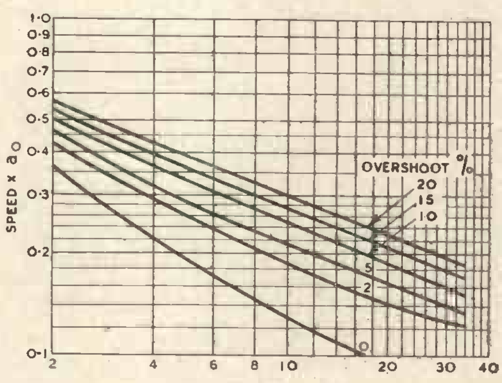


Fig. 4. *The speed of amplifier chains with single circuits, adjusted for certain values of overshoot.*

The information in Table III was obtained from Table II by interpolation. In Table III the speed and k are given for arbitrary values of overshoot.

TABLE II

The speed and overshoot of $F_{n,k}(t)$ for certain values of n and k.

n	k^2	Overshoot Per cent.	Speed
4	0	0	0.224
	1.6	2.2	0.372
	1.0	6.2	0.469
	1.667	13.8	0.633
	3.0	27.6	0.956
8	0	0	0.149
	0.6	2.6	0.271
	1.0	8.4	0.369
	1.35	14.7	0.456
	1.667	21.0	0.539
16	0	0	0.102
	0.6	2.5	0.206
	1.0	10.6	0.295
	1.35	20.9	0.386
	1.667	31.9	0.480
32	0	0	0.0715
	0.6	2.1	0.157
	1.0	13.0	0.238
	1.35	28.9	0.338

TABLE III

The speed of $F_{n,k}(t)$ and the value of k for certain values of n and overshoot.

n	Overshoot Per cent.	k^2	Speed
2	2	0.645	0.552
	5	1.100	0.670
	10	1.861	0.850
	15	2.742	1.040
	20	3.810	1.250
4	2	0.58	0.368
	5	0.89	0.442
	10	1.33	0.553
	15	1.77	0.657
	20	2.21	0.765
8	2	0.56	0.260
	5	0.78	0.314
	10	1.09	0.393
	15	1.36	0.459
	20	1.62	0.526
16	2	0.56	0.196
	5	0.74	0.235
	10	0.98	0.289
	15	1.16	0.334
	20	1.32	0.378
32	2	0.59	0.156
	5	0.71	0.179
	10	0.90	0.216
	15	1.06	0.251
	20	1.19	0.285

The figures given here are the result of quite a lot of arithmetic—it seemed so to one who is not a computer. The experience got from it has shown that the harmonic synthesis method of evaluating operators is practicable. It has two main advantages: an explicit solution is not necessary, and the greater part of the numerical work is simple and is almost a machine process.

7. Results for Single and Double Circuits

The information is now available for a comparison between single and double circuits. The envelopes for each case are given by equations (4), Section 4. The comparison will be made between two amplifier chains, each with the same number of valves (n the same), the same total capacitance per stage, the same gain, and the same overshoot. Then the ratio of the speeds for the two cases, single and double circuits, is the comparative figure.

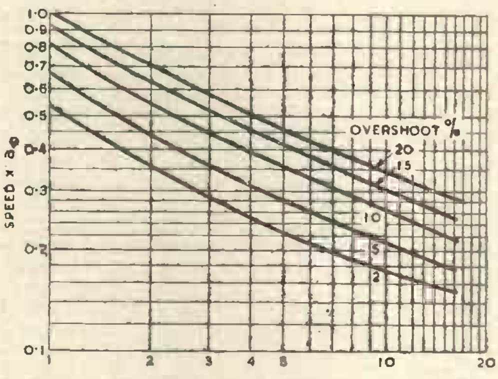


Fig. 5. *The speed of amplifier chains with double circuits, adjusted for certain values of overshoot.*

The overshoot is adjusted to the required amount by adjustment of k. This has already been done for several values of overshoot in Table III. All that remains to be done, therefore, is to multiply the speeds of Table III by the appropriate function of k, according to equations (4). One example will make this clearer.

Consider four valves ($n = 4$) coupled by double circuits, adjusted to give 20 per cent. overshoot. By equation (4), F_{2n}, i.e., F_8 is required.

From Table III, $k^2 = 1.62$ and speed $= 0.526$

$$\text{Thus required speed} = 0.526 \frac{2k}{1 + k^2} a_0 = 0.511\ a_0$$

Table IV gives the speed with single and double circuits for several values of overshoot and n, in terms of a_0. Figs. 4, 5, exhibit these results, and Fig. 6 gives the relative speed of double and single circuits.

To use Table IV for a practical case, the procedure is as follows. Given the total gain required, the number of valves and their mutual conductance, the capacitance per stage, and the permissible overshoot :—

R_0 is given by $(gR_0)^n = \text{Gain}$

a_0 is given by $a_0 = \dfrac{1}{2R_0C}$

Speed is given by Table IV in terms of a_0. If the required speed is given rather than the number of stages, a trial and error process will decide n.

TABLE IV

The speed of amplifier chains with single and double circuits, adjusted for certain values of overshoot. For each value of n the gain is the same for the three cases. The figures for speed are to be multiplied by a_0.

n	Speed of Single Circuits on tune	Overshoot Per cent.	Speed of Single Circuits staggered	Speed of Double Circuits
1	1	2		0.539
		5		0.669
		10		0.810
		15		0.920
		20		1.015
2	0.3679	2	0.430	0.355
		5	0.462	0.441
		10	0.503	0.547
		15	0.537	0.631
		20	0.570	0.708
4	0.2240	2	0.293	0.249
		5	0.321	0.311
		10	0.362	0.393
		15	0.395	0.453
		20	0.427	0.511
8	0.1490	2	0.208	0.188
		5	0.235	0.232
		10	0.272	0.289
		15	0.299	0.333
		20	0.325	0.374
16	0.1024	2	0.157	0.151
		5	0.178	0.176
		10	0.205	0.216
		15	0.227	0.251
		20	0.248	0.284
32	0.0715	2	0.124	
		5	0.137	
		10	0.157	
		15	0.175	
		20	0.193	

Fig. 6 shows that the comparative speed crosses the unity line at about 6 per cent. overshoot for n lying between 2 and 16. Thus if the permissible overshoot is less than 6 per cent., single circuits are better ; if, greater than 6 per cent., double circuits are better. The permissible overshoot depends,

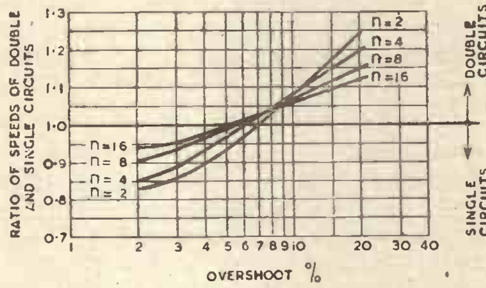


Fig. 6. *The ratio of the speeds of double and single circuits as a function of overshoot.*

of course, on the application ; e.g., for amplification of television signals it is probably about 6 per cent., in which case there would be nothing to choose between single and double circuits.

8. Identification of k by the Steady State Characteristic

So far the emphasis has been on the shape of the output envelope resulting from a given adjustment of the amplifier chain, and this adjustment has been expressed by the parameter k. The converse problem, to calculate the various impedances making up the circuits so as to give a certain value of k, is straightforward ; but in any practical case errors are certain to accumulate, and the final adjustment is best done experimentally.

Many designers are accustomed to think in terms of the amplitude—frequency characteristic of an amplifier in the steady state condition. The most obvious thing about this characteristic for the circuits considered is that it can have twin peaks, and it is usual to take the ratio of the gain at the peaks to the gain at the centre as a measure of the adjustment. It is not difficult to show that this ratio is

$$\left.\begin{array}{ll}\left[\dfrac{1+k^2}{2k}\right]^{n/2} & \text{for single circuits} \\ \left[\dfrac{1+k^2}{2k}\right]^{n} & \text{for double circuits}\end{array}\right\} \quad \ldots \quad (15)$$

provided $k \geqslant 1$. For $k < 1$ the characteristic has only a single peak. $k = 1$ is thus a critical value for the amplitude—frequency characteristic, at which it changes from a single to double peaks.

It is worth emphasising that whereas there is a critical value of k for the amplitude-frequency characteristic, there is no critical value of k for the overshoot. It has been shown in section 5 that if $k > 0$ there is an overshoot. Due to this discontinuity in the one case, there is no possibility of obtaining a simple relation between the overshoot and the peak to centre ratio.

9. Conclusions

The relative efficacy of staggered single circuits and double circuits as means of increasing the speed of an amplifier has been shown to depend on the permissible overshoot. Only if rather a large overshoot is permitted do double circuits show an improvement. For practical purposes it may be concluded that double circuits are no better than single circuits. The choice must, therefore, depend on other factors, such as rejection of interference on adjacent channels, and ease of design and convenience of adjustment. Clearly double circuits will give greater rejection, other things being equal; equally clearly, single circuits are easier to design and adjust. The figures given should be sufficient for the design of amplifiers, up to any likely number of stages.

The author is grateful to The Mullard Radio Valve Company for permission to publish this article.

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[3] Karl Pearson. Tables of the Incomplete Γ-Function.
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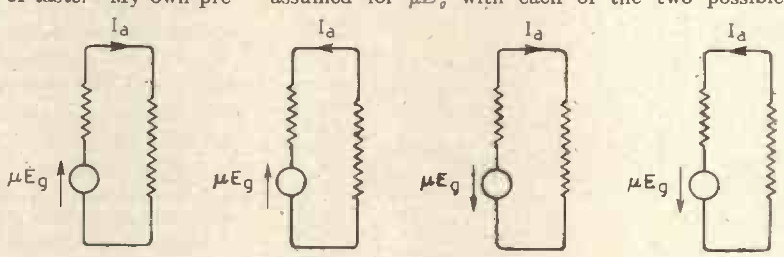
CORRESPONDENCE

Valve Vectors

To the Editor, "Wireless Engineer."

SIR,—Dr. Sturley's letter on Valve Vectors in your August issue, based on my comparison of two possible sign conventions, shows that correct results may be obtained whatever convention is used and that the choice is a matter of taste. My own preference is to make the fictitious E.M.F. μE_g act in such a direction that it produces a current in the same direction as the H.T. battery. This assumption leads to the following results: (1) The same sign convention is used for the alternating and the steady currents in the anode circuit, so that the total current at any instant may be found by summation. (2) μE_g and E_g have the same sign and appear in phase on a vector diagram. In Sturley's diagrams they have the same sign but appear 180° out of phase. This feature is liable to puzzle students, unless it is realised that the moduli $|E_g|$ and $\mu|E_g|$ are implicitly understood. (3) If the P.D. across the load (E_0) increases, the anode voltage (E_a) decreases by an equal amount. In Sturley's convention the anode voltage variation E_a is equal to the change in P.D. across the load owing to the choice of positive direction for current variation. This again is likely to be confusing for students. In his letter Dr. Sturley states correctly that his convention involves reversing his fictitious anode current I_a' to get the actual alternating anode current I_a. He goes on to say that in my convention the "alternating anode voltage component E_0" must be reversed in order to get the actual anode-cathode voltage E_a. This statement is not correct, because E_0 was defined as the alternating P.D. *across the load* in my scheme.

The use of various sign conventions is made clearer by taking further an idea suggested by the Editorial in the September issue of *Wireless Engineer.* Four possible conventions are obtained by combining each of the two possible directions assumed for μE_g with each of the two possible directions assumed for I_a. These possibilities are represented in the diagrams; (*a*) represents Sturley's convention and differs from Terman's, which is represented at (*c*) provided μE_g is replaced by the equivalent $-\mu E_g$ acting in the opposite direction. (*d*) is used by Howe, Emrys Williams and others and is my own preference. It will be seen that (*b*) and (*c*) necessitate a negative sign in the equation relating current and E.M.F. since the positive directions assigned to these quantities are opposite in direction round the circuit.

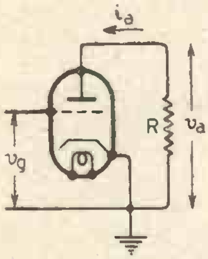


(a) (b) (c) (d)

Cardiff. R. G. WOOD.

To the Editor, "Wireless Engineer."

SIR,—It may save authors some trouble to be told that any convention may be used in valve circuits (is it also permissible to "put a minus sign in Ohm's law"?) but it will not help the reader, and particularly the student, to solve his own problems. The purpose of this note is to state the case for using one particular convention because it alone is consistent with the context of the



$$i_a = \frac{\mu v_g}{R+R_a}$$

$$v_a = -Ri_a = -\mu v_g \frac{R}{R+R_a}$$

Fig. 1.

problem. The conditions which should be satisfied by a valve circuit convention include the following :

(*a*) It must accord with the fact that a valve is a passive device, i.e. all currents flowing through it are due to externally applied E.M.F.'s. (This will determine the sign of μ.)

(*b*) Since the cathode is a common earth point in so many circuits, both grid and anode potentials must be reckoned as potentials from cathode. (This excludes the expression of the output as a cathode-to-anode potential.)

(*c*) The positive phase of the alternating anode current must be that which adds to the steady current. (How embarrassing, if one works to the opposite convention, to find that on increasing the amplitude of the signal input, the instantaneous anode current falls to zero on *positive* peaks of the alternating component of current.)

The μ of a valve should be defined by the behaviour of the valve itself, not of a particular circuit in which the valve may sometimes be used. The anode current of a triode is a function of both anode and grid potentials, and there is a fixed equivalence between the two such that the general expression for anode current can be written as

$$I_a = f(V_a + \mu V_g) \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

This shows that μ is a positive quantity, since increase in the (positive) value of either V_a or V_g will increase I_a. In fact, the function f approximates to a 3/2 power law, but if one considers only small changes about a suitably chosen operating condition there is an approximately linear relation between the changes, and representing changes by lower-case symbols,

$$i_a = (v_a + \mu v_g)/R_a \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Since (2) is a direct first-order (linear) approximation to (1), condition (*a*) is automatically satisfied, as also are (*b*) and (*c*). If now, in an actual circuit, v_a is derived from a source of E.M.F. e_a in series with a resistance R, we have the relation $v_a = e_a - Ri_a$; and substituting this in (2) gives

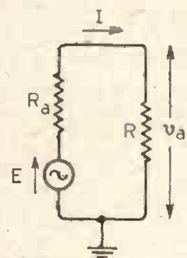
$$i_a = (e_a - Ri_a + \mu v_g)/R_a \quad \ldots \quad \ldots \quad (3)$$

The voltage v_a, measured from the cathode, is also the output voltage, so that the latter is $e_a - Ri_a$: but in a normal amplifier circuit, $e_a = 0$, so that the output voltage is $- Ri_a$. This is where the minus sign first enters into the anode circuit ; and it is introduced legitimately, without any violence to Ohm's law, as a result of the fact that the valve is a *passive* circuit element. Straightforward algebraical manipulation of equation (3) then yields the familiar result

$$\text{Output voltage} = -\mu v_g \cdot \frac{R}{R + R_a} \quad \ldots \quad (4)$$

This leads to the equivalent circuit in which the valve is *replaced* by a fictitious generator of E.M.F. $-\mu v_g$ in series with a resistance R_a. But note that the valve is *replaced* by the equivalent circuit : equation (4) describes the action on the external circuit only, and has nothing to say about the internal working of the real valve. It does, however, give the same direction of current in the external circuit as equations (2) and (3) which relate to the valve, and therefore satisfies condition (*c*).

This is the point which seems to have been missed in the recent British discussion (though it has been mentioned by Terman in a discussion in *Proc. I.R.E.*) : you cannot have both the valve and the equivalent circuit, and you would have no right to complain even if the current inside the equivalent circuit appeared to differ from that



$$E = -\mu v_g$$

$$I = \frac{E}{R+R_a} = \frac{-\mu v_g}{R+R_a}$$

$$v_a = RI = -\mu v_g \frac{R}{R+R_a}$$

Fig. 2.

inside the valve. But in Fig. 1 i_a reckoned anticlockwise round the circuit is equal to $\mu v_g/(R + R_a)$; while in Fig. 2, I reckoned clockwise round the circuit is equal to *minus* $\mu v_g/(R + R_a)$. Clearly the current is in fact exactly the same in both cases, and they unite in corresponding with equation (4) for the output voltage.

The algebraical substitution on (4) of the relation $g_m = \mu/R_a$ leads at once to the equivalent current-generator circuit representing the equation

$$\text{Output voltage} = -g_m v_g \cdot \frac{RR_a}{R + Ra} \quad \ldots \quad (5)$$

In the past, your Editorial page has often served as an arbiter in matters of radio symbols and conventions. To say that every author may have his own child, as implied in your September Editorial, is not even a "Judgment of Solomon," and I hope you will continue to review this problem until a definite conclusion is reached.

London, N.21. D. A. Bell.

Technical Library

THE extension of Lewis's lending library by the inclusion of Medical and Scientific books in foreign languages is under consideration. Its possibility is dependent on there being an extensive demand for such books, and in order to estimate this the firm has prepared a questionnaire, which is being circulated to subscribers.

Others interested can obtain a copy from 136, Gower Street, London, W.C.1.

The Extended Employment of THÉVENIN'S THEOREM*

By A. Lee, M.A., M.I.E.E., and D. K. C. MacDonald, M.A., A.Inst.P., Grad.I.E.E.

(Military College of Science)

THE use of Thévenin's theorem† whereby a circuit composed of linear elements is replaced for the purposes of analysis by the output impedance (measured across the two relevant terminals) in series with a generator of voltage equal to the open-circuit voltage measured across these terminals, and the use of the allied "constant-current" theorem (sometimes quoted as "Norton's theorem"), appear often to be restricted in general use to "steady-state" analyses. A well-known example of this use is the replacement of a triode valve, for the purpose of analysis of the anode output circuit, by an impedance equal to the anode slope resistance (at low frequencies) in series with a generator providing a voltage of magnitude μv_i, where v_i is the input signal measured between grid and cathode.

It is the intention here to show by a number of examples how Thévenin's theorem can frequently be of service in obtaining rapid results in so-called "transient" problems. It is also shown how "initial conditions" may readily be included in certain cases. It is appreciated that these problems are all soluble quite generally by the use of operational calculus, in particular the employment of the Laplace Transform. There are, however, many who, though on the one hand familiar with Thévenin's theorem, on the other find it difficult to acquire facility in the use of the Laplace method or are otherwise unfamiliar with it. The problems are also soluble by the general application of standard Linear Differential Equation theory through determination of the Particular Integral and Complementary Function, but solution is frequently tedious by this approach. It should be noted that the analysis of the problems discussed here has been set out in detail, but moderate practice enables rapid solution to be achieved.

The examples chosen are of a type which are suggested in particular by problems arising in simple dielectric theory, but have also application in time-base analysis, etc.

It is first assumed that the solution to the problem depicted in Fig. 1‡ is well-known. The condenser is discharged and the switch is closed at $t = 0$.

On closing the switch at $t = 0$:

$$i = \frac{E}{R}\epsilon^{-t/T} \quad (T = RC)$$

$$v_R = E\epsilon^{-t/T}$$

$$v_c = E\{1 - \epsilon^{-t/T}\}$$

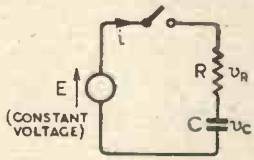


Fig. 1 (*Left*).

Fig. 2 (*Right*).

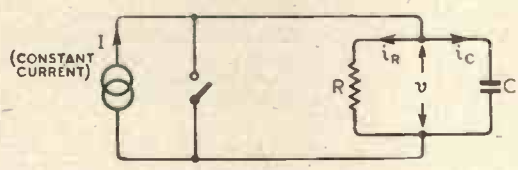


Fig. 2 presents a rather similar problem, the solution of which will be found useful in problems of the type to be discussed.

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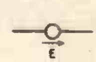
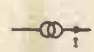
* MS. accepted by the Editor, June 1945.

† This is the common designation of the theorem, but more correctly it should be ascribed to Helmholtz (1853). (See Editorial, *Wireless Engineer*, July 1943.)

‡ The following conventions have been adopted:



represents a generator of electromotive force E in the direction indicated and of negligible impedance.



represents a generator maintaining a constant current I through its terminals where the arrow indicates the direction of flow.

On opening the switch at $t = 0$:

$$v = IR\{1 - \epsilon^{-t/T}\} \quad (T = RC)$$

$$i_c = I\epsilon^{-t/T}$$

$$i_R = I\{1 - \epsilon^{-t/T}\}$$

Now consider the circuit of Fig. 3 (*a*).

In computing v_1, the circuit apart from C (which is to be regarded as an external element), may be analysed by the application

A similar example is shown in Fig. 4 (*a*) and its "development" in Figs. 4 (*b*) and 4 (*c*).

Again from Fig. 4 (*c*) it follows that:

$$v_1 = \frac{EC_2}{C}\epsilon^{-t/T} \quad (T = RC = R(C_1 + C_2))$$

$$v_2 = E - v_1 = E\left\{1 - \frac{C_2}{C}\epsilon^{-t/T}\right\}$$

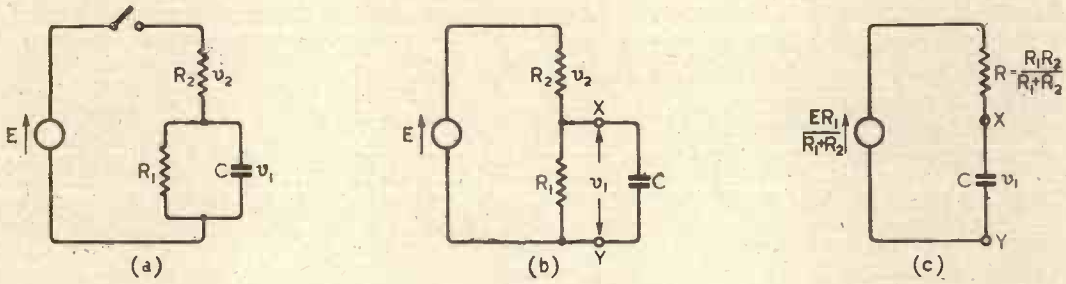


Fig. 3.

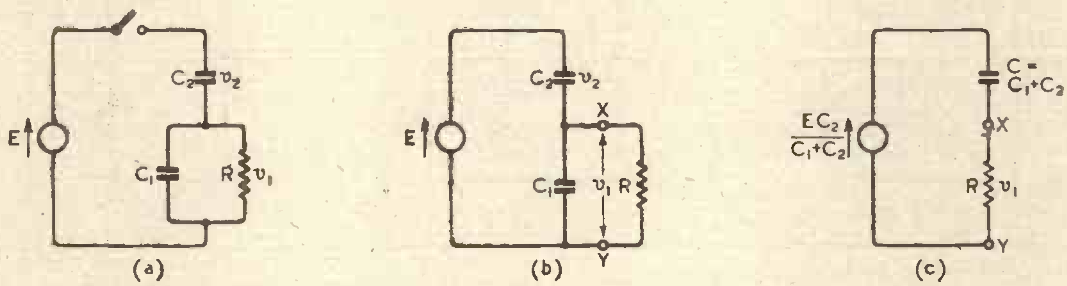


Fig. 4.

of Thévenin's theorem as illustrated by Figs. 3 (*b*) and 3 (*c*).

In these figures X and Y are the "relevant terminals" referred to above. From Fig. 3 (*c*) it immediately follows that

$$v_1 = \frac{ER_1}{R_1 + R_2}\left\{1 - \epsilon^{-t/RC}\right\} = \frac{ER}{R_2}\left\{1 - \epsilon^{-t/T}\right\}$$

$$\left(T = RC = \frac{R_1 R_2}{R_1 + R_2} C\right)$$

$$\therefore v_2 = E - v_1$$

$$= E\left\{1 - \frac{R_1}{R_1 + R_2} + \frac{R_1}{R_1 + R_2}\epsilon^{-t/RC}\right\}$$

$$= \frac{E}{R_1 + R_2}\left\{R_2 + R_1\epsilon^{-t/RC}\right\} = E\left\{\frac{R}{R_1} + \frac{R}{R_2}\epsilon^{-t/T}\right\}$$

It should be noted that in drawing the "equivalent" circuit, the fact that the "time-constant" is $T = RC$ is appreciated immediately. The general operational approach does not always disclose such information so readily.

At this point it may be of interest to indicate how initial conditions can be introduced. Let it be assumed that initially the voltage on $C_1 = V_1$. Then, by application of Thévenin's theorem to the condenser itself or by examination of the relevant differential equation, it may be seen that the

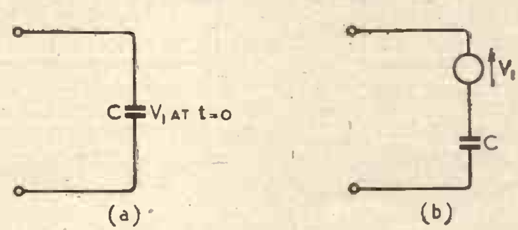


Fig. 5.

condenser and its equivalent circuit appear as in Figs. 5 (*a*) and 5 (*b*).

Introducing this initial condition into the preceding example, the development is shown in Figs. 6 (*a*), (*b*) and (*c*), in which

$$e = (E - V_1)\frac{C_2}{C} + V_1 = \frac{E}{C}\left\{C_2 + \frac{V_1}{E}C_1\right\}$$

Whence the solution is :

$$v_1 = \frac{E}{C}\left\{C_2 + \frac{V_1}{E}C_1\right\}\epsilon^{-t/T}$$

$$(T = RC = R(C_1 + C_2)).$$

$$\therefore \quad v_2 = E - v_1 = \frac{E}{C}\left\{C - [C_2 + \frac{V_1}{E}C_1]\epsilon^{-t/T}\right\}$$

A final well-known example in classical dielectric theory may be of interest. The problem is shown in Fig. 7 (*a*).

Employing the "constant-current" theorem we have the circuit of Fig. 7 (*b*), in which

$$i \equiv E\left(\frac{1}{R_2} + C_2 D\right)$$

Thus $v_1 \equiv e\{1 - \epsilon^{-t/T}\}$

$$\equiv \frac{ER}{R_2}\left\{1 - \epsilon^{-t/T}\right\} + \frac{ERC_2}{R_2}D\left\{1 - \epsilon^{-t/T}\right\}$$

in which

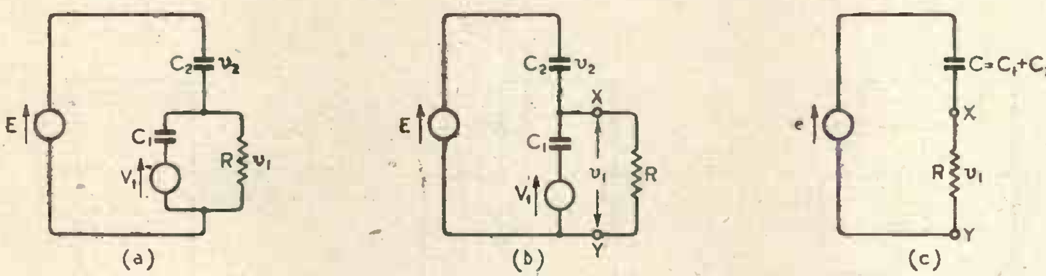
$$T = RC = \frac{R_1R_2}{R_1 + R_2}(C_1 + C_2)$$

Whence, performing the single differentiation :

$$v_1 = \frac{ER_1}{R_1 + R_2}\left\{1 - \epsilon^{-t/T}\right\} + \frac{EC_2R_1}{R_1 + R_2}\cdot\frac{R_2}{RC}\cdot\epsilon^{-t/T}$$

$$= \frac{ER_1}{R_1 + R_2}\left\{1 - \left(1 - \frac{T_2}{T}\right)\cdot\epsilon^{-t/T}\right\}$$

in which $T_2 = R_2C_2$.



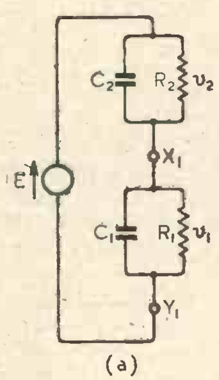
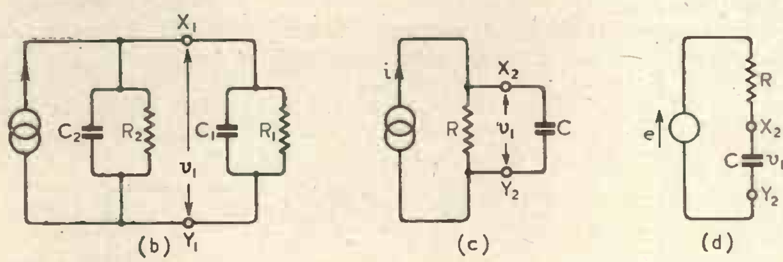


Fig. 6 (*Above*).

Fig. 7 (*Below*).

This result can also be obtained direct from the circuit representation of Fig. 7 (*c*) by employing the solution of the problem in Fig. 2.



where D indicates the process of simple time-differentiation. The circuit in turn reduces to Fig. 7 (*c*), where

$$R = \frac{R_1R_2}{R_1 + R_2} \qquad C = C_1 + C_2$$

Re-transforming to the "constant-voltage" form we have Fig. 7 (*d*), in which

$$e \equiv iR \equiv ER\left\{\frac{1}{R_2} + C_2 D\right\}$$

Further,

$$v_2 = E - v_1$$

$$= E\left[\left\{1 - \frac{R_1}{R_1 + R_2}\right\} - \left\{\frac{R_2}{R_1 + R_2}\cdot\frac{R_1}{R_2}\left(\frac{T_2}{T} - 1\right)\right\}\cdot\epsilon^{-t/T}\right]$$

$$= \frac{ER_2}{R_1 + R_2}\left\{1 - \left(1 - \frac{T_1}{T}\right)\cdot\epsilon^{-t/T}\right\}$$

in which $T_1 = R_1C_1$.

The latter result could, of course, be obtained readily from symmetry considerations.

By similar methods it may be verified that if in Fig. 7 (*a*) C_1 and C_2 be initially charged

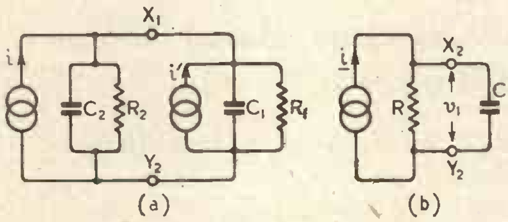


Fig. 8.

$$(a)\begin{cases} i \equiv E\{1/R_2 + C_2D\} - V_2C_2D \\ i' \equiv V_1C_1D \end{cases}$$

$$(b)\begin{cases} i \equiv E\{1/R_2 + C_2D\} + [V_1C_1 - V_2C_2]D \\ R = \dfrac{R_1R_2}{R_1 + R_2}; \quad C = C_1 + C_2 \end{cases}$$

to V_1 and V_2 respectively, successive stages in the development are represented by Figs. 8 (*a*) and 8 (*b*) corresponding to Figs. 7 (*b*) and 7 (*c*), giving

$$v_1 = \frac{ER_1}{R_1 + R_2}\left\{1 - \epsilon^{-t/T}\right\} + \frac{E}{C}\left\{C_2 - \frac{V_2}{E}C_2 + \frac{V_1}{E}C_1\right\}\epsilon^{-t/T}$$

Finally it should, of course, be noted that the form of analysis is equally applicable to problems involving "inductive transients," and that in this case initial conditions involving initial steady currents in the inductances can similarly be taken into account.

Book Review

Waveform Analysis

By R. G. MANLEY, B.Sc. Pp. 75 + xi, 103 diagrams and 39 tables. Chapman and Hall Ltd., 37 Essex Street, London, W.C.2. Price 21s.

The radio and communication engineer is so accustomed to thinking of radiated, travelling and stationary waves, and of these "waves" as having a "form," that he may need to be reminded that a waveform was originally, and perhaps strictly still is, a graphic record. This book deals with the analysis of recorded waveforms, with particular reference to those of mechanical vibration and allied quantities. Such waveforms are often characterised by the absence of the fundamental and a number of contiguous harmonics; this occurs because the fundamental cycle corresponds e.g. to eight and nine revolutions respectively of two rotating systems geared together in that ratio. Once-per-revolution vibrations of the two systems thus appear as eighth and ninth harmonics of the basic cycle, and all lower harmonics are absent.

After preliminary chapters, one of which deals very well with the combination of sinusoids of various frequency ratios, the author deals with the analysis of waveforms by analysis of the envelope and by what he terms the method of superposition; this is the division of the basic cycle into two or more equal parts, and the addition of corresponding ordinates whereby some components are eliminated from the plotted result, and others are accentuated. There are chapters on Fourier analysis, both theoretical and practical (in the latter some limitations of numerical methods, often overlooked, are mentioned) and a brief chapter on Lissajous'* figures.

One short chapter deals with "Mechanical and other Aids," and includes a brief discussion of direct electrical methods of analysis of electrical (i.e., non-recorded) waveforms. Although the author says his remarks "should not be taken as condemnatory of the general notion," he does not seem to be completely unbiased since one of his objections, that a list of frequencies and amplitudes alone does not specify the wave shape, is equally applicable to any means whereby this partial specification is obtained. In the discussion he says: "A filter . . . employing condensers . . . would require frequent calibration as condensers are notoriously unreliable. An accurate frequency source is required for the calibration and this . . . is not easy to obtain." The impression given is that the author is not here writing from first-hand experience, and the whole section might profitably be omitted from a later edition.

The bibliography is badly arranged. The reader has first to turn to the chapter heading to find its number, then to refer to the appropriate entry by chapter and number, then in some cases to refer to a list of general references. The total number of references is such that they might all be given as footnotes. There is no mention of Whittaker and Robinson's "Calculus of Observations."

There are five appendices; one is on "Effect of non-harmonic components, or of choosing a false cycle"; another includes a table of sine and cosine harmonic terms, from first to sixteenth harmonic at intervals of 1/96 of the basic cycle. There is also a glossary of terms. The style of writing is generally good and the occasional use of a term of laboratory jargon is enlivening rather than offensive.

F. A.

* The name of this celebrated scientist is consistently misspelt in this book, "Lissajou" even appearing in heavy-type chapter headings. In Deschanel's "Natural Philosophy" one reads of M. Lissajous and of Lissajous' curves; also Tyndall's "Sound" and Catchpool's "Textbook of Sound" have the correct spelling. In Watson's "Textbook of Physics" the text has Lissajous' figures, but in the index it is Lissajous's figures. Poynting and Thomson may have been the original culprits, for in both text and index of their "Textbook of Physics" we find Lissajou's figures and "Lissajou obtained. . . ." It is fairly obvious how the mis-spelling has arisen. A parallel case would be Law of Moses = Moses' law = Moses's law = Mose's law = Law of Mose. We hope that, if the book referred to ever reaches a second edition, the author will remove this blemish.

It may interest readers to know that Jules Antoine Lissajous was born at Marseilles in 1822 and died in 1880. His "l'Etude Optique des Mouvements Vibratoires" was published in 1873. The actual curves were described from a mathematical but not optical point of view in 1815 by N. Bowditch, the American mathematician, who translated Laplace's "Mécanique Céleste."—G.W.O.H.

MULTICHANNEL COMMUNICATION SYSTEMS*

Preliminary Investigation of Systems Based Upon Modulated Pulses

By F. F. Roberts, B.Sc.(Eng.), and J. C. Simmonds, Ph.D.(Eng.)
(*P.O. Radio Branch*)

SUMMARY.—A survey is made of those multichannel communication systems which make use of modulated pulse chains. The principles underlying the systems are considered at some length and the advantages and disadvantages as compared with conventional multichannel systems are discussed. Experimental apparatus employing amplitude modulated pulses is described which gave seven good quality speech channels in a band-width of 110 kc/s.

CONTENTS

Introduction

IN recent years the so-called ultra-high frequencies of the radio spectrum were being increasingly exploited by frequency-modulated transmitters, and such transmitters were proving economic to construct and operate, as compared with conventional equipment providing equal quality service. The rapid developments of radar and the associated centimetre-wave techniques during the war now offer the telecommunications engineer new fields for development, fields in certain ways similar but more extensive than those already being occupied by frequency modulation. A brief survey shows, on the one hand, a great volume of experience (and theory) of the design, production and operation of amplifiers particularly adapted to the handling of pulses, and on the other hand a number of new sources of high-frequency power, of a type for which pulse modulation offers distinct advantages. It seems not unlikely that the new achievements will have repercussions in lower-frequency fields, and it will perhaps be best in what follows to approach the whole topic from the low-frequency direction.

The idea of transmitting information in a series of separate bursts is by no means novel. The Baudot telegraph system employs this principle in order (in effect) to load a given frequency spectrum more fully, by what amounts to "interlacing" a number of distinct code transmissions. It is the purpose of this paper to present a general picture of the means whereby pulses of electrical energy may be made to convey "simultaneously" many independent channels of speech or other intelligence, and, finally, to describe an experimental seven-channel equipment, developed several years ago, and employing amplitude-modulated pulses.

PART I

1.1. General Principles of Pulse or Time-Allocation, Communication Systems

Multichannel communication systems may be divided broadly into two classes, namely,

(1) A class in which the frequency bands of the individual channels are shifted

* MS. accepted by the Editor, June 1945.

bodily by modulation and assembled so as to occupy a practically continuous spectrum consisting of adjacent bands allocated to the individual channels.

(2) A class in which the whole of a relatively large frequency spectrum is made available for consecutive small time intervals to each of the individual channels in cyclic order.

The first of these classes is familiar in its well-established application to carrier telephony on cables. The second class may be analysed still further.

In the Baudot*[11] system of multiplex telegraphy a rotating selector arm connects a common line to the several senders in sequence, each sender transmitting the code for one digit whilst the selector arm passes over its contacts. The signal in the line consists of digits from all the senders in sequence, together with an identifying signal necessary for the maintenance of the synchronism of the corresponding rotating arm at the receiving end. Here the digits coming in from the line are distributed to the several receivers for record and storage on tape. It will be understood that both transmission and reception on any individual channel are intermittent, so that some form of storage is necessary at each end of the line. At the sending end the operator himself may be the means of storage, but generally tape will serve this purpose at both ends.

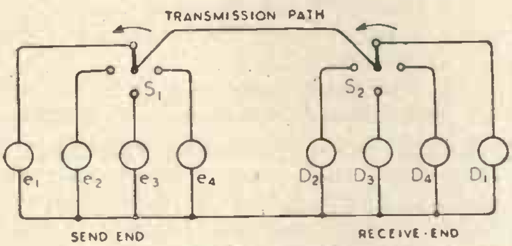


Fig. 1. *Basic time-allocation system.*

The nature of the time allocation that occurs in the simplest form of pulse multiplex now to be considered is similar to that in the Baudot system, but with a fundamental difference in the relative magnitudes of the time intervals involved in the signals on each channel and the intervals allotted to each channel for connection to the line. In the Baudot system, the rate of switching from channel to channel is so slow that a complete digit can be sent by each channel during each switching interval; in pulse multiplex the rate is made so high that the instantaneous channel voltage has time to change by only a limited amount in the interval between two successive occurrences of the switching pulse, and by a quite negligible amount during the pulse itself, when the particular channel is connected to the line. The greater part of the individual channel signal, on the short time scale, is not transmitted at all—the "gaps" are filled by a form of integrating or storage action inherent in the "low-pass" frequency characteristic of the receiver following the demodulation at the far end of the line. Apart from the difference in the speed of rotation of the switching contact arm, therefore, the pulse multiplex system could be realised, theoretically at least, by a mechanical arrangement of the same form as that of Baudot.

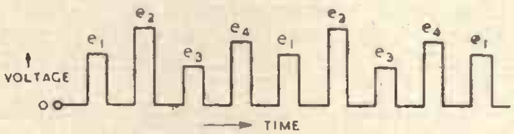


Fig. 2. *Ideal waveform of received current.*

The principle of time allocation for multiplex telephony systems can perhaps be more clearly understood by reference to Figs. 1 and 2. S_1 and S_2 represent the synchronised switches, which connect the generator e_1 to the detector D_1, the generator e_2 to the detector D_2, etc., in turn. If e_1, e_2, etc., are constant in magnitude the waveform of the current in the transmission path, assuming ideal conditions, will be of the form shown in Fig. 2. If e_1, e_2, etc., are not constant, then each successive pulse e_1 will differ in magnitude from the preceding e_1 pulse, and similarly for the pulses e_2, etc. It is convenient to refer to the series of pulses e_1 as the pulse-chain e_1, and so on. The several pulse-chains are seen to be interlaced.

Now it is easily seen that the frequency of switching, i.e., the number of complete revolutions per second of the switches S_1 and S_2 must be at least equal to twice the maximum frequency contained in the signals to be transmitted on the channels. For example, if telephony signals are transmitted containing a maximum frequency of 3 kc/s, the switching frequency must be at least 6 kc/s. If the switching frequency in this case were only 3 kc/s, then it would be impossible to distinguish the 3 kc/s telephony component from a D.C. signal.

* See Bibliography for numbered references.

The following three methods of performing the functions of S_1 and S_2 are available :—

(*a*) Mechanical methods.

(*b*) Electronic switching using normal thermionic valves.

(*c*) Electronic switching using special devices.

The frequency of switching required for telephone transmissions is rather high for mechanical methods, but the mechanical scanning methods used in some television systems might be adapted to this problem. For example, a beam of light controlled by rotating mirrors could be made to fall on a succession of photo-electric cells, one cell being used for each channel. The emission of the cells would then be controlled either by grid modulation, giving amplitude modulation of the pulse outputs from the cells, or by a small vibrating mirror placed before each cell and operated by the speech current to control the phase of the pulses from each cell.

Switching by means of normal valves is quite practicable and various methods of operation present themselves. One obvious method is to employ double-grid valves,[3] and to apply to one grid a negative bias such that no anode current can flow. By reducing the bias for a period anode current can be allowed to flow, and thus the required switching action obtained. A similar method is, of course, possible with triode valves. Both methods require some mechanism to reduce the negative bias at the correct instant. This will be discussed later.

Fig. 3. *Switching pulse waveform.*

Switching by means of specially constructed electron tubes[3, 4, 7, 25] has much to commend it, and may ultimately prove to be the best solution to the problem. In its simplest form the tube consists of a rotating electron beam which makes contact with electrodes in turn. Many variations of this have been proposed, and some of the proposals have suggested the use of secondary emission. Switching in this way would, no doubt, present its own difficulties; one possibly being poor signal/noise ratio due to low beam current. By means of this method of switching it may ultimately be possible to reduce the channel equipment at each terminal to a much smaller bulk than that required by valve switching or by the conventional frequency allocation method of multiplex.

1.2. Production of Pulses

In the previous section it was pointed out that when switching by normal types of valves is employed some mechanism must be provided to neutralise the negative bias which normally reduces the valve anode current to zero. To fix ideas consider the scheme employing double-grid valves. Now, in order that the valve may conduct for any required period, the negatively biased grid must be made positive, or at any rate much less negative, during the period. This can obviously be brought about by applying a large positive pulse to the grid during the required period. It is clear that a number of switching valves will be required, one for each channel, and that each will require a positive pulse to render it conducting at the necessary instant. Thus, if this system of switching is used, chains of positive voltage pulses, which are displaced in time relative to one another as shown in Fig. 3 must be produced.

Many ways exist of producing the required pulse chains, but in general they can be placed in two classes :—

(*a*) The pulse chain for the first channel is generated and the other pulse chains obtained from this by suitable delay networks.

(*b*) The pulse chains required for each channel are generated independently.

In class (*a*) it is necessary to produce a pulse-chain, each pulse of which is of the required duration and is repeated at the desired channel switching frequency. Some of the possible methods of producing the required pulse-chains are summarised very briefly below.

(1) Multiplication of two recurrent square waves of slightly different time phase. Multiplication may be simulated by addition, followed by a double diode "gate," which limits all potentials except those lying between predetermined values.

(2) By removing the tips of a sinusoidal voltage wave of large magnitude—if required the tips can then be flattened to give rectangular pulses by means of a limiter.

(3) If a capacitor is discharged through an inductor, for example by means of a gas-filled relay, a very sharp pulse of voltage can be obtained. This pulse can be removed from the rest of the waveform, which can be easily made recurrent, and thence the required pulse-chain obtained.

(4) Differentiation of a square-wave by application to a short time-constant circuit.

(5) By means of blocking oscillators.

(6) By means of circuits employing non-linear inductance.

Pulses produced by these methods will, in general, be of different shapes, but if desirable

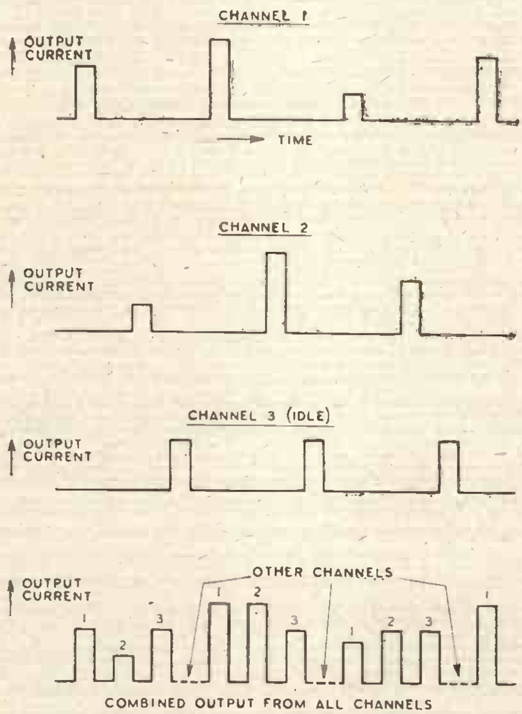


Fig. 4. *Amplitude-modulated pulses*

they can all be made to approximate very closely to rectangular pulses. The question of the best pulse shape is considered briefly in section 1.7.1. Having produced the required pulse-chain, from it other similar pulse-chains, delayed by different time intervals, must be produced. Theoretically the delay can be obtained by means of a delay network of negligible attenuation and phase distortion. In practice, however, it is not possible to obtain the required maximum delay with a reasonable number of delay sections. Theoretically the delay could also be obtained by means of lengths of coaxial cable, but unfortunately prohibitive lengths would be necessary. This difficulty may be overcome in the future by the development of a coaxial cable having a solenoidal inner conductor wound perhaps upon some high permeability low-loss material.

Now consider class (*b*). To ensure periodicity of the pulses it is desirable that they should all be controlled by the same device. Thus, starting from a common sinusoidal e.m.f. of the correct frequency other sinusoidal e.m.f.'s can be derived which are delayed by the required time, and from these e.m.f.'s the pulse-chains can be formed by any of the methods enumerated above. In general, a large amount of equipment is required to produce the pulse-chains as each channel requires its own pulse generating equipment. Fortunately, however, by employing the pulse producing method given under (2) above, it is possible to avoid the use of special pulse-forming equipment associated with each channel apart from that necessary to produce the sinusoidal e.m.f.'s of differing phases. This scheme will be described later at length.

1.3. Modulation of Pulses

Each chain of pulses must be modulated by the intelligence to be transmitted on the corresponding channel. Methods available for modulating the pulses will now be considered.

1.3.1. *Amplitude modulation*

Two simple ways of modulating the chain of pulses are available, i.e., by double grid or by triode valves. In the first case the pulse voltage is applied to one grid and the signal voltage to the other, whilst in the second case the pulse is applied between grid and earth and the signal injected between cathode and earth. When this modulation process is carried out, the output from each valve will be as shown in Fig. 4, assuming rectangular switching pulses are used. The gaps between the adjacent pulses of different chains are introduced to decrease the inter-channel crosstalk—this aspect of time allocation multiplex is discussed in Section 1.7.1.

It should be noted that in Fig. 4 the time-scale of the modulation has been shortened in order to clarify the diagrams, but it must be remembered that successive pulses in a given chain are normally much more nearly equal—the only exception being for modulation frequencies near the maximum.

1.3.2. *Pulse-width modulation*

If the switching pulse applied to the triode, as described in the previous section, has sloping sides, not only will the height but also the width of the output pulse of anode current vary with the modulating signal. By limiting the amplitude of the anode current pulse, perhaps by operating the valve into anode current saturation, a form of modulation results which has particular advantages. For example, non-linear distortion in the transmission path does not affect operation. Moreover, constant amplitude pulse modulation is the only type that can usefully be applied to certain types of V.H.F. generators. Modifications of this form of modulation are possible—the pulse centre can be made independent of the modulation and both sides of the pulse allowed to vary; alternatively, one side only may be made to vary.

1.3.3. *Delay modulation*

A further method of modulation can be obtained by maintaining the height and width of the pulses constant and varying the relative instant at which the pulse is produced according to the modulation. This has the effect of increasing or decreasing the time between successive pulses of the same pulse-chain. This system of modulation will be referred to as "delay" modulation. Possible methods of obtaining delay modulation will now be briefly described.

It has already been pointed out that the required chains of switching pulses can be obtained by applying a large sinusoidal e.m.f. of the correct phase to the control grid of a valve operating with a large negative bias. In these circumstances anode current flows for that period during which the instantaneous value of the e.m.f. approaches the negative bias voltage. The centre of the pulse, therefore, coincides with the centre of the positive half cycle of the e.m.f. and obviously delay modulation can be obtained by controlling the phase of the e.m.f. by the modulating signal. Control of the e.m.f. phase by the modulation can be affected by connecting a "reactance valve" across a reactive element of a phase-divider—the variable reactance of the valve being varied according to the modulating signal.

Another method is to apply to the pulse-forming valve a signal consisting of a large and a small component having, say, 90° phase difference. The phase of the resultant e.m.f. can then be controlled by the magnitude of the small component without the magnitude of the resultant e.m.f. varying appreciably. Variations of this method are, of course, possible; for example, both the components of the pulse-forming e.m.f. could be controlled to make the magnitude of the resultant e.m.f. more independent of the modulation. If most of the negative bias is produced by the grid current of the pulse-forming valve slight variations of the magnitude of the resultant e.m.f. are of little consequence.

Still another method makes use of a peculiar property of the circuit shown in Fig. 5. When $\frac{1}{\omega C}$ is made equal to $2\omega L$ the magnitude of the impedance between A and B at the angular frequency ω is constant for all values of R from zero to infinity, whilst the angle of the impedance varies from $-90°$ to $+90°$.

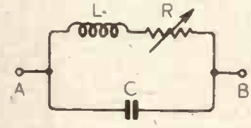


Fig. 5. *Phase-shifting circuit.*

If a circuit of this type is fed by a constant current generator, e.g., a pentode valve, of angular frequency ω the phase of the voltage produced between A and B will depend upon the value of R, but its magnitude will be independent of R. Thus, by controlling R in accordance with the modulating signal, the phase of the voltage across AB, and therefore of the pulse produced, can be controlled by the modulating signal. Several ways of controlling the value of R are apparent. Probably the best and most convenient is to use the anode-cathode circuit of a triode valve to take the place of R and to control the effective resistance of this path by applying the modulating signal to the control grid of the triode.

1.3.4. *Other types of pulse modulation*

The amplitude, width, and delay systems of modulation represent the basic types for pulse transmission of several channels. More elaborate systems are, of course, possible, and may have limited advantages in special cases. An interesting arrangement has recently been described[27] in which the modulation consists in varying the spacing between a pair of pulses. Such a system will, therefore, require two pulses per channel. It will obviously reduce the average transmitter power, but at the expense of requiring a considerably wider overall bandwidth.

Two other possible systems may be described as pulse frequency and pulse number modulation. The former is somewhat akin to the delay system, and consists of short pulses transmitted at a variable rate depending upon the amplitude of the modulating signal. In the latter method the number of short pulses transmitted is made dependent upon the amplitude of the modulating signal.

1.4. The Frequency Spectrum of the Composite Modulated Waveform

It has been shown that the final output signal from a time-allocation multiplex system consists of a number of chains of current or voltage pulses. In connection with the design or equalisation of the transmission path it is desirable to know the frequency components of the composite output. The frequency spectrum of variously modulated "exponential" pulse-chains has been considered elsewhere,[22, 23, 24] and, as this special case does not differ fundamentally from the more general case, the general case will be dealt with very briefly. The expressions and remarks given below refer to any pulse shape having symmetry about its centre line.

1.4.1. *Amplitude modulation*

Whatever the shape of the switching pulse, providing it is symmetrical about the centre line and periodic, it can be subjected to Fourier analysis and, for the chain of pulses which has its centre at a time corresponding to zero, represented by a series of the form :—

$$i = \sum_{\nu=0}^{\infty} a_\nu \cos \nu\omega t \quad \ldots \quad \ldots \quad (1)$$

where i = output current

a_ν = constant corresponding to ν

ν = positive integer

ω = angular channel pulse frequency, i.e. $2\pi \times$ rate of repetition of the pulses in each chain.

For any particular pulse-shape the constants a_ν can be obtained by well-known methods, and tables are available which give the values of a_ν for many common shapes.[20]

From equation (1) it is seen that the frequency spectrum of an unmodulated channel is composed of all multiples of the channel pulse frequency. The composite current from N equally spaced unmodulated channels, assuming wave-form and amplitude of all unmodulated pulse-chains to be identical, will be :—

$$I = \sum_{n=1}^{N} \sum_{\nu=0}^{\infty} a_\nu \cos \nu \left(\omega t - \frac{2\pi n}{N}\right) \quad \ldots \quad (2)$$

It is obvious from this expression that the lowest angular frequency component is $N\omega$, neglecting the zero frequency component.

Now let the pulse given by equation (1) be amplitude modulated, the current is then given by :—

$$i = \sum_{\nu=0}^{\infty} a_\nu (1 + m \sin pt) \cos \nu\omega t \quad \ldots \quad (3)$$

where m = depth of modulation

p = angular frequency of the modulating signal.

The combined output current from N modulated channels is easily seen to be :—

$$I = \sum_{n=1}^{N} \sum_{\nu=0}^{\infty} a_\nu \cos \nu \left(\omega t - \frac{2\pi n}{N}\right) + \tfrac{1}{2} \sum_{n=1}^{N} \sum_{\nu=0}^{\infty} a_\nu \left[\sin\left\{(\nu\omega + p_n)t - \frac{2\pi n}{N}\right\} - \sin\left\{(\nu\omega - p_n) - \frac{2\pi n}{N}\right\}\right] \quad \ldots \quad (4)$$

As before, the lowest multiple of the channel pulse frequency present is the N^{th}, and the spectrum can be considered as consisting of carriers of ω, 2ω, 3ω, etc., modulated with the frequencies p_n but with carrier suppression on the first $(N - 1)$ carriers.

1.4.2. *Pulse width modulation*

Consider a rectangular pulse shape and let the centre of the pulse occur at fixed time intervals. The current output corresponding to this type of switching pulse is given by :—

$$i = i_{\max} S + \frac{2i_{\max}}{\pi} \sum_{\nu=1}^{\infty} \frac{1}{\nu} \sin \nu S\pi \cos \nu\omega t \quad (5)$$

where S = duration of pulse divided by the time between adjacent corresponding pulses. If the pulse width is varied by the modulating signal, S becomes a function of time, say $(1 + A \cos pt)S_0$. In these circumstances the output current is given by :—

$$i = i_{\max}(1 + A \cos pt)S_0 + \frac{2i_{\max}}{\pi} \sum_{\nu=1}^{\infty} \frac{1}{\nu} \sin [\nu\pi(1 + A \cos pt)S_0] \cos \nu\omega t \quad \ldots \quad \ldots \quad (6)$$

This expression contains components of angular frequency $(\nu\omega \pm np)$, where n is zero or any odd positive integer. Thus the frequency spectrum, although similar to that of a frequency modulated signal, is more complex.

1.4.3. *Delay modulation*

Delay modulation may be regarded as phase modulation of the pulse repetition frequency. Equation (5) may thus be modified to :—

$$i = i_{max} S + \frac{2i_{max}}{\pi} \sum_{\nu=1}^{\infty} \frac{1}{\nu} \sin \nu S\pi \cos (\nu\omega t + \phi_{max} \sin pt) \quad \dots \quad (7)$$

Though more complex than equation (6) this result shows that components $(\nu\omega \pm np)$ are still present, but also that here there is no direct term in p, as in (6). This makes delay modulation inherently more private.

1.5. Demodulation

The term " demodulation " when applied to time-allocation multiplex means the separation of a pulse chain corresponding to one channel from all the other pulse-chains, and in addition the conversion of this separated pulse-chain into a replica of the original modulating signal. With amplitude and width modulation the separated chain of the pulses can be converted to the modulating signal simply by means of a low-pass filter, and this is also possible with delay modulation if a special separator pulse shape is employed, but in the case of width and delay modulation spurious frequencies will

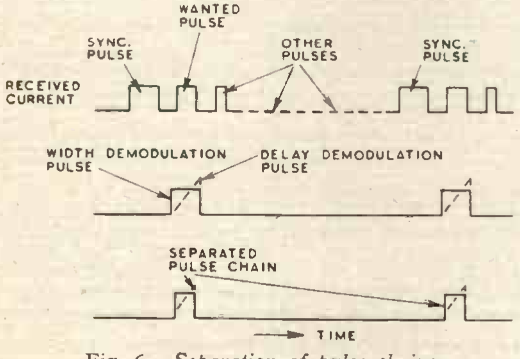


Fig. 6. *Separation of pulse chains.*

also be present. The relative amplitude of these spurious frequencies can, however, be greatly reduced by making the pulse-chain frequency high compared with the modulating frequencies.

An alternative scheme for both pulse-width and delay modulation may be obtained by arranging, perhaps by means of valve circuits, that the leading or trailing edges of the pulse of a separated pulse-chain give a charge to a capacitor which discharges through a resistor. By correctly adjusting the time-constant of the capacitor and resistor the voltage across the resistor can be made to follow the modulating signal closely. This scheme has particular advantages with regard to improvement of signal-to-noise ratio.

Regarding the separation of one pulse-chain from the other chains, it is obvious that a similar process will serve, whatever the type of modulation. This process consists simply of multiplying, e.g., by means of double-grid valves, the composite modulated output from the multiplex transmitting equipment by a pulse correctly placed in time. This is illustrated for pulse-width modulation in Fig. 6. By correctly sha-ing the separating pulse, in some circumstances the magnitudes of the unwanted frequency components in the separated output may be reduced.

1.6. Synchronising

Some method of synchronising or locking is obviously necessary in the time-allocation system of multiplex to ensure that a given send channel remains connected to the same receive channel. It is also obvious that the synchronising must be carried out by some special signal transmitted either with or quite distinct from the channel pulse-chains. This special signal, when received and separated from the channel pulse-chains, can be used to control the separating pulse generator circuits at the receiving end. Methods of transmitting the special signal are discussed in this section ; one method of controlling the receiving end pulse generating circuits is discussed in Section 2.1.3.

Perhaps the simplest way of introducing the synchronising pulse is to increase the amplitude of one of the channel pulse chains. At the receiving end the synchronising pulse-chain is easily separated from the remainder of the received signal, for example, by applying the whole signal to a suitably negative-biassed valve, or better still to a grid current biassed valve. Alternatively one of the pulse-chains can be reversed in polarity. These two types of synchronising signals are shown in Fig. 7. One advantage of the latter method is that synchronising could not be affected by an abnormally large amount of modulation on one of the channel pulses—assuming, of course, amplitude modulation. There seems little to choose between the two systems, as the necessary channel limiting action advisable in the first system (to prevent abnormal channel modulation peaks affecting the synchronisation) might be provided in the

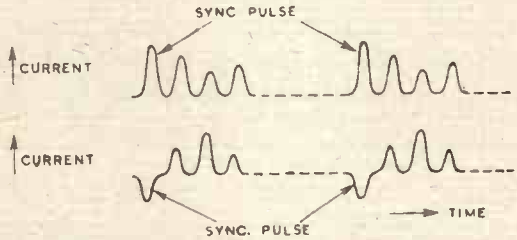


Fig. 7. *Alternative methods of inserting synchronising pulses.*

modulators themselves. Another method, which would perhaps be more useful with pulse-width and delay modulation systems, is to increase the width of the pulses of one of the channel pulse-chains. Peak limiting on the other channels is still advisable for the same reasons as above. The synchronising signal could, of course, be transmitted on a separate main carrier frequency, or could be transmitted with the composite pulse-chain signal at a frequency lower than the lowest speech frequency to be transmitted. In the latter case high-pass or band-pass filters would be required to eliminate the synchronising signal from the audio output channels.

1.7. The effect of Distortion of the Waveform by the Transmission Path

In the preceding sections it has been assumed that the waveform of the received signal is identical with that of the transmitted signal. Actually such will not be the case, and divergencies of the transmission path from the ideal will distort the waveform. If a cable circuit is used distortion will result from the finite bandwidth even assuming perfect attenuation and phase equalisation throughout the available frequency band. This applies also to a radio circuit, but here distortion can also arise due to variations of the transmission path, for example, due to fading and to reflections from both moving and stationary objects.

1.7.1. *The effect of limited bandwidth*

The simplest case of limited frequency bandwidth occurs when frequency components below a certain frequency are transmitted without distortion and when frequency components above a certain frequency are completely attenuated. If a rectangular voltage pulse is applied to such a transmission path then its shape is altered as shown in Fig. 8.[26] The shape of the distorted pulse in this simple case is easily obtained by analysis. From Fig. 8 it is apparent that some interference between channels will result from the use of a transmission path of this form. With an amplitude modulated system this interference will appear as cross-talk between the various channels, and its magnitude can be easily estimated from the ratio of the area of the wanted pulse to that of the other pulses over the same period of time. In the figure this is the ratio of the shaded area to the black area. The adjacent channel cross-talk for a ten-channel scheme with a bandwidth of 100 kc/s and a pulse-chain frequency of 6 kc/s, estimated in this way, is about 40 db. when the gap between pulses is equal to the pulse width.

In the case of the simple transmission circuit being considered, an expression for the cross-talk ratio due to the finite bandwidth can be easily derived[18] for the case of amplitude modulated pulses. It is :—

$$\text{C.T.R.} = \frac{\left\{a_0^2 + \sum_{\nu=1}^{H} \frac{a_\nu^2}{2}\right\}}{\left[a_0^2 + \sum_{\nu=1}^{H} \frac{a_\nu^2}{2} \cos\left\{\frac{2\pi\nu}{N}(m - n)\right\}\right]} \quad \ldots \quad (8)$$

where the symbols have the meanings given earlier, with the addition that H is the highest order harmonic of the pulse frequency freely transmitted together with its upper sideband, and where the cross-talk from the mth channel is measured at the nth channel. A similar but perhaps simpler expression for the special case of the exponential pulse has been given elsewhere,[23] and for this special pulse shape cross-talk effects have been discussed at some length. The advantages of the exponential pulse shape are apparently two-fold—mathematical analysis is simplified, and such pulses are easily obtained (see method 2 of Section 1.2.). Reference should be made to the original papers for further details.

The cross-talk associated with typical systems employing rectangular, triangular, sinusoidal and exponential pulse shapes has been estimated, and it has been found that all these pulse shapes give cross-talk ratios of the same order. With these pulse shapes the cross-talk ratio alternates in sign, and there are therefore best frequencies for cut-off. It also appears, therefore, that by properly shaping the attenuation characteristic of the transmission path the cross-talk can be reduced, theoretically, to zero, between any two channels. The cross-talk ratio to be obtained with any type of transmission characteristic can be estimated by suitably modifying the method used to develop equation (8). Interesting curves showing the cross-talk ratio for the exponential pulse and its variation with cut-off frequency and pulse parameter have been given elsewhere.[23]

So far imperfections of the transmission characteristic at the higher frequency only have been considered. In reference 22 for the special case of the exponential pulse, the effect of low-frequency distortion of the transmission characteristic has been considered. Similar results are to be expected with other shaped pulses, and broadly speaking to obtain a cross-talk ratio better than 40 db. the low frequency response must be constant to within 1.0 db. at frequencies below half the pulse chain frequency—a variation in response of 0.1 db. would result in a cross-talk ratio of some 60 db. Thus it is desirable to keep that portion of the response characteristic which corresponds to the low-frequency portion of the transmitted wave form flat to about 0.1 db. The phase response, of course, as distinct from the case in the conventional frequency-allocation multiplex system, is just as important as the amplitude response

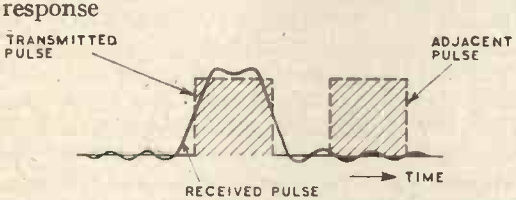


Fig. 8. *Effect of limited frequency band-width upon pulse shape.*

Unlike cross-talk due to high-frequency distortion, cross-talk due to low-frequency distortion affects all channels equally. Thus, by properly shaping the low-frequency response of the transmission characteristic, it should be possible to achieve some reduction of cross-talk due to high-frequency distortion. In practice it is desirable to make the cross-talk on all channels equal by increasing low values and decreasing high values; this may well prove possible by "low-frequency balancing."

In connection with cross-talk balancing it has been suggested that a small fraction of the output of each receive channel be fed into all the other channels in such a way as to balance out the cross-talk.[3]

The preceding discussion refers almost exclusively to amplitude-modulated pulses. Except in the case of very severe adjacent channel cross-talk, the level of cross-talk in pulse-width or delay modulated systems can be made very low by means of the amplitude limiting circuits.

1.7.2. *The effect of reflections in the transmitting path.*

In telecommunications systems employing a radio link it is quite likely that in some circumstances multiple reflections will occur. If this should happen, the received signal will really consist of several components each of which has traversed a different path. In other words, the received signal, in a time-allocation system, may consist of a number of composite pulse-chain waveforms each displaced in time relative to the others. To determine the allowable difference in transmission time over the several paths, consider an eight-channel system in which the pulse width corresponds to about 30° and the space between pulses to 15°, and let the pulse-chain frequency be 8 kc/s. If there is a time delay between any two of the received waveforms greater than about 2.5 microseconds, the pulses from the different channels will overlap and serious cross-talk will result if the magnitudes of the several waveforms are likely to be of the same order. In the above simple analysis it has been assumed that, although there are several transmission paths, each path carries the signal without distortion. Actually this will not necessarily be so, and certain frequency components of the transmitted signal may be reflected by some regions of the transmitting medium whilst other components may not be reflected. Reflections of this type will result in a distorted waveform, similar to that produced by phase distortion, and cross-talk will again result.

It is seen, therefore, that the time-allocation system of multiplex is not suitable for use with radio links if serious multiple reflections are likely to occur. Even with cable links irregularities in the cable system would introduce cross-talk, but this would be of a low order. As a general rule it will be less difficult to avoid reflections on an ultra-short wave radio link than at lower frequencies, but even in this case reflections from buildings, rocks and even from aircraft may prove to be troublesome. It appears, therefore, that the time-allocation system of multiplex has a somewhat restricted field of application ; preferred fields are indicated in conjunction with ultra-short wave radio and cable or wave-guide links.

1.8. Modulation of the High-frequency Carrier

The composite signal from the multiplex transmitter comprising a number of pulse-chains can be used to amplitude, frequency or phase modulate a transmitter in the usual ways. If amplitude modulation is used it is obvious that non-linearity of any part of the transmitting circuit will only reduce the relative heights of the pulses. The effect of this will be to introduce distortion in the individual channels in the case of amplitude modulated pulses, but cross-talk will not be introduced as in the conventional frequency-allocation system. Very bad non-linearity might, of course, affect the synchronising of an amplitude modulated pulse system. In the case of delay or width modulation, transmitter non-linearity can have no effect whatever. It follows, therefore, that with the time-allocation system low power amplitude modulation can be used with its attendant advantages. The power stages of the transmitter would in fact be similar to those common in frequency modulation.

At present there are technical objections to amplitude modulation of certain very high-frequency generators, for example, magnetrons, and undoubtedly a field exists here for the development of pulse-width and delay modulation time allocation systems, for use with highly directional beam radio links and with wave-guide links.

1.9. Signal-to-Noise Ratio

With any of the pulse modulation systems considered any random variation of the pulse amplitude or pulse spacing will result in increased noise at the output of the receiving equipment. For this reason, as well as others, the pulse generating equipment must be very stable, but this should prove no more difficult than the stabilisation of the carrier frequencies and modulation efficiency in conventional frequency-allocation systems.

1.9.1. *Amplitude modulated pulses*

From the point of view of signal-to-noise ratio, the amplitude modulated pulse multiplex system may be expected to compare unfavourably with the conventional frequency-allocation multi-channel systems, for the following reasons :—

(*a*) Channel pulse peak amplitudes must be well below the synchronising pulse amplitude.

(*b*) Both sidebands are transmitted on each harmonic of the synchronising frequency.

(*c*) No advantage with regard to overload can be taken of the random relation between the signals in the different channels.

It is assumed, of course, that the peak overload power of the transmission system is the same in each case and that the noise is uniformly distributed throughout the frequency spectrum—the fact that the pulse system will require a greater total band-width does not contribute appreciably to the noise until the band-width considerably exceeds twice the value for the conventional multi-channel system.

The first factor, (*a*) above, may contribute up to 6 db. to the degradation in signal-to-noise ratio, while factor (*b*) will add a further 3 db. The greatest influence, however, is that listed under (*c*), and this can be quite serious when the number of channels is large. For example, with ten channels the degradation would be roughly 8 db., and 15 db. for one hundred channels.[27]

A more exact analysis based upon a comparison of an eight-channel time-allocation system having 8 kc/s pulse chain frequency and 100 kc/s frequency band-width with an eight-channel single sideband frequency allocation system having 4 kc/s band-width per channel has been made. It was found that the signal-to-noise ratio is about 16 db. worse for the time allocation scheme than for the frequency allocation scheme, a result in good agreement with the value predicted by more general considerations.

It should be noted that there is no method available for reducing noise on an amplitude-modulated pulse system operating within an assigned frequency band-width.

1.9.2. Pulse-width and delay modulation

With any modulation scheme which makes use of the duration or position of the pulses in time it is theoretically possible to remove most of the noise, providing it does not, on the average, exceed a certain level, and providing the sides of the pulses are infinitely steep, i.e. rectangular pulses. This noise-reducing process such as might be produced by a double diode "gate" is illustrated in Fig. 9. Of course, if the noise peaks are

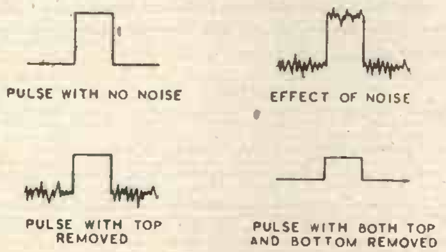


Fig. 9. *Noise reduction by amplitude limitation.*

greater than one-half the pulse height it is impossible to eliminate the noise. Further, since it is not possible, due to restricted frequency band-width, to make the sides of the pulses infinitely steep, some noise will remain on the sides even after the noise on the top and bottom of the waveform is removed. Also the peak value of the noise will sometimes exceed any finite value. Even so a considerable reduction in the noise should be possible. Regarding the application of time-allocation systems to very high-frequency transmitting systems, where large frequency bands are available, it may be that the time required to start and stop the generator may set a limit to the noise reduction.

The alternative demodulating scheme proposed under Section 1.5 will obviously tend to improve the signal-to-noise ratio, as the noise, providing it is not of a relatively large amplitude, will not exert any appreciable control over the pulse of current fed to the capacitor.

1.10. Comparison of the Time-allocation Multiplex with the Frequency-allocation Multiplex

As will be seen in Part II, where an experimental time-allocation multiplex system is described, the time-allocation scheme has the great advantage that only common components are required, for example, capacitors and resistors of the type used in radio sets, as compared with the special filters required by the frequency-allocation scheme, and further, quite large tolerances are allowable on the nominal values of most of the components.

Further developments of the time-allocation system, particularly in the electron switching by special tubes, may result in a worth-while reduction of floor space as compared with that required by the frequency-allocation system.

It is impossible to make a general statement regarding the relative merits of the two systems, judged from the point of view of cross-talk. However, an eight-channel time-allocation system (seven working channels), each channel having a 3.3 kc/s band, has been obtained with a transmission band of 110 kc/s (modulation bandwidth, 220 kc/s on the radio carrier) and a cross-talk ratio better than 40 db. Similar results would be expected with either a cable or a radio link, neglecting the effect of reflections in the latter case. Using the frequency-allocation system 25 working channels could be obtained with a bandwidth of 110 kc/s, but if this system were used with a radio link, high power modulation of the transmitter and the application of negative feedback would be necessary to reduce the intermodulation to a satisfactory value. Alternatively a linear frequency modulated system using a deviation ratio of unity could possibly be developed to transmit 25 channels in a total radio band-width not greatly exceeding 220 kc/s. Low-power modulation can be used with the time-allocation scheme without deterioration of the cross-talk ratio. Intermodulation should be negligible. Reflections or fading may produce serious cross-talk with the time-allocation scheme, but only distortion on separate channels of the frequency-allocation scheme.

Assuming the received noise voltage to be uniformly distributed over the whole of the transmission band, it can be shown that for roughly comparable eight-channel systems the signal-to-noise ratio is about 16 db. worse for the time-allocation scheme using pulse amplitude modulation than for the frequency-allocation scheme. Theoretically, at least, it is possible to effect a very considerable improvement in the signal-to-noise ratio in those time-allocation schemes which depend for modulation upon the pulse duration or position of the pulse in time.

From the above it may be concluded that the time-allocation system of multiplex may be preferable to the frequency-allocation system in the following circumstances.

(a) Where robustness and ease of repair are of prime importance.

(b) When difficulty arises in production of the special filters required by the conventional frequency - allocation scheme.

(c) For use with short-wave radio links.

(d) In applications where pulse modulation of the transmitter is possible whilst amplitude, frequency or phase modulation is difficult, for example, with magnetron generators.

(*To be concluded.*)

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WIRELESS PATENTS

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ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

569 260.—Pick-up circuit comprising an electron-coupled oscillator or reproducing frequency-modulated phonograph records.

Radio Corporation of America. Convention date (U.S.A.) 23rd September, 1942.

569 493.—Protecting and waterproofing a piezo-electric element particularly when used in a pick-up, loudspeaker, or like transducer circuit.

The Brush Development Company (assignees of O. Kornei). Convention date (U.S.A.) 8th March, 1941.

DIRECTIONAL WIRELESS

569 303.—D. F. system in which the outputs from different aerials are distinctively modulated, and the side-band components are combined to give a direct bearing on a C.R. indicator.

Radio Transmission Equipment, Ltd. and C. E. G. Bailey. Application date 2nd September, 1940.

569 406.—Directive aerial array for radiating a blind-landing beam giving an hyperbolic glide-path of constant intensity.

Standard Telephones and Cables, Ltd. (assignees of A. G. Kandoian). Convention date (U.S.A.) 6th March, 1941.

569 435.—Equi-signal beacon system in which the overlapping beams are so modulated as to offset the effect of reflected and scattered signals.

Marconi's W.T. Co., Ltd. and S. B. Smith. Application date 2nd December, 1940.

569 440.—Equipment for training pilots to the use of beam approach paths and other radio-navigational aids.

P. W. W. Jensen. Convention date (U.S.A.) 20th November, 1942.

RECEIVING CIRCUITS AND APPARATUS

569 281.—Arrangement and locking of arch or tunnel-shaped screening-elements on the chassis of a wireless receiver.

D. Jackson and Pye, Ltd. Application date 11th November, 1943.

569 451.—Magnetic control means for increasing the normal accuracy of tuning devices of the pin-and-recess or "click" type.

Philips Lamps, Ltd. and C. L. Richards. Application date 18th October, 1943.

569 517.—Three-electrode valve operating at any selected frequency, irrespective of the effects of the inter-electrode capacitances.

Standard Telephones and Cables, Ltd. (assignees *of M. Dishal; W. Hotine; and J. S. Le Grand). Convention date (U.S.A.) 30th November, 1942.*

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569 436.—Means for preventing "dark spot" distortion in the television signals generated by scanning a photo-sensitive screen of the mosaic type.

Marconi's W.T. Co., Ltd. (assignees of O. H. Schade). Convention date (U.S.A.) 21st August, 1942.

TRANSMITTING CIRCUITS AND APPARATUS

569 297.—Method of superposing signal frequencies on an A.C. power-network through two rigidly-coupled asynchronous generators which provide a frequency step-up.

Landis and Gyr. S.A. Convention date (Switzerand) 3rd December, 1942.

569 608.—Keying arrangement, comprising a gas-filled tube and a vacuum tube, for producing square-topped signals in a tape-controlled Morse transmitter.

F. B. Dehn (communicated by Press Wireless, Inc.). Application date 13th July, 1943.

569 655.—Movable vane forming a variable-capacitance bridge for tuning an oscillator-valve coupling of the transmission line type.

Ferranti, Ltd.; R. G. B. Gwyr; and J. F. Capper. Application date 4th December, 1940.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

569 339.—Generating trains of waves, separated by comparatively-long quiescent intervals, as used for determining distances by reflection.

The British Thomson-Houston Co., Ltd., and D. J. Mynall. Application date 19th December, 1941.

569 417.—Communication system in which each radio receiver is made operative when, and only when, a master station is transmitting.

United Air Lines Transport Corp. Convention date (U.S.A.) 22nd June, 1942.

569 474.—Oscillograph with a comparatively low-frequency time-base for observing and regulating the pulsed transmission used in radiolocation.

Standard Telephones and Cables, Ltd.; M. M. Levy; and T. W. Elliott. Application date, 29th January, 1943.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

569 218.—Making and processing the sealing pinch of an electron discharge tube.

The M-O Valve Co., Ltd. and G. Moggridge. Application date 5th May, 1943.

569 224.—Preventing waste of cathode emission in a short-wave valve of the type in which the electrodes consist of a set of coaxial cylinders.

The M-O Valve Co., Ltd. and J. Bell. Application date 6th August, 1943.

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569 346.—High-voltage discharge tube in which the heat produced by electron bombardment of the anode is utilised to reduce, say, tungsten oxide to the pure metal.

A. Muller. Application date 9th December, 1942.

569 494.—Construction of the cavity resonators and back-coupling elements in an electron-discharge tube of the velocity-modulation type.

Westinghouse Electric International Co. Convention date (U.S.A.) 13th August, 1941.

SUBSIDIARY APPARATUS AND MATERIALS

568 674.—Apparatus for automatically testing and classifying mica or other dielectric sheets used for making condensers.

A. K. Croad (communicated by Aerovox Corpn.). Application date 11th March, 1943.

568 683.—Potentiometer network for controlling the shift and astigmatism of the spot in a cathode-ray tube adopted for A.C. or D.C. working.

A. C. Cossor, Ltd., and A. Levin. Application date 11th October, 1943.

568 765.—Instrument for measuring current surges or transients by their effect on the combination of a fixed and a moving magnet.

E. L. Damant. Convention date (South Africa) 3rd November, 1942.

568 836.—Valve-oscillator circuit for the measurement of capacitances and inductances by a resonance method.

K. Wessely. Application date 27th October, 1943.

569 302.—End-cap and terminal arrangement for a cylindrical condenser of the interleaved type.

A. H. Hunt, Ltd.; A. H. Dilley; and A. E. C. Bennett. Application date 25th August, 1943.

569 279.—Cathode-ray indicator for measuring or comparing the frequency characteristics of filter networks, equalisers, and amplifiers.

Automatic Telephone and Electric Co., Ltd.; T. B. D. Terroni; and J. R. Cannon. Application date 11th November, 1943.

569 285.—Piezo-electric oscillator made of primary potassium phosphate, or of any crystal that is iso-morphic with it.

"Patelhold" Patentverwertungs &c. A. G. Convention date (Switzerland) 22nd November, 1942.

569 296.—Preventing leakage to or from the timing condenser, through the valve, in a pentone circuit for measuring short intervals of time.

R. K. Dundas, Ltd. and G. I. Hitchcock. Application date 26th November, 1943.

569 454.—Spring-clip supports and mounting for a piezo-electric crystal with plated or coated electrodes.

Standard Telephones and Cables, Ltd. (assignees of S. A. Bokovoy and H. W. N. Hawk). Convention date (U.S.A.) 7th October, 1942.

569 473.—Process for coating metal surfaces with selenium for use in photo-electric cells and rectifiers.

Standard Telephones and Cables, Ltd. (assignees of A. von Hippel). Convention date (U.S.A.) 12th July, 1941.

ABSTRACTS AND REFERENCES

Compiled by the Radio Research Board and published by arrangement with the Department of Scientific and Industrial Research

Comparative Length of the Abstracts.—*It is explained to new readers that the length of an abstract is no sign, by itself, of the importance of the work concerned. An important paper in English may be dealt with by a short abstract, or even, if it is in a journal readily obtainable, by a square-bracketed addition to the title, while a paper of similar importance in a language other than English may be given a long abstract. In addition to these questions of language and accessibility, the nature of the work has, of course, a great effect on the useful length of its abstract.*

PROPAGATION OF WAVES

3458. WAVE GUIDES AND THE SPECIAL THEORY OF RELATIVITY.—W. D. Hershberger. (*Journ. Applied Phys.*, Aug. 1945, Vol. 16, No. 8, pp. 465–468.)

Author's summary :—" The Lorentz transformation is applied to the H_{01} solution of Maxwell's equations used to describe wave propagation in conducting pipes of rectangular cross section. When group velocity for the wave is employed in the transformation, the solution obtained is that one characterising wave-guide operation at cut-off frequency, thus demonstrating that the speed associated with power or signal transmission is group velocity. When phase velocity for the wave is employed in the transformation, and we treat all quantities appearing in the new solution as real, we find that the problem has been reduced to one in magnetostatics and the significance of this solution is pointed out. The use of the inverse Lorentz transformation to find wave-guide solutions from known solutions of problems in statics is indicated."

3459. ON THE CLASSICAL THEORY OF RADIATING ELECTRONS.—C. J. Eliezer & A. W. Mailvaganam. (*Proc. Cambridge Phil. Soc.*, Aug. 1945, Vol. 41, Part 2, pp. 184–186.)

Introduces a state of equilibrium between the emitted and absorbed radiation fields after a sufficient lapse of time, as a principle to be satisfied by the physical solution of the relativistic equations of motion of a point electron in an electromagnetic field, to discriminate between the physical and non-physical solutions.

3460. THE HUYGENS PRINCIPLE AND MAXWELL'S EQUATIONS FOR VACUUM.—C. W. Oseen. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 28th Dec. 1944, Vol. 31, Part 1, Section A No. 4, 17 pp. : in French.)

3461. DEVELOPMENT OF ELECTROMAGNETIC THEORY FOR NON-HOMOGENEOUS SPACES—A CORRECTION.—B. Liebowitz. (*Phys. Review*, 1st/15th June 1945, Vol. 67, Nos. 11/12, p. 364.)

Correction to 1102 of 1944.

3462. DIFFRACTION OF RADIO-WAVES AROUND THE GLOBE.—W. A. Fock. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 20th March 1945, Vol. 46, No. 8, pp. 310–313.)

" A theoretical discussion of the problem of propagation of radio-waves around a homogeneous Earth surface. Diffraction effects are considered, but the influence of the ionosphere is neglected."

3463. RADAR TECHNIQUES. PART IV — BOUNDARIES.—C. B. De Soto. (*QST*, Aug. 1945, Vol. 29, No. 8, pp. 48–52, 86–88.)

The dependence of reflection of waves on the conductivity, permeability and dielectric constant of the reflecting medium is discussed and a chart of the first and last of these properties is given for typical terrain. The dependence of the reflection coefficient of surfaces on the angle of incidence of the waves is examined and mention is made of the methods by which the propagation and reflection characteristics are used in radar to obtain an outline picture of the terrain over which an aircraft is flying.

For previous parts *see* 2650 of August and 2878 of September.

3464. CORRELATION OF FIELD AND CIRCUIT THEORY.—L. L. Libby & N. Marchand. (*Communications*, May 1945, Vol. 25, No. 5, pp. 46, 76–77, 80–81.)

A 2-page article.

3465. TRANSMISSION, REFLECTION, AND GUIDING OF AN EXPONENTIAL PULSE BY A STEEL PLATE IN WATER. I. THEORY.—Osborne & Hart. (*See* 3560.)

3466. " INTRODUCTION TO MICROWAVES " [Book Review].—S. Ramo. (*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, p. 30.)

3467. " FIELDS AND WAVES IN MODERN RADIO " [Book Review].—S. Ramo & J. R. Whinnery. (*Communications*, May 1945, Vol. 25, No. 5, p. 94.)

" . . . basically a text for student engineers. However it may also serve as a source of information for specific design calculations in the field of microwaves."

3468. IONOSPHERIC MEASUREMENTS IN CONNECTION WITH THUNDERSTORM RESEARCH [Correlation of Abnormal E Ionisation with Thunderstorms].—W. Stoffregen. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 18th Aug. 1944, Vol. 30, Part 4, Section A, No. 19, 10 pp. : in English.)

3469. ON THE EFFECT OF A VERTICAL MAGNETIC FIELD IN A CONDUCTING ATMOSPHERE : *and* ON SUNSPOTS AND THE SOLAR CYCLE : *and* ON THE EXISTENCE OF ELECTROMAGNETIC HYDRODYNAMIC WAVES.—H. Alfvén. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 22nd April 1943, Vol. 29, Part 2, Section A, No. 11, 6 pp. : Section A, No. 12, 17 pp. : Section B, No. 2, 7 pp. : in English.)

These three papers are all concerned with a new theory of sun-spots. "If a conducting liquid is placed in a constant magnetic field, a mechanical motion in the liquid will in general give rise to an e.m.f., which produces electric currents. The interaction between the magnetic field and these currents causes mechanical forces which change the state of motion of the liquid.

"Thus the application of a magnetic field to a conducting liquid causes a mutual interaction between hydrodynamic motion and electric current. Thus kinetic energy can be converted into electromagnetic energy and *vice versa*. This mechanism makes possible the existence of a kind of combined electromagnetic-hydrodynamic wave, which—as far as I know—has as yet attracted no attention." It is suggested that the conditions necessary for the production of such waves exist in the sun, and that sun-spots may in fact consist of such waves, originating in the interior and reaching the surface in the sun-spot zones.

3470. ON THE THEORY OF SUN-SPOTS.—C. Walén. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 25th May 1944, Vol. 30, Part 3, Section A, No. 15, 87 pp. : in English.)

In a long mainly mathematical paper, the author develops Alfvén's theory of sun-spots (*See* 3469 above). The theory is that, as the result of interaction between electromagnetic and hydrodynamic forces in the sun, considered as a conducting liquid, "closed magnetic rings" are produced in the interior of the sun by hydrodynamic vorticity. The ring travels along the lines of force of the sun's general magnetic field and produces a pair of sun-spots ("a bi-polar sun-spot group") by reflection at the surface of the sun.

3471. EXPERIMENTAL DETERMINATION OF ASYMPTOTIC ORBITS IN THE EARTH'S MAGNETIC FIELD.—K. G. Malmfors. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 25th May 1944, Vol. 30, Part 2, Section A, No. 12, 10 pp. : in English.)

Direct observation of the trajectories of electron rays in the dipole magnetic field of a magnetised sphere. The results are related to the diurnal variation of cosmic radiation.

3472. ON A SYSTEM OF DIFFERENTIAL EQUATIONS STUDIED BY C. STÖRMER.—J. Malmquist. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 26th Jan. 1944, Vol. 30, Part 1, Section A, No. 5, 8 pp. : in French.)

The equations refer to the trajectories of electrified corpuscles under the influence of an elementary magnet.

3473. THE ULTRA-VIOLET SOLAR RADIATION IN SPECTRAL RANGE UVA.—T. E. Aurén. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 4th Aug. 1942, Vol. 28, Part 3, Section A, No. 11, 29 pp. : in English.)

Measurements of the solar radiation in the wavelength range 312–400 mμ are described, using the "Uviolmeter" with a filter of $CuSO_4$ solution contained in a cell with quartz or "uviol" glass windows. Tables of results show very good agreement, for the Transmission Factor, with similar measurements taken in Washington. During warm seasons the transmission is subject to rapid changes, and becomes steadier during cold weather.

3474. BEHAVIOUR OF ULTRA-VIOLET AND DAYLIGHT RAYS IN THE SOLAR CYCLE.—J. R. Ashworth. (*Nature*, 28th July 1945, Vol. 156, No. 3952, p. 115.)

The intensities of the ultra-violet and daylight rays have been observed to vary with the sunspot cycle, having a minimum at the sun-spot maximum. The ionisation of the upper air is a probable cause.

3475. SOLAR RADIATION.—(*Wireless World*, Sept. 1945, Vol. 51, No. 9, p. 268.)

Comment on 398 of 1944 and a summary of 3474.

3476. DIRECTIONAL MEASUREMENTS OF COSMIC RADIATION.—H. Alfvén & K. G. Malmfors. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 1st Nov. 1943, Vol. 29, Part 3, Section A, No. 24, 16 pp. : in English.)

Describes methods and results of measurement of diurnal variation of cosmic radiation as a function of direction over a period of about 600 days. It is concluded that the variations cannot be attributed to atmospheric effects but may be due to effects of the magnetic fields of the sun or the earth. *See also* 3477.

3477. BAROMETER EFFECT OF COSMIC RADIATION.—F. Lindholm. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 25th May 1944, Vol. 30, Part 2, Section A, No. 13, 16 pp. : in German.)

See also 3476.

3478. ON THE ORIGIN OF COSMIC RADIATION.—O. Klein. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 12th Feb. 1945, Vol. 31, Part 3, Section A, No. 14, 9 pp. : in English.)

A theory is advanced that an essential part of the cosmic radiation originates from annihilation processes taking place in intergalactic space between reversed matter, consisting of negative nuclei and positive electrons, and ordinary matter. It is suggested that half the distant nebulae consist of such reversed matter and that the intergalactic space contains matter of both kinds at an extremely low density allowing processes to take place whereby ordinary and reversed atoms annihilate each other.

3479. COMMUNICATIONS ON 5 METRES AT DISTANCES GREATER THAN 200 KMS. [Experiences with Transmitter LU2AG].—(*Revista Telegrafica*, June 1945, No. 393, p. 374.)

3480. ON THE RELATION OF THE SURFACE TEMPERATURE OF THE SEA TO THE AIR TEMPERATURE.—J. W. Sandström. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 4th

Aug. 1942, Vol. 28, Part 3, Section A, No. 13, 24 pp.: in English.)

The collected results of measurements of the surface temperatures of the sea over the period 1900–1937 for the rectangle 49°N, 8°W to 50°N, 9°W (Copenhagen). The results for the month of January are presented in pictorial form together with similar records of air temperature.

3481. MONTHLY MEAN SURFACE TEMPERATURES OF THE SEA *and* THE VARIATIONS OF THE ATMOSPHERIC PRESSURE.—J. W. Sandström. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 1st Nov. 1943, Vol. 29, Part 3, Section A, No. 16, 18 pp.: *and* 28th Dec. 1944, Vol. 31, Part 1, Section A, No. 5, 35 pp.: in English.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3482. LIGHTNING-PROTECTED CABLES.—Inskip. (*See* 3657.)

PROPERTIES OF CIRCUITS

3483. A METHOD FOR COMPUTING THE RESONANT WAVE-LENGTH OF A TYPE OF CAVITY RESONATOR.—L. S. Goddard. (*Proc. Cambridge Phil. Soc.*, Aug. 1945, Vol. 41, Part 2, pp. 160–175.)

The results of 3706 are used to calculate the field inside a cylindrical resonator having equal axial cylindrical plugs. "A process . . . is given for solving the equation which leads to the resonant wave-length λ, both in the case where all the resonator parameters are given and we wish to find λ, and also in the case where λ is given and one of the parameters (the outer radius) is to be found.

". . . the methods developed may be used in the treatment of problems involving the transmission and reflexion of energy along wave-guides or transmission lines when there is a sudden discontinuity in the cross-section."

3484. V-H-F TRANSMISSION-LINE ELEMENT CHART [for determining the Tuning Frequency of a Capacity-Loaded Line].—F. C. Everett. (*Communications*, July 1945, Vol. 25, No. 7, pp. 66–67.)

3485. [Calculation of the] FREQUENCY OF CAPACITANCE TUNED LINES AND RESONANT LINE OSCILLATORS.—H. A. Brown. (*Communications*, May 1945, Vol. 25, No. 5, pp. 51–56, 90–93.)

A five-page description of a graphical method based on approximations to the complete theory. An experimental check that is quoted shows discrepancies of 3% and 7% between observed and computed values.

3486. THE REACTANCE THEOREM FOR A RESONATOR.—W. R. MacLean. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, pp. 539–541.)

Author's summary:—"The Foster reactance theorem which states that in any loss-free network, $dX/d\omega$ is positive, is here proved for any loss-free resonator. However, to establish the existence of an input impedance, the author feeds the resonator with a coaxial (or other suitable) transmission line. The proof is based upon an extension of Helmholtz's theorem of adiabatic invariants. The variation of frequency is attained by a slow (adiabatic) movement of a short-circuiting plug in the transmission line while the cavity is oscillating."

3487. LOSS-FREE TRANSMISSION LINES.—R. Sibson. (*Wireless Engineer*, Sept. 1945, Vol. 22, No. 264, pp. 420–428.)

The problem of matching a loss-free transmission line to an arbitrary load is discussed, using the circle diagram with several illustrative examples. The paper gives the analytical conditions for a match to be possible using a single stub system, a double stub system and quarter-wave slugs in the form of metallic projections or dielectric sections.

3488. CORRELATION OF FIELD AND CIRCUIT THEORY.—L. L. Libby & N. Marchand. (*Communications*, May 1945, Vol. 25, No. 5, p. 46, 76–77, 80–81.)

A 2-page article.

3489. CONTRAST EXPANSION: THE USE OF NEGATIVE FEEDBACK: ITS ADVANTAGES OVER EARLIER METHODS.—J. G. White. (*Wireless World*, Sept. 1945, Vol. 51, No. 9, pp. 275–278.)

The first of two articles.

3490. A VOLUME EXPANDER FOR AUDIO AMPLIFIERS.—H. K. Weidemann. (*QST*, Aug. 1945, Vol. 29, No. 8, pp. 19–22.)

A system is described for obtaining satisfactory audio volume expansion by the insertion of a circuit between the microphone or pick-up and any conventional amplifier. Rapid control is obtained without distortion or objectionable speaker "thumps", and the overall characteristic of the expander can be easily varied. The arrangement also has possibilities as a volume compressor.

3491. VALVE AMPLIFIER FOR A SPECTROPHONE.—S. A. Cogan, S. M. Luchin and V. I. Siforov. (*Comptes Rendus* (*Doklady*) *de l'Ac. des Sci. de l'URSS*, 20th February 1945, Vol. 46, No. 5, pp. 186–187.)

See 3611 for article on the Spectrophone.

3492. EXTENDING THE FREQUENCY RANGE OF THE PHASE-SHIFT OSCILLATOR.—R. W. Johnson. (*Proc. I.R.E.*, Sept. 1945, Vol. 33, No. 9, pp. 597–603.)

Author's summary:—"Methods for facilitating the design of phase-shift oscillators at extreme frequencies of a fraction of a cycle to a few megacycles are discussed. It is shown that, if the input impedance of each section of a lumped resistance-capacitance network is made K times that of the previous section, the gain required for oscillation can be reduced to a theoretical minimum of 8 for a three-section network with K high, as against 29 for a K of unity. A new circuit element called the "resistance-capacitance transmission line", consisting of a resistance covered by a well-insulated and grounded metal surface, is introduced and is analysed as a phase-shifting network to give reliable operation in a phase-shift oscillator at frequencies up to a few megacycles. Curves are presented to facilitate the design of the latter type of oscillator. Various configurations of the resistance-capacitance transmission line are discussed and experimental results are presented."

3493. "N"-PHASE RESISTANCE-CAPACITANCE OSCILLATORS.—R. M. Barrett. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, pp. 541–545.)

Author's summary:—"This paper describes the design of a series of resistance-capacitance tuned oscillators of the polyphase type. A single-mesh phase-shift network is used for coupling the *N* tubes of the oscillator which are arranged in a feedback ring. Limiting the discussion to oscillators of odd phases, the author has developed design formulas and has analysed typical circuits. Experimental results are shown to check closely those predicted by theory."

3494. MULTIVIBRATOR CIRCUITS.—M. V. Kiebert, Jr., & A. F. Inglis. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, pp. 534–539.)

Authors' summary :—"A simplified method is presented for the calculation of the voltage wave forms of nonsinusoidal voltage generators in which the circuit action is dependent upon the exponential charging and discharging of capacitors. A number of multivibrator circuits are then discussed and analysed in accordance with this method."

3495. "SEE-SAW" OR "PARAPHASE"? ORIGIN OF THE CIRCUIT : SOME PRACTICAL POINTS.—R. E. H. Carpenter : M. G. Scroggie. (*Wireless World*, Sept. 1945, Vol. 51, No. 9, pp. 263–265.)

A discussion of 2603 of August, and British Patent No. 325833.

3496. THE VIBRATRON.—F. Rieber. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 100.)

Very short abstract. *See also* 3342 of October.

3497. CRYSTAL FILTERS : PART III—QUARTZ CRYSTAL RESONATORS.—R. L. Corke. (*P.O. Elec. Eng. Journ.*, July 1945, Vol. 38, Part 2, pp. 39–42.)

"A brief description . . . of the X-cut quartz crystal resonator with a simple explanation of its operation as an element of a filter." (For Parts I and II *see* 2930 of September.)

3498. CRYSTAL BAND-PASS FILTER.—B. Matthias & P. Scherrer. (*Helvet. Phys. Acta*, 20th October 1943, Vol. 16, No. 5, pp. 432–434 : in German.)

". . . it was possible to construct normal speech filters in which the inductance of the additional coils only amounted to a third of the value necessary for an equivalent quartz filter. In addition, a really broad-band filter could now be constructed. The band width achieved exceeded 14% of the mean frequency passed by the filter, and the rejection damping was so great that the filter satisfied all practical requirements."

See also 3434 of 1944.

3499. MULTI-SECTION [Three Section or Less] FILTER DESIGN PROCEDURE [using Universal Grouping Charts].—P. Selgin. (*Communications*, July 1945, Vol. 25, No. 7, pp. 40–44, 70–72, 74–75.)

A 7-page article giving charts and formulae.

3500. APPROXIMATE FORMULAE FOR THE CALCULATION OF ATTENUATION [of Cables] FROM OPEN AND CLOSED IMPEDANCES.—P. R. Bray. (*P.O. Elec. Eng. Journ.*, July 1945, Vol. 38, Part 2, pp. 52–55.)

See also E. W. Smith, *Journ. I.E.E.*, Vol. 73, p. 213, and A. Rosen, *Journ. I.E.E.*, Vol. 68, p. 499.

3501. RESISTIVE ATTENUATORS, PADS AND NETWORKS. PARTS 4 AND 5.—P. B. Wright. (*Communications*, May 1945, Vol. 25, No. 5, pp. 62–70, 86–90 ; June 1945, Vol. 25, No. 6, pp. 68, 72–83.)

"In this [8-page] instalment [Part 4] derivations and formulas are given for the π, *multiple bridge* and *lattice* networks. A key or master chart is presented, providing all of the relationships between the *hyperbolic*, *exponential*, *algebraic* and *symbolic* functions used throughout this series. Charts for the *lattice* to *T* equivalences are also offered."

The *bridged T* network is analysed in Part 5 (5 pages).

(For Parts 1—3 *see* 2178 of July.)

3502. EXPERIMENTAL DETERMINATION OF IMPEDANCE FUNCTIONS BY THE USE OF AN ELECTROLYTIC TANK.—Hansen & Lundstrom. (*See* 3651.)

3503. A RECENT DEVELOPMENT IN TELEGRAPH REPEATERS FOR SUBMARINE CABLES.—F. O. Morrell, R. O. Carter & A. N. McKie. (*P.O. Elec. Eng. Journ.*, July 1945, Vol. 38, Part 2, pp. 34–38.)

A repeater designed for Wheatstone or teleprinter operation, comprising "an attenuation equaliser followed by a push-pull amplifier working on a modified impulse basis, with a special circuit to restore the D.C. and low-frequency components of the signal. Duplex facilities are provided."

3504. VALVE VECTORS AGAIN : AMPLIFIED EXPLANATION FOR STUDENTS [of Statement in 2179 of July].—K. R. Sturley. (*Wireless World*, Sept. 1945, Vol. 51, No. 9, pp. 271–273.)

3505. VALVE EQUIVALENT CIRCUIT CONVENTIONS AND NEGATIVE FEEDBACK.—G. W. O. H. (*Wireless Engineer*, Sept. 1945, Vol. 22, No. 264, pp. 417–419.)

Editorial comment on a paper by G. Builder (D.S.I.R., Australia) entitled "Valve Equivalent Circuit Conventions", in which he favours using the positive sign for currents flowing in the same direction as the steady current in, for example, an amplifier equivalent circuit. This convention gives negative values for the amplification factor and gain.

3506. A STRANGE CONVENTION.—G. W. O. H. *and* A "STRANGE" CONVENTION?—H. Jefferson : G. W. O. H. (*Wireless Engineer*, July 1945, Vol. 22, No. 262, p. 315, *and* September 1945, Vol. 22, No. 264, p. 442.)

Editorial comment and subsequent correspondence on conventions for indicating the directions of currents and voltages in a circuit.

3507. REMOTE-CONTROL OF OUTPUT LEVEL [in Broadcasting or Commercial Systems to provide Effective Dynamic Range Control].—R. P. Aylor, Jr. (*Communications*, July 1945, Vol. 25, No. 7, pp. 49, 81–84.)

Two circuits are described, one using variable voltage feedback, and the other using a variable H-pad.

3508. AUTOMATIC H.F. HEATING CONTROL.—(*See* 3722.)

3509. Producing Nearly Constant Alternating Voltages for Calibration.—W. Stockman. (*Communications*, July 1945, Vol. 25, No. 7, pp. 46–47.)

An elementary circuit using diodes as limiters, reducing a 10% change in line voltage to 1%.

TRANSMISSION

3510. New Lifeboat Radio Covers 1000 Miles and Flashes SOS Automatically.—(*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, p. 12.)

Radiomarine Corporation of America have developed a lifeboat radio equipment that automatically transmits SOS and radio direction finder signals. It has facilities for two-way radiotelegraph and radiotelephone. Operating on 500 kc/s its range is from 50 to 200 miles. Operating on 8280 kc/s the range is 1000 miles.

3511. Emergency Lifeboat Transmitter: Auto Transmission of Tone-Modulated Distress Signals [on 500 kc/s] with Provision also for Telephony [in 24, 36 and 63 metre Bands].—(*Wireless World*, Sept. 1945, Vol. 51, No. 9, pp. 266–268.)

Designed to operate with a long aerial held up by a kite or balloon, or with a short emergency aerial. The power supply is a special 12V 12AH battery, and aerial power of 10–15W (500 kc/s) or 20–25W (short wave) is available.

3512. The Design of a Frequency-Modulated Transmitter [Station LU3A].—E. Richheimer. — (*Revista Telegrafica*, May 1945, No. 392, pp. 275–282.)

3513. German and Japanese [Portable] Communications Equipment. — (*Communications*, May 1945, Vol. 25, No. 5, p. 60.)

Four photographs with very brief descriptions.

3514. A Better Electronic Keyer [to regulate Dashes, Dots and Spaces in Manual Keying]. — H. Beecher. (*QST*, Aug. 1945, Vol. 29, No. 8, pp. 44, 45 and 94.)

The circuit described is claimed to be more dependable and foolproof and easier to handle than any of its predecessors.

See also 2562 of 1940.

RECEPTION

3515. V-H-F [about 100 Mc/s] Receiver and Converter Design.—R. E. Samuelson. (*Communications*, June 1945, Vol. 25, No. 6, pp. 62, 65–66.)

A general discussion with special reference to F–M.

3516. Exalted-Carrier Amplitude- and Phase-Modulation Reception.—M. G. Crosby. (*Proc. I.R.E.*, Sept. 1945, Vol. 33, No. 9, pp. 581–591.)

Author's summary:—" An amplitude- or phase-modulation receiving system is described in which the harmonic distortion produced by fading of the carrier with respect to the sidebands is eliminated. The various parts of such a receiver, including the carrier filter, automatic-frequency-control discriminator, and detecting systems, are described. Analyses are given of the selectivity effect due to carrier exaltation and of exalted-carrier diode and multigrid detection. The optimum degree of carrier exaltation and the effect of carrier limiting are discussed." Observations were taken in the 15, 11 and 9 Mc/s bands, using two different antenna systems separately and in diversity, with an exalted and unexalted receiver alternately for five-minute intervals over a period of 180 minutes. The number of faults (fading distortions classified as undesirable) per minute was noted. Results for the three different antenna systems showed a ratio of faults per minute in the unexalted case to those in the exalted case varying from 3 to 5. A greater improvement would be expected if audio volume-limiting equipment were used.

3517. Frequency Conversion Circuit Development.—H. Stockman. (*Communications*, May 1945, Vol. 25, No. 5, pp. 58, 82–85.)

A two-page historical article concluding 2950 of September.

3518. Conversion Loss of Diode Mixers Having Image-Frequency Impedance. — E. W. Herold, R. R. Bush & W. R. Ferris. (*Proc. I.R.E.*, Sept. 1945, Vol. 33, No. 9, pp. 603–609.)

Authors' summary:—" The theory of the two-electrode nonlinear mixer for superheterodyne use is developed so as to include the effect of resistive impedance at image frequency. The general theory is applied to the calculation of conversion loss under optimum conditions of matching the intermediate-frequency circuit to the mixer stage. Even when the intermediate-frequency circuit is not matched to the mixer, this matched-impedance conversion loss is important in the determination of the over-all signal-to-noise ratio of a receiver. This loss is computed for an idealised diode with different operating conditions, for various values of image-frequency impedance, and for different values of radio-frequency circuit losses.

" Although the chief effect of different image-frequency impedances is a change in the optimum operating conditions and in the required local-oscillator power, there is also an effect on the minimum conversion loss. Very low impedances or very high impedances result in smallest conversion loss. The impedances often encountered at ultra-high frequency (image-frequency impedance approximately the same as signal-frequency impedance) result in an increase in conversion loss which may be between 0 and 3 decibels, depending on the circuit losses."

3519. Army Set Type R107.—(*Wireless World*, Sept. 1945, Vol. 51, No. 9, p. 278.)

Correction to 3286 of October.

3520. Tonal-Range and Sound-Intensity Preferences of Broadcast Listeners.—Chinn & Eisenberg. (*See* 3567.)

3521. Sets for Export.—F. V. Cribb. (*Wireless World*, Sept. 1945, Vol. 51, No. 9, p. 285.)

Letter naming desirable features of broadcast receivers for use in Kenya. *See also* 2202 of July.

3522. German and Japanese [Portable] Communications Equipment. — (*Communications*, May 1945, Vol. 25, No. 5, p. 60.)

Four photographs with very brief descriptions.

3523. Radio-Noise-Meter Performance.—P. Eisenberg. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, p. 550.)

A letter dealing with 395 of 1943. Includes suggestions for an experimental psychological research programme to determine "the exact amount of interfering noise where agreeableness ends and disagreeableness begins".

AERIALS AND AERIAL SYSTEMS

3524. Microwave Impedance Measurements with Application to Antennas. I.—King. (*See* 3605.)

3525. Microwave Impedance Measurements with Application to Antennas. II.—R. King & D. D. King. (*Journ. Applied Phys.*, Aug. 1945, Vol. 16, No. 8, pp. 445–452.)

Authors' summary:—"Following a critical discussion of the problems of theory and experiment and their coordination, experimentally determined curves for the impedance of a symmetrical, cylindrical antenna terminating a two-wire line are given and interpreted. The conclusion is reached that the impedance of an antenna, especially near anti-resonance, depends in a large measure on the proximity and the nature of the input terminals."

3526. Microwave [10 cm] Model Antennas [for Class Demonstration of the Properties of Longer Wave Systems].—M. A. Honnell. (*Communications*, June 1945, Vol. 25, No. 6, pp. 43, 85–88.)

A two-page article.

3527. The Straight Receiving Aerial: Deduction of Approximation Formula for the Aerial Current.—J. Müller-Strobel & J. Patry. (*Helvet. Phys. Acta*, 28th March 1944, Vol. 17, No. 2, pp. 127–132: in German.)

Hallén developed a theory of sending and receiving aerials (2763 of 1939) based on Maxwell's equations, but did not derive a formula that was suitable for practical use. A practical formula is deduced in this paper, for aerials short compared with the wavelength.

3528. Ground-Plane Antennas.—E. D. Smith. (*QST*, Aug. 1945, Vol. 29, No. 8, pp. 28–29 and 96.)

An aerial system suitable for a ground transmitter communicating with aircraft in the frequency band 112–116 Mc/s. A vertical quarter-wave antenna with a form of artificial ground made of two crossed dipoles in the horizontal plane immediately underneath the vertical radiator. A tunable stub is provided for matching to a transmission line. *See also* 3836 of 1940 and 1575 of 1944.

VALVES AND THERMIONICS

3529. Electron-Repulsion Effects in a Klystron.—L. A. Ware. (*Proc. I.R.E.*, Sept. 1945, Vol. 33, No. 9, pp. 591–596.)

This paper is an extension of an article by Savelyev (3228 of 1942). The use of the klystron as an amplifier and an oscillator is considered, with particular reference to the optimum operating conditions, taking account of the debunching effect of the mutual repulsions between the electrons. The author assumes the depth of modulation to be small and the time of flight of an electron through the buncher to be negligible. He concludes that in the case of an amplifier the debunching effect sets an upper limit on the length of the drift space, thus limiting the gain; but for an oscillator the effect is small if the conditions are optimum.

3530. Reflex Oscillators.—J. R. Pierce. (*Bell Lab. Record*, Aug. 1945, Vol. 23, No. 8, pp. 287–290.)

An elementary description of the action of a velocity-modulated tube with simple constructional details of its application as a micro-wave oscillator.

3531. On the Theory of the Split-Anode Magnetron.—F. Lüdi. (*Helvet. Phys. Acta*, 1st March 1943, Vol. 16, No. 1, pp. 59–82: in German.)

See 3338 of 1943.

3532. Space Charge and Electron Deflections in Beam Tetrode Theory.—S. Rodda. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, pp. 649–652.)

A modification of Gill's equation is proposed, based on a combination of the space charge theory and the deflection theory, supposing that the electrons are given transverse deflections at the grid and screen wires. (For parts 1 and 2 *see* 3304 of October.)

3533. Thoriated Tungsten Wire Tested by Simple Device [Use of Geiger Counter to indicate Thorium Content reduces Checking Time by 87%].—(*Sci. News Letter*, 21st July 1945, Vol. 48, No. 3, p. 36.)

3534. The Electron Gun of the Cathode Ray Tube—Part I.—H. Moss. (*Journ. British I.R.E.*, Jan./Feb. 1945, Vol. 5, No. 1, pp. 10–22. Discussion pp. 23–25.)

". . . an attempt to give a simple but logical account of the fundamental principles of the design of electron guns of radial symmetry."

3535. The Secondary Electron Emission of Pyrex Glass.—Mueller. (*See* 3648.)

3536. Theory of Photoelectric Emission from Metals.—H. Y. Fan. (*Phys. Review*, 1st/15th July 1945, Vol. 68, Nos. 1/2, pp. 43–52.)

Author's summary:—"The theory of volume effect in photoelectric emission is developed. Formulae are derived for the rate of electron excitation and for the photoelectric yield. The calculated threshold frequencies for volume effect are 5.91×10^{14} and 5.69×10^{14} for sodium and potassium respectively. The estimated photoelectric yields for these metals are of the same order of magnitude as those calculated for surface effect and are comparable with those observed experimentally. The volume effect should not, therefore, be neglected except in the immediate neighbourhood of the threshold frequency. Approximate estimation indicates that light absorption of sodium and potassium in the visible and ultra-violet regions should be largely due to quantum excitation of electrons. Accurate calculation of electron excitation and absorption requires detailed knowledge of electron wave functions."

3537. New Tubes [Details of Tube Types 6N4, 2C40, GL-3C22, 1B48, CK510AX, 6AJ5, 2523N1/128AS, OA2, 4-25QA and 822-S].—(*QST*, Aug. 1945, Vol. 29, No. 8, pp. 46–47.)

3538. POWER VALVES FOR H.F. HEATING EQUIPMENT.—F. E. Henderson. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, pp. 643–645.)

Discussion of choice of oscillator valve for specific applications.

3539. EXPERIMENTS ON COUNTERS WITH GRIDS.—Korff. (*See* 3653.)

3540. INDUCTION HEATING IN RADIO TUBE MANUFACTURE.—E. E. Spitzer. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 640.)

Paragraph on degassing and getter flashing quoted from *Trans. Electrochem. Soc.*, 1944.

3541. INVESTIGATION OF RESONANCES IN FILAMENTS BY A MECHANICAL ACTUATION AND MEASUREMENT OF ELECTROMAGNETICALLY INDUCED VOLTAGES.—R. W. Carlisle & H. W. Koren. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 71–72.)

The mounted filament is caused to vibrate in a magnetic field, and the induced electromotive force is measured, after suitable amplification.

3542. NEW ELECTRONIC SEAL [for Fusing Glass to Steel: Enables Staple Metal to be used instead of Special Alloys].—(*Elec. Review*, 31st Aug. 1945, Vol. 137, No. 3536, p. 288.)

DIRECTIONAL WIRELESS

3543. A NEW TYPE OF AUTOMATIC RADIO DIRECTION FINDER.—C. C. Pine. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, pp. 522–527.)

The instrument is designed as a lightweight automatic direction finder for aircraft use. One laboratory model made weighs 25 pounds. Crossed loops and a sense aerial are used in conjunction with a single receiver and either a crossed-coil or cathode-ray tube indicator. The sense voltage is applied permanently to the receiver, and voltages from the loops are applied cyclically by means of either a mechanical or electronic switch. At the output of the receiver a similar switch operating in synchronism distributes voltages to the appropriate indicator terminals. Suitable smoothing arrangements are introduced at the indicator to remove switching-frequency components. The intermediate-frequency stages of the receiver are modulated at 600 c/s so as to provide a modulated output to the detector for all incoming signals.

3544. "RADIO DIRECTION FINDERS" [Book Review].—D. S. Bond. (*Communications*, May 1945, Vol. 25, No. 5, pp. 94–95.)

". . . a textbook and reference for advanced engineering students."

3545. RADIOLOCATION.—(*Wireless Engineer*, Sept. 1945, Vol. 22, No. 264, p. 419.)

A 200 word note, with a photograph, on a centimetre-wave anti-aircraft gun-laying equipment, embodying a technique for identifying aircraft as friend or foe.

3546. ACHIEVEMENTS OF RADAR.—(*Wireless World*, Sept. 1945, Vol. 51, No. 9, pp. 269–270.)

A short description of the main wartime applications of radar.

ACOUSTICS AND AUDIO-FREQUENCIES

3547. SCHLIEREN PHOTOGRAPHY OF SOUND WAVES.—F. D. Carlson, K. C. Clark & J. C. Eisenstein. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 101–102.)

Very short abstract.

3548. EXPERIENCE WITH AN FM CALIBRATOR FOR DISK RECORDING HEADS.—H. E. Roys. (*Journ. Soc. Mot. Pict. Eng.*, June 1945, Vol. 44, No. 6, pp. 461–471.)

The usual method of calibrating the recording head for amplitude of movement during cutting, by means of a microscope, is slow and tedious, and becomes inaccurate at the higher frequencies. In the F.M. method described, two tiny condenser plates are mounted a few thousandths of an inch on either side of the vibrating stylus shank. Variations of capacitance caused by the moving stylus change the frequency of the oscillator and the tuning of the discriminator.

3549. SOUND ON THE RECORD.—R. N. Farr. (*Sci. News Letter*, 9th June, 1945, Vol. 47, No. 23, p. 359.)

New and improved methods of sound recording developed in recent years will give longer recording periods at a lower cost. Mechanical recording on plastic film is the most economical method and compact portable equipment has been developed for this purpose. Other systems involve photographic recording on film, mechanical recording on discs, or magnetic recording on steel wire.

3550. BETTER SOUND FOR MOVIES.—(*Sci. News Letter*, 9th June, 1945, Vol. 47, No. 23, p. 359.)

A report of improved loud speakers and public address systems for picture theatres.

3551. PRACTICAL CONSIDERATIONS OF "HIGHER FIDELITY" IN SOUND TRANSMISSION AND REPRODUCTION.—G. M. Nixon. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 102–103.)

Expanded title only.

3552. THE PROBLEM OF FREQUENCY RANGE IN SPEECH AND MUSIC REPRODUCTION.—R. P. Glover. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 103.)

Abstract.

3553. SOME ENGINEERING ASPECTS OF AUDIO FREQUENCY WIRE BROADCASTING IN GREAT BRITAIN.—P. Adorjan. (*Journ. British I.R.E.*, Jan./Feb. 1945, Vol. 5, No. 1, pp. 28–39. Discussion, pp. 39–44.)

3554. BASIC MEASUREMENTS ON THE PHYSICAL CHARACTERISTICS OF SPEECH TRANSMISSION SYSTEMS.—L. L. Beranek. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 101.)

Expanded title only.

3555. MODERN RADIO LOUDSPEAKERS.—E. Lindström. (*Ericsson Review*, 1945, No. 1, pp. 19–23.)

A description of the design and construction of Svenska Radioaktiebolaget's latest types.

3556. ELECTRIC MEGAPHONES.—A. J. Sanial. (*Communications*, July 1945, Vol. 25, No. 7, pp. 33–35, 64–65, 68–69, 76–80.)

A 6-page article describing the characteristics required and the principles of design, in particular the prevention of oscillation due to acoustic feedback.

3557. The Voice of Ship Command.—L. B. Cooke. (*Bell Lab. Record*, July 1945, Vol. 23, No. 7, pp. 241–245.)

A brief description is given of the amplifier and control equipment for the combined general, engineer's, and aviators' battle announcing systems on a large U.S. aircraft carrier. The frequency range of the 40-watt, 120 db gain pre-amplifiers is 500-6000 c.p.s.; volume compression of 2 : 1 is employed. In large systems one or two additional 500 watt amplifiers are used driven by the 40 watt pre-amplifier.

3558. Headphone Measurements and Their Interpretation.—D. W. Martin & L. J. Anderson. (*Journ. Accous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 101.)

Very short abstract.

3559. A General Proof of the Reciprocity Theorem for Electroacoustic Transducers.—L. L. Foldy & H. Primakoff. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 102.)

Abstract.

3560. Transmission, Reflection, and Guiding of an Exponential Pulse by a Steel Plate in Water. I. Theory.—M. F. M. Osborne & S. D. Hart. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 1–18.)

Particular attention is given to the consideration of the plate as an elastic two-dimensional waveguide. The phase velocities of propagation in the principal normal modes are closely related to the corresponding values for the plate in vacuum. The effect of the water on the principal symmetric mode is to add a small attenuation term due to radiation loss into the water. The principal antisymmetric mode is slightly attenuated at high frequencies and strongly attenuated at low frequencies. The cut-off occurs at the frequency at which the phase velocity along the plate equals the velocity of sound in water. The presence of the water also introduces two additional modes, one symmetric and one antisymmetric. At high frequencies their phase velocities are very close to, but a constant fraction of, the velocity of sound in water. At low frequencies the phase velocity of the symmetric mode approaches the velocity of sound in water, and that of the antisymmetric mode approaches zero. The phase velocities of these modes are always real. The antisymmetric mode accounts for most of the properties of the precursor, an oscillation preceding the explosion wave as it travels along the plate.

The methods used are applicable to the evaluation of the phase velocities in an electromagnetic waveguide.

The results of the theory are briefly compared with experiment. Details of the experiments will be given in a later report.

See also 2429 & 3265 of 1938.

3561. Electrical-Acoustical Equivalents.—C. E. Harrison. (*Communications*, June 1945, Vol. 25, No. 6, pp. 44–45.)

An analysis of the relationship between electrical power and sound pressure levels.

3562. The Absolute Calibration of Condenser Microphones by the Reciprocity Method. A Review.—F. M. Wiener. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 102.)

Very short abstract.

3563. Anti-Noise Characteristics of Differential Microphones.—H. E. Ellithorn & A. M. Wiggins. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 104.)

Title only.

3564. A Working Standard for Sound Pressure Measurements.—F. Massa. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 29–34.)

Author's summary :—" This paper discusses the necessary requirements to be met in an ideal sound pressure measurement standard. It also describes the design and shows the characteristics of a new microphone that meets these requirements to a greater degree than do existing units which are generally available for use as laboratory standards. The new microphone is stiffness-controlled and has an acoustic impedance approximately equal to 0.001 cc of air throughout the entire audio-frequency range up to 20 kc. The structure approximates a rigid cylinder $\frac{5}{8}$-inch diameter × $\frac{15}{16}$-inch long and is linear to sound pressure measurements up to several million dynes/cm². "

3565. Frequency Response Preference Tests for Record Reproduction.—B. B. Bauer. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 102.)

Very short abstract.

3566. Group Audiometry.—J. D. Harris. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 73–76.)

Author's summary :—" The use of commonly available apparatus is described for a group test of auditory acuity as a function of frequency. Reliability is only slightly less than that of a careful individual examination. The techniques which produce highest reliability are described. Validity is satisfactory in terms of deviation from results of an individual test. The test is simple to take. Several checks on malingering are provided which make group audiometry practicable with populations not highly selected for age or intelligence."

3567. Tonal-Range and Sound-Intensity Preferences of Broadcast Listeners.—H. A. Chinn & P. Eisenberg. (*Proc. I.R.E.*, Sept. 1945, Vol. 33, No. 9, pp. 571–581.)

The tonal-range and sound-intensity preferences of a cross-section of listeners were investigated with a view to determining the method of reproduction the listener would choose for use and enjoyment in his own home.

About 500 subjects, in small groups, took part and over 10 000 preferences were noted. The subjects comprised " average " listeners, professional musicians and a group of F-M listeners. A wide variety of programme material, including music, songs and speech, was presented at three tonal ranges, designated narrow, medium and wide.

The main conclusions are :—

(a) Preference for the narrow-medium ranges over the wide.

(b) This preference persists when subjects are told the one is " low-fidelity " and the other " high fidelity".

(c) Optimum sound level 60–70 db above reference level.
(d) Higher sound intensities for speech than for music.
(e) Similar distribution of preference in all groups of listeners.

3568. Relation Between the Theory of Hearing and the Interpretation of Speech Sounds.—W. A. Munson. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 103.)
Very short abstract.

3569. Clinical Phenomena in Conductive Media: The Individual Earpiece.—M. B. A. Schier. (*Journn. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 77–82.)
Optimum performance by a hearing aid can only be obtained if it is coupled to the wearer's ear by an earpiece designed to suit the individual. The paper describes clinical and experimental experience obtained with such earpieces, and considers the many factors involved.

3570. Factors Governing the Intelligibility of Speech Sounds.—N. R. French & J. C. Steinberg. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 103.)
Very short abstract.

3571. Sound Conduction in the Head and in the Adjacent Regions.—A. Jellinek. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 105.)
Short abstract.

3572. Acoustical Impedance of Fog.—R. N. Ghosh. (*Indian Journ. of Phys.*, Dec. 1944, Vol. 18, No. 6, pp. 341–346.)
Author's summary :—" The acoustical impedance of porous bodies has been related to their porosity and flow resistance, and it is possible to evaluate it when their physical properties are known. In the present note the acoustical impedance of air containing water particles in suspension has been calculated in a straightforward manner directly from the hydrodynamical laws. The resulting formula is practically similar to that for solids."

3573. Observed Classical Sound Absorption in Air.—W. H. Pielemeier. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 24–28.)
Author's summary :—" A brief treatment of the theory and methods of measuring absorption of sound in gases precedes the data which are presented in the form of curves. The measurements were made with a Pierce acoustic interferometer at a frequency of 1927 kc/sec in air. This frequency is high enough to satisfy Hardy's and Krasnooshkin's required conditions to obtain reliable results by this method. The experimental result agrees with Krasnooshkin's value of $\alpha_0\lambda_0^2 = (255 \pm 5)(10)^{-6}$ cm." *See also* 2914 of 1944, and 845 of March.

3574. Absorption and Scattering by Absorbent Cylinders.—R. K. Cook. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 100.)
Very short abstract.

3575. Influence of Room Proportions on Normal Frequency Spacing.—R. H. Bolt. (*Journn. Acous. Soc, Am.*, July 1945, Vol. 17, No. 1, p. 101.)
Abstract.

3576. Theory of the Effect of Wall Irregularities on the Distribution of Sound in a Room.—P. M. Morse. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 100–101.)
Short abstract.

3577. Application of the Wave Theory of Room Acoustics to the Measurement of Acoustic Impedance.—C. M. Harris. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 35–45.)
Author's summary :—"A method is presented for the measurement of acoustic impedance of large areas of material, at low frequencies, under actual mounting conditions and at various angles of incidence. It is then used to check the assumption in the wave theory of room acoustics that the boundary conditions for the sound field can be expressed in terms of a normal acoustic impedance which is not a function of angle of incidence. The impedance of material covering a wall is computed from two of the room's acoustic properties, the decay constants and frequencies of the normal modes of vibration. In this way the impedance of a large area that vibrates as a panel may be measured where determinations by methods using small samples are not applicable. By using large areas, the average impedance of a number of small samples may be obtained at once. The new method has the advantage that a direct and simple check of this value of the impedance may be secured by measurements of pressure distribution of the normal modes."

3578. Acoustic Pulse Testing.—E. F. Shrader. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 101.)
Short abstract.

3579. "International Congress of Musicology" [Book Review].—(*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 89–90.)
Papers read at the Congress held at New York, September 11th–16th 1939.

3580. Incremental Coupled Musical Scales.—M. H. Gwynn. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 104.)
Short abstract.

3581. The Musical Scale of Just Intonation.—N. Urquhart. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 103–104.)
Abstract.

3582. Wave-Front Determination in a Unidirectional Supersonic Beam.—L. W. Labaw. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 19–23.)
The piezoelectric action of a Rochelle salt crystal microphone is used to determine the excess pressure amplitude in a high-frequency compressional wave beam in a liquid. The wave front may be determined by following a maximum as the microphone is moved across the beam at right angles to the direction of propagation. Changes in the wave front of 0.01 cm at a frequency of 1200 kilocycles, are easily measurable.

3583. The Measurement of the Velocity of Supersonic Waves in Gases.—H. Bömmel. (*Helvet. Phys. Acta*, 20th October 1943, Vol. 16, No. 5, pp. 423–425 : in German.)
The diffraction of light by gases in supersonic

vibration was used to determine the wavelength, and hence the velocity, of supersonic waves in CO_2, O_2, N_2, A, and Air, at frequencies of 951, 2853 and 4755 kc/s. No dispersion was observed. Dispersion was observed in accordance with theory, in a mixture containing CO_2 at high pressure.

PHOTOTELEGRAPHY AND TELEVISION

3584. BRITAIN'S POSTWAR TELEVISION PLANS.—A. Hunter. (*Communications*, May 1945, Vol. 25, No. 5, pp. 48–49.)

Summary of the recommendations of the Hankey Committee.

3585. REPORT OF THE BRITISH TELEVISION COMMITTEE.—(*Proc. I.R.E.* (Australia), June 1945, Vol. 5, No. 10, pp. 3–12.)

3586. RESTARTING TELEVISION.—(*Elec. Review*, 7th Sept. 1945, Vol. 137, No. 3536, p. 346.)

The Television Development Committee of the Radio Industry Council have decided to apply to the Government for the immediate introduction of a television transmission from Alexandra Palace.

3587. PROJECTION TELEVISION.—D. W. Epstein & I. G. Maloff. (*Journ. Soc. Mot. Pict. Eng.*, June 1945, Vol. 44, No. 6, pp. 443–455.)

The two basic problems of projection television are : (1) the provision of cathode ray tubes capable of producing very bright pictures with the necessary resolution, and (2) the design of efficient optical systems. Problem (1) has been solved by using higher operating voltages, whilst the second problem has been solved by the development of a reflective optical system, seven times more efficient than a good f/2 refractive lens, consisting of a spherical mirror and an aspherical correcting lens. The use of moulded plastic mirrors and lenses reduces the cost.

3588. COAXIAL CABLES AND TELEVISION TRANSMISSION.—H. S. Osborne. (*Journ. Soc. Mot. Pict. Eng.*, June 1945, Vol. 44, No. 6, pp. 403–418.)

The author visualises a nation-wide network of coaxial cables for television and telephone transmission. The technical features of such cables, and associated amplifiers and repeaters are discussed.

3589. TELEVISION CIRCUIT [New Stations at Boston, Jamaica, Long Island, Indianapolis ; Several Department Stores apply for Construction Permits].—(*Gen. Elec. Review*, Aug. 1945, Vol. 48, No. 8, p. 60.)

3590. TELEVISION/CINEMA COMPARISONS.—J. M. T. Evans. (*Wireless World*, Sept. 1945, Vol. 51, No. 9, p. 284.)

Letter referring to 3319 of October. Comparison of a television mosaic with the film grain of a cinema picture is invalid, as the former is fixed, whereas the latter changes from frame to frame, and is therefore less noticeable.

3591. FORMATION OF IMAGE IN A STRONG MAGNETIC LENS.—K. Siegbahn. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 26th Jan. 1944, Vol. 30, Part I, Section A, No. 1, 12 pp. : in English.)

Busch's simple formula for the focal length of a magnetic lens suffices for c.r. tube applications but not for ultramicroscopy. The paper shows how to calculate the focal length when the form of the field is known by measurement and can be closely approximated by a function such as $H(z) = H_0 \exp - (z/b)^2$.

3592. [Direct] MODULATION OF A CARRIER WAVE BY A LOW VELOCITY ELECTRON CAMERA [the Isoscope].—R. Barthélemy. (*Génie Civil*, 1st May 1945, Vol. 122, No. 9, p. 70.)

Short abstract of paper read before the Académie des Sciences.

3593. ON THE CAPACITY AND RESISTANCE OF SELENIUM BARRIER-LAYER PHOTO-ELEMENTS.—A. E. Sandström. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 28th Dec. 1944, Vol. 31, Part I, Section A, No. 2, 31 pp. : in English.)

Author's summary :—" 1. Although quite sufficient in the D.C. circuit, the usual model of a selenium barrier-layer photo-element is too simple when the element is used in an A.C. circuit. For calculation purposes a model was developed where due regard was taken to the capacity between the electrodes. The present results indicate that even this model is incomplete, but it is sufficient and convenient for frequencies between 400 and 800 cycles per second.

" 2. The barrier-layer capacity of the unilluminated element increases if the element is exposed to light. When the element is restored to darkness the capacity rapidly decreases. The capacity between the electrodes seemingly remains constant inside the rather wide limits of errors. The decrease of the barrier-layer capacity with the lapse of time after an exposure obeys a similar law to that of the simultaneous increase in barrier-layer resistance.

" 3. The barrier-layer capacity is a linear function of the inverse value of the resistance (i.e., the conductance). A formula is found giving the relation between the capacity and the resistance of the barrier-layer. The constants entering into this formula are determined for the three elements in question.

" 4. A hypothetical explanation is given of the relation between barrier-layer capacity and barrier-layer resistance. Based on this a short discussion is given on the barrier-layer and the mechanism of such changes which are due to exposure to light."

MEASUREMENTS AND STANDARDS

3594. A FREQUENCY STANDARD FOR USE AT HIGH AND LOW FREQUENCIES.—R. P. McLoughlin. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 46–70. The original paper (in Spanish) appeared in *Revista Electrontecnica*, Oct. 1941, Vol. 27, p. 383 onwards.)

A secondary frequency standard is described that consists of a tuning-fork oscillator controlling a multivibrator. A regenerative amplifier is used that provides adequate selectivity to allow the selection of any harmonic in the range 1 kc/s to 2 Mc/s. A special steel is used to make a fork with very low temperature coefficient of frequency.

The following performance figures are given. Variation of frequency with change in temperature, for constant supply voltage, $\Delta T = 35°$ C (0° to 35°), $\Delta f/f = -3.6 \times 10^{-8}$; variation with supply voltage for constant temperature, $\Delta V = 50$V

(230 V to 180 V), $\Delta f/f = -1.7 \times 10^{-8}$. A bibliography of 125 items is given.

3595. Oscillograph for the Direct Measurement of Frequency Employing a Signal Converter.—P. Nagy & M. J. Goddard. (*Wireless Engineer*, Sept. 1945, Vol. 22, No. 264, pp. 429–441.)

This paper describes a mains-driven oscillograph with velocity-calibrated time-base for the direct measurement of frequency to an accuracy of ± 1 per cent. A deflection-modulated cathode-ray valve, called the "Signal Converter", is used as the time-base generator. Factors affecting the accuracy of measurement include stability of the output condenser with respect to temperature changes, widths of the reference line and trace, parallax between the screen and transparent disc, deflection sensitivity of the cathode ray tube, and variations of mains voltage. Methods of dealing with these are described. *See* 3393 of 1943 for an account of the signal converter.

3596. On the Piezoelectric ΔE-Effect of Crystals akin to Rochelle Salt.—Matthias. (*See* 3644.)

3597. The Inverse Piezoelectric Effect of KH_2PO_4.—von Arx & Bantle. (*See* 3643.)

3598. The Dependence on Field Strength of the Resonant Frequency of Crystals akin to Rochelle Salt.—W. Bantle, B. Matthias & P. Scherrer. (*Helvet. Phys. Acta*, 30th June 1943, Vol. 16, No. 3, pp. 209–211: in German.)

The considerable difference between the resonant frequencies of crystals akin to Rochelle salt with air-spaced and contact electrodes is shown to be due to the considerable field-strength dependence of the "reversible susceptibility".

3599. High Frequency Vibrations of Thin Crystal Plates.—Ekstein. (*See* 3645.)

3600. Taming the Vacuum-Tube Voltmeter: Part II—Construction of a Practical Instrument.—M. Silver. (*QST*, Aug. 1945, Vol. 29, No. 8, pp. 34–39.)

Further details of the instrument described in Part I (*see* 3333 of October) are discussed. Additional factors contributing to all-round utility and probable limits of accuracy and constructional details are described and examined.

3601. A Crystal-Controlled 75-Mc Signal Generator [for Aligning Aircraft Beacon Receivers].—W. C. Grasel. (*Communications*, June 1945, Vol. 25, No. 6, pp. 46–51.)

The crystal frequency is twice tripled, and the signal can be amplitude modulated at 400, 1300 and 3000 c/s to a depth of 30 per cent. The attenuator is in two parts, a five-step decade, and a smoothly variable tapped inductance. Circuit details are given. The instrument is battery-operated.

3602. A Device for Indicating Small Changes in Electrolytic Resistance.—G. G. Blake. (*Journ. of Scient. Instr.*, Sept. 1945, Vol. 22, No. 9, pp. 174–176.)

The resistance of a column of electrolyte is capacitively coupled in parallel with the oscillatory circuit of a valve oscillator. The changes in Q due to changes of the resistance cause changes in the anode current of the valve, which are measured with a backed-off microammeter. "An application is described for indicating changes in the electrolytic resistance of a solution flowing through a pipe system. When sufficient change takes place . . . a relay operates. . . ."

3603. Study of the Use of the Wheatstone Bridge for Continuous Recording of Variations in Electric Resistance.—E. Brasey. (*Helvet. Phys. Acta*, 12th April 1943, Vol. 16, No. 2, pp. 145–172: in French.)

Author's summary:—"When the Wheatstone bridge is used for continuous recording of resistance variation by means of the deflections of the bridge galvanometer, any sensitivity can be obtained by means of an infinite number of combinations of values of the arms of the bridge.

"The diagrams [derived] . . . give the means of choosing the combination that corresponds best to the conditions imposed by the physical phenomenon recorded by the variation of resistance [e.g., temperature]."

3604. Electrical Testing of Coaxial Radio Frequency Cable Connectors.—C. Stewart, Jr. (*Proc. I.R.E.*, Sept. 1945, Vol. 33, No. 9, pp. 609–619.)

The "insertion" and the "null shift" methods of measuring the characteristic impedance of connectors are described.

In the former, the connector is inserted between a standing wave detector and a length of absorbing cable. The standing wave is investigated and the reflection coefficient and characteristic impedance are deduced from charts.

The latter method is applicable only to bulkhead plugs, adaptors, etc., and not to plugs and sockets connected to cables. The null point of a slotted line is found for the line open and closed with and without the connector attached, and the impedance calculated from the usual formula $Z_c = Z_0 \sqrt{(\Delta S_s/\Delta S_0)}$.

The power factor of the connector can be deduced from the formula $P = C_1(Q_1 - Q_2)/(C_1 - C_2)\, Q_1Q_2$ using the "Q" meter. A mathematical development of the theory follows.

3605. Microwave Impedance Measurements with Application to Antennas. I.—D. D. King. (*Journ. Applied Phys.*, Aug. 1945, Vol. 16, No. 8, pp. 435–444.)

The theoretical bases of the resonance-curve and standing-wave transmission-line methods are reviewed. The practical details of a balanced two-wire apparatus using the resonance-curve method at $\lambda = 40$ cms are discussed and described. The maximum error in the measured values of resistance and reactance of the line termination "should not be greater than 10 per cent", but "there are two regions where it may be greater".

3606. Microwave Impedance Measurements with Application to Antennas. II.—King & King. (*See* 3525.)

3607. Calibration of Decibel Meters.—P. K. Hudson. (*Communications*, July 1945, Vol. 25, No. 7, pp. 58–59, 86.)

3608. A New Method of Determining the Strength and Direction of a Magnetic Field.—von Friesen. (*See* 3631.)

3609. THE MEASUREMENT OF CROSSTALK IN TELEPHONE [Multi-Channel Carrier] APPARATUS WITH AN ARTIFICIAL VOICE AND A WEIGHTED TRANSMISSION MEASURING SET.—L. S. Crutch. (*P.O. Elec. Eng. Journ.*, July 1945, Vol. 38, Part 2, pp. 48–51.)

"The use of an artificial voice as the disturbing source enables standard test conditions to be reproduced more rapidly than is possible with normal methods employing the human voice . . . use is made of . . . [a standard transmission measuring set], suitably weighted, and a psophometer is not then required."

3610. ON THE PROBLEM OF HEAT CONDUCTION IN A SEMI-INFINITE RADIATING WIRE.—Lowan. (*See* 3701.)

3611. SPECTROPHONE—AN INSTRUMENT FOR INVESTIGATION OF INFRA-RED ABSORPTION SPECTRA OF GASES AND FOR QUANTITATIVE AND QUALITATIVE SPECTRUM ANALYSIS OF MULTI-COMPONENT GAS MIXTURES.—M. L. Veingerov. (*Comptes Rendus* (*Doklady*) *de l'Ac. des Sci. de l'URSS*, 20th February 1945, Vol. 46, No. 5, pp. 182–185.)

An optic-acoustical method is used. Monochromatic radiation, interrupted at a sound frequency, is transmitted through the gas enclosed in a cell. When absorption takes place there is an increase in temperature and consequently an increase in pressure giving rise to sound vibrations in the gas, at the interrupting frequency. These are recorded by means of a microphone, and are then amplified. The amplifier output is rectified and connected to a sensitive galvanometer, so that the deflections are dependent on the amount of absorption in the gas.

3612. ELECTRICAL MEASUREMENT OF VERY SMALL CHANGES IN ATMOSPHERIC PRESSURE.—Saxer & Dessauer. (*See* 3761.)

SUBSIDIARY APPARATUS AND MATERIALS

3613. A LABORATORY OSCILLOGRAPH.—E. M. Pardo. (*Revista Telegrafica*, June 1945, No. 393, pp. 347–352.)

The design and construction of a general purpose instrument with amplifiers for the frequency range 25 c/s to 3 Mc/s.

3614. THE ELECTRON GUN OF THE CATHODE RAY TUBE—PART I.—H. Moss. (*Journ. British I.R.E.*, Jan./Feb. 1945, Vol. 5, No. 1, pp. 10–22. Discussion pp. 23–25.)

" . . . an attempt to give a simple but logical account of the fundamental principles of the design of electron guns of radial symmetry."

3615. THE RESOLVING POWER OF THE MAGNETIC ELECTRON MICROSCOPE.—V. E. Cosslett. (*Journ. of Scient. Instr.*, Sept. 1945, Vol. 22, No. 9, pp. 170–174.)

Author's summary :—"The chief factors limiting the performance of electron microscopes are discussed : spherical and chromatic aberration, diffraction, imperfections in lens construction. Methods of approach to the correction of aberrations are reviewed. It appears preferable to proceed from a consideration not of the final aberration equations, but from the fundamental equations of electron motion, with the use of relaxation methods. It is shown that, even if the mechanical difficulties in lens construction are overcome, a very great reduction in spherical aberration is required to improve the resolution to below 10A. Further reduction in chromatic aberration is unnecessary in present circumstances."

3616. A DISCUSSION OF THE ILLUMINATING SYSTEM OF THE ELECTRON MICROSCOPE.—J. Hillier & R. F. Baker. (*Journ. Applied Phys.*, Aug. 1945, Vol. 16, No. 8, pp. 469–483.)

Authors' summary :—"A practical means for estimating the average performance of an electron microscope is proposed. Some first-order theory of the operation of an electron-microscope objective is given to demonstrate the extreme sensitivity of the instrument to the adjustment of the illuminating system. It is shown that by considering the illumination as being produced by a two-lens system it is possible to explain qualitatively all the effects observed in practice in connection with the illumination of the specimen. Practical information regarding the exact adjustment of the illuminating system is also given. The cause and elimination of multiple images is discussed. Changes in the design of the electron source and the use of an interchangeable aperture in the condenser lens are shown to improve the average performance of the instrument considerably."

3617. THE STRUCTURE OF CERTAIN MUSCLE FIBRILS AS REVEALED BY THE USE OF ELECTRON STAINS.—C. E. Hall, M. A. Jakus, & F. O. Schmitt. (*Journ. Applied Phys.*, Aug. 1945, Vol. 16, No. 8, pp. 459–464.)

Phosphotungstic acid is a useful electron stain, i.e., has high electron scattering power for use in electron microscopy.

3618. CALCULATION OF MAGNETIC LENSES WITH A GIVEN FIELD CONFIGURATION.—N. Svartholm. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 25th Nov. 1942, Vol. 28, Part 4, Section B, No. 16, 8 pp. : in German.)

3619. [Theoretical and Experimental] INVESTIGATIONS ON THE USE OF MAGNETIC LENSES FOR β-SPECTROSCOPY.—K. Siegbahn. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 25th Nov. 1942, Vol. 28, Part 4, Section A, No. 17, 27 pp. : in German.)

3620. A NEW MASS SPECTROGRAPH.—C. Reutersvärd. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 26th Jan. 1944, Vol. 30, Part 1, Section A, No. 7, 4 pp. : in German.)

3621. A NEW DESIGN FOR A HIGH VACUUM PUMP.—M. Siegbahn. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 25th May 1944, Vol. 30, Part 2, Section B, No. 2, 4 pp. : in English.)

The efficiency of the Gaede type of molecular pump using a flat steel disc has been greatly increased by using a circular disc having a number of concentric flanges, running in a correspondingly grooved enclosure. Pumping speeds up to 48 litres/sec have been obtained. This type is claimed to have advantages over the diffusion pump.

3622. NEW ELECTRONIC SEAL [for Fusing Glass to Steel : Enables Staple Metal to be used instead of Special Alloys].—(*Elec. Review*, 31st Aug. 1945, Vol. 137, No. 3536, p. 288.)

3623. THE CASCADE GENERATOR AS A SOURCE OF STABILISED VOLTAGE.—H. Greinacher. (*Helvet. Phys. Acta*, 30th June 1943, Vol. 16, No. 3, pp. 265-276 : in German.)

Describes various combinations of condensers and selenium or valve rectifiers excited by a mechanically-commutated battery, suitable for stable high-voltage supplies (one or two thousand volts) for counter tubes and the like.

3624. 400-CYCLE INVERTORS FOR MILITARY AIRCRAFT.—C. P. Hayes & L. L. Ray. (*Electrical Eng:g.*, May 1945, p. 233.)

Short abstract in *Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 656.

3625. THE INFLUENCE OF POLARIZATION ON THE ELECTRIC BREAKDOWN STRENGTH AND ITS DEPENDENCE ON TEMPERATURE.—G. Malmlöw. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 26th Jan. 1944, Vol. 30, Part 1, Section B, No. 1, 8 pp. : in English.)

Author's summary :—"Measurements of the electric breakdown strength of mica and potassium bromide at direct and alternating voltage have shown that the values obtained at direct current are influenced by polarization phenomena.

"In cases where polarization phenomena cannot be avoided measurement at alternating current is the only, or at least the simplest, way of arriving at true values of breakdown strength.

"The true electric breakdown strength of KBr is, at least between 220 and 300°K, independent of temperature as predicted by the quantum mechanical theory of Zener and Franz."

3626. THERMOPLASTICS FOR [Insulating and Protecting] ELECTRICAL CONDUCTORS.—H. C. Crafton, Jr., & H. B. Slade. (*Communications*, June 1945, Vol. 25, No. 6, pp. 52, 54, 88–91.)

A 3-page summary of an A.I.E.E. paper, including a diagrammatic summary of the main relevant properties of 28 plastic substances.

3627. STAYPAK—IMPROVED WOOD WITHOUT RESINS.—U.S. Forest Products Laboratory. (*Journ. Franklin Inst.*, July 1945, Vol. 240, No. 1, pp. 68–69.)

Staypak is made by compressing wood or veneers and introducing a plasticising softening action while the wood is under pressure. Water is used as the softening agent ; it was found that ". . . to produce a compressed product practically free from springback it was only necessary to compress for the proper length of time at somewhat higher temperatures and moisture contents than had previously been used."

3628. SILICONES : ORGANIC SILICON COMPOUNDS WITH EXCEPTIONAL PROPERTIES AS INSULATORS.—(*Wireless World*, Sept. 1945, Vol. 51, No. 9, p. 265.)

A short summary of 3357 of October.

3629. MAGNETIC DUST CORES [Their Construction, Properties and Applications].—E. R. Friedlaender. (*Journ. British I.R.E.*, May/July 1945, Vol. 5, No. 3, pp. 106–121. Discussion pp. 121–125.)

3630. THE ELECTRIC RESISTANCE AT THE CURIE POINT OF NICKEL.—B. E. Nilsson. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 1st Nov. 1943, Vol. 29, Part 3, Section B, No. 9, 7 pp. : in English.)

Specimens of pure nickel show a sharp kink in the resistance-temperature curve at the Curie point (362° C), corresponding to a decrease in the temperature-coefficient of resistance.

3631. A NEW METHOD FOR DETERMINING THE STRENGTH AND DIRECTION OF A MAGNETIC FIELD.—S. von Friesen. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 1st Nov. 1943, Vol. 29, Part 3, Section B, No. 10, 7 pp. : in Swedish.)

A closed copper ring on a spherical former is air-driven into rotation inside a multi-turn solenoid. The resulting e.m.f. induced in the solenoid depends on the intensity of the magnetic field and its direction relative to the axis of rotation. If the indicating voltmeter is preceded by amplification inversely proportional to frequency, the reading is independent of frequency, i.e., of the speed of rotation.

The compactness of the device makes it suitable for use in ore prospecting and other geophysical investigations.

3632. FERROMAGNETIC PROPERTIES OF THE COMPOUND Fe_3Si_2.—C. Guillaud. (*Génie Civil*, 1st May 1945, Vol. 122, No. 9, p. 70.)

Abstract of paper read to the Académie des Sciences.

3633. THE MODERN METALLURGY OF SOME WROUGHT COPPER ALLOYS [the Composition and Mechanical Properties of Copper Alloys in general, with particular reference to Some Special Bronzes and Brasses, with Some Applications].—R. H. Harrington. (*Gen. Elec. Review*, Aug. 1945, Vol. 48, No. 8, pp. 41–49.)

3634. A CINDERELLA METAL [Magnesium : its Use during the War and Possible Applications in the Future].—(*Journ. Franklin Inst.*, July 1945, Vol. 240, No. 1, pp. 71–72. From article in *Compressed Air Magazine*, Vol. 49, No. 11.)

3635. ON THE EXPANSION HYSTERESIS OF INVAR.—C. Benedicks & P. Sederholm. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 13th April 1943, Vol. 29, Part 1, Section A, No. 6, 15 pp. : in English.)

Using three separate methods of measuring expansion, it is shown that hysteresis exists in the expansion of invar, and that the value of this hysteresis decreases with repeated thermal cycles. Comparative experiments on nickel of commercial purity show that a certain amount of hysteresis may also occur in this metal.

3636. ONE-PHASE OR TWO-PHASE CONDITIONS IN THE SYSTEM Fe–Ni ; THEORIES OF METEORIC IRON AND INVAR.—C. Benedicks. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 4th Aug. 1942, Vol. 28, Part 3, Section A, No. 14, 32 pp. : in English.)

A study of the microstructure of Fe–Ni alloy systems. The 36 % Ni alloy, Invar, was observed to contain two phases, one rich in Fe in the form of globules. It is believed that the partial transition of the highly dispersed Fe-rich phase into the Ni-rich phase, involving a contraction, counteracts the normal expansion of the alloy.

3637. Resistance of Liquid and Solidified Selenium.—G. Borelius, F. Pihlstrand, J. Andersson & K. Gullberg. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 25th May 1944, Vol. 30, Part 2, Section A, No. 14, 30 pp.: in English.)

3638. Inner Photoelectric Effect of Selenium in the Infra-Red.—I. Weibull. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 3rd Nov. 1943, Vol. 29, Part 4, Section B, No. 14, 6 pp.: in English.)

The variation of the "inner photo-electric effect" in selenium at wavelengths longer than $0.8\,\mu$, the starting point of pronounced activity, has been studied by means of a "quartz prism monochromator". The threshold of activity is in the region $1.3\,\mu$ to $1.5\,\mu$, with a slow rate of increase of activity with decreasing wavelength until the $0.8\,\mu$ region is reached.

3639. Thermo-Electric Power of Liquid and Solidified Selenium.—G. Borelius & K. Gullberg. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 12th Feb. 1945, Vol. 31, Part 3, Section A, No. 17; 10 pp.: in English.)

Measurements are given of the thermo-electric power and work function of liquid, fine crystalline and spherolitic selenium. It is shown that for liquid selenium good agreement is obtained with Wilson's theory of semi-conductors. For coarse-grained crystalline selenium, the measured absolute thermoelectric power is given by a formula $\theta = 1000 + 1.3\,t$ micro-volts per degree in which t is the temperature in deg. C. These measurements do not agree with the theory discussed.

3640. Absorption and Excitation of Zinc Silicate Phosphors.—C. K. Lui. (*Journ. Opt. Soc. Am.*, July 1945, Vol. 35, No. 7, pp. 492–494.)

Author's summary:—"Excitation spectrum of zinc silicate phosphor showed two bands. A major band is located between 2250A and 2900A, and a minor one between 1950A and 2250A. Absorption measurements of clear willemite crystals showed two similar bands located at about the same positions. Absorption measurements for zinc silicate phosphor showed a band located between 2000A and 3000A. These results indicate that the excitation spectrum of a phosphor also measures the absorption of that phosphor."

3641. A New Variety of Alkali-Halide Phosphors.—F. D. Clement. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 10th March 1945, Vol. 46, No. 7, pp. 270–272.)

A method of producing phosphors for luminescent screens is described in which the base salt is volatilized under vaçuum and condensed on the screen and later a fine sublimate of the activator is added. The luminescent intensities of various combinations of salt and activator are compared, and it is shown that a higher efficiency is obtained if both base and activator are volatilized and condensed together.

3642. New Etching Pattern of Quartz and Its Uses for the Determination of Electric Axes and the Detection of Crystalline Defects.—S.-P. Choong. (*Journ. Opt. Soc. Am.*, Aug. 1945, Vol. 35, No. 8, pp. 552–558.)

When a plate of quartz cut normal to the optic axis is etched by hydrofluoric acid in the presence of an electric field, the etching pattern is related to the electric axes and to crystalline defects.

3643. The Inverse Piezoelectric Effect of KH_2PO_4.—A. von Arx & W. Bantle. (*Helvet. Phys. Acta*, 20th October 1943, Vol. 16, No. 5, pp. 416–418: in German.)

Summary only.

Measurements are made for temperatures between 122.9°A and 141°A and potential gradients up to $\pm$ 2500 V/cm. The variation of $\Delta l/l$ with potential gradient is linear for temperatures above 124°A, is non-linear between 124°A and 123°A, and below 123°A, the expected hysteresis is observed. The results are in good agreement with results of Bantle and Caflisch. (*See* 2904 of 1944, and *Helvet. Phys. Acta*, 30th June 1943, Vol. 16, No. 3, pp. 235–250: in German.)

3644. On the Piezoelectric ΔE-Effect of Crystals akin to Rochelle Salt.—B. Matthias. (*Helvet. Phys. Acta*, 12th April 1943, Vol. 16, No. 2, pp. 99–135: in German.)

Author's summary:—"The anomalous elastic behaviour of crystals akin to Rochelle salt is explained by a theory analogous in some respects to the theory of the ΔE-effect in ferromagnetic materials. The anomalous variation of the modulus of elasticity of Rochelle salt can now be calculated simply from the anomalous variation of permittivities with temperature.

"The cause of large damping of resonance frequencies, at which the crystal vibrates at an angle less than 45° to the b and c axes, and normal to the a axis, is found in hysteresis losses; the measurements give quantitative confirmation of this assertion. All measurements are carried out by two different methods. In the first, the resonance curve is displayed dynamically [using a frequency-modulated signal], and in the second, it is displayed "statically" using a standard-signal generator.

"The static measurements provide a visible interpretation of the fall of permittivities with frequency up to the range of the piezoelectric resonance points of the crystals."

3645. High Frequency Vibrations of Thin Crystal Plates.—H. Ekstein. (*Phys. Review*, 1st/15th July 1945, Vol. 68, Nos. 1/2, pp. 11–23.)

Author's summary:—"The boundary conditions of free vibration can be satisfied on the major surfaces of a plane-parallel plate if the displacement components are assumed to be products of trigonometric functions. In addition, the boundary conditions can be approximately satisfied on the minor surfaces when the plate is thin. The theory leads to a frequency equation

$$\nu = \tfrac{1}{2}\,(c/\rho)^{\frac{1}{2}}[(n/2b)^2 + k\,(m/2a)^2]^{\frac{1}{2}}$$

which has been found empirically to satisfy observations. The theoretical values of the constant k are 3.7 and 1.8 for the AT and BT quartz plates, respectively, while the observed values are 3.9 and 1.7, respectively."

3646. Historic Firsts: Wire-Mounted [Quartz] Crystals.—(*Bell Lab. Record*, July 1945, Vol. 23, No. 7, pp. 246–247.)

3647. A New Type of Oscillating Crystal [Lithium Potassium Tartrate].—C. P. Fagan. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, pp. 648, 652.)

"The fact that a crystal of such low "Q" [about 2,000] would oscillate in the above circuit indicates that the substance is of the order of ten times the piezo-electric activity of quartz." The indicated temperature coefficient is -426 parts in 10^6 per $+1°$C. "While these crystals appear to be useless as frequency stabilising elements the ease with which they can be prepared will be of interest to amateurs. Such crystals might be used as thermometers in a suitable holder, and might also be used as a stable substitute for Rochelle salt."

3648. The Secondary Electron Emission of Pyrex Glass.—C. W. Mueller. (*Journ. Applied Phys.*, Aug. 1945, Vol. 16, No. 8, pp. 453–458.)

Measurements were made by a method utilising the conductivity of the heated glass to carry the current. Accelerating voltages between 50 and 10 000 volts were used, and the secondary emission ratio showed a sharp maximum of about 2.2 at 400 volts.

No significant change in emission with temperature was observed over the temperature range 240–420° C.

Changes in the behaviour of the glass as a consequence of previous bombardment were evident.

3649. Magnifying Details in a Complex Waveform.—(*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 640.)

". . . a high speed sweep is used to magnify the trace [on a C.R. tube] . . . singling out one time element and suppressing the rest." Summary of a paper by R. Feldt (*The Du Mont Oscillographer*, Jan./Feb. 1945.)

3650. Elastic Hysteresis in Wires and Strips of Quartz and Other Materials.—T. Eeg-Olofsson. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 28th Dec. 1944, Vol. 31, Part 1, Section A, No. 3, 28 pp.: in German.)

A theoretical and experimental study. The other materials are glass, "Jenaer Normalglas", mica, copper, copper-beryllium, steel and phosphor-bronze.

3651. Experimental Determination of Impedance Functions by the Use of an Electrolytic Tank.—W. W. Hansen & O. C. Lundstrom. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, pp. 528–534.)

Authors' summary:—"It is shown that impedance and gain functions [in terms of frequency] can be determined by the use of an electrolytic tank. The method is amply accurate and is rapid and convenient when the locations of the poles and zeros of the function to be determined are known. Full details of the theory are given, a suitable experimental set-up is described, and typical results are shown."

3652. Correction of G–M Counter Data.—J. D. Kurbatov & H. B. Mann. (*Phys. Review*, 1st/15th July 1945, Vol. 68, Nos. 1/2, pp. 40–43.)

A new formula for the correction of the errors in data obtained with G–M counter tubes due to their finite resolving time.

3653. Experiments on Counters with Grids.—S. A. Korff. (*Phys. Review*, 1st/15th July 1945, Vol. 68, Nos. 1/2, p. 53.)

β-particles were counted by a number of Geiger counters differing in grid structure, one having no grid.

It was noted that the applied voltage could be reduced from about 1400 volts with no grid, to about 950 volts with a grid 7.5 mm. in diameter and to about 550 volts with a grid 2 mm in radius. Resolving time was reduced by the introduction of a grid.

3654. An Automatic Wilson Cloud Chamber with New Illumination and a New Type of Coil for a Homogeneous Magnetic Field.—E. von Zeipel. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 26th Jan. 1944, Vol. 30, Part 1, Section A, No. 2, 27 pp.: in English.)

The new type of coil referred to is a development of the well known Helmholtz pair. The coils have a tapered section and give a field homogeneity "about 20 times as great as that of the Helmholtz ideal coil". The theory of this new coil is fully detailed.

3655. Temperature of Distribution in Toroidal Electrical Coils of Rectangular Cross Section.—T. J. Higgins. (*Journ. Franklin Inst.*, Aug. 1945, Vol. 240, No. 2, pp. 97–112.)

This paper is an extension of a previous paper by the same author (*see Trans. Am. Soc. Mech. Eng.*, Vol. 66, pp. 665–670). Here a more general theory is developed for calculating the maximum and mean temperatures and the temperature distribution in the coils. The resulting formulae are rapidly convergent series. Calculated values give excellent agreement with measured values.

3656. Making Power Cables [Impressions Gained during a Visit to a Cable Works; mainly concerning Standard Paper-Insulated, Lead-Covered, Wire-Armoured or Steel-Tape-Armoured Cable].—(*Elec. Review*, 31st Aug. 1945, Vol. 137, No. 3536, pp. 283-288.)

3657. Lightning-Protected Cable.—L. S. Inskip. (*Bell Lab. Record*, July 1945, Vol. 23, No. 7, pp. 248–251.)

Breakdown of lead-sheathed co-axial cable from lightning discharge can be minimised by increasing the conductance of the outer sheath and increasing the insulation resistance between the sheath and the core. A six-tube coaxial cable is described in which high sheath conductivity is obtained by providing a 10 mil copper jacket insulated from the lead sheath and surrounding it, and in which high insulation resistance is obtained (10 000 volts d.c.) by a system of paper-insulated wrappings. The whole cable is semi-flexible and the outer copper sheath is protected from both chemical action and mechanical damage during installation.

3658. Two-Voltage High-Potential Tester for Wire.—H. T. McLean. (*Gen. Elec. Review*, Aug. 1945, Vol. 48, No. 8, pp. 37–39.)

This paper describes equipment designed to speed up the testing of wire insulation. The wire is drawn between two pairs of electrodes, a low voltage being applied to the first pair and a high voltage to the second. The number of breakdowns per unit length is recorded by high speed counters. The gear requires a 110 volt 60 cycle supply and can deliver test voltages up to 11 kV. By its use 20 reels per hour can be tested.

3659. Coaxial Cables and Television Transmission.—Osborne. (*See* 3588.)

3660. The Unit Bay 1B Coaxial Cable Transmission System.—R. A. Brockbank & C. F. Floyd. (*P.O. Elec. Eng. Journ.*, July 1945, Vol. 38, Part 2, pp. 43–47.)

Authors' summary :—" This is the first of a series of four articles describing the Unit Bay 1B coaxial cable transmission system which is being installed throughout this country to provide multi-channel telephone circuits on trunk routes."

3661. The Litz Problem [Discussion of Methods of Baring the Ends of Litzendraht Stranded Wire for Soldering].—" Diallist." (*Wireless World*, Sept. 1945, Vol. 51, No. 9, p. 286.)

3662. Fungus Growths and Electric Apparatus.—A. C. Titus. (*Gen. Elec. Review*, Aug. 1945, Vol. 48, No. 8, pp. 19–22.)

Fungus attack can cause deterioration of electrical materials but high humidity is a greater danger. Fungicides can be used but dangers may arise from evolution of semi-toxic and corrosive fumes from them. Fungicides are not permanent at high operating temperatures.

STATIONS, DESIGN AND OPERATION

3663. The Third Pan-American Conference on Radiocommunications [Rio de Janeiro, June 1945].—(*Revista Telegrafica*, May 1945, No. 392, pp. 292, 296.)

Representation and programme (mainly frequency allocation).

3664. Topics for the Forthcoming [Third Pan-American] Conference [on Radiocommunications, Rio de Janeiro, June 1945].—A. T. Consentino. (*Revista Telegrafica*, May 1945, No. 392, pp. 290–291.)

3665. FCC Allocates 44–108 Megacycles [to Television, Amateur Transmission, Non-Government Fixed and Mobile Stations, and F-M and Facsimile Broadcasting].—(*QST*, Aug. 1945, Vol. 29, No. 8, pp. 11–12.)

3666. Allocation below 25 Mc/s.—(*QST*, Aug. 1945, Vol. 29, No. 8, pp. 24–26.)

The proposals of the F.C.C. for allocation of frequencies below 25 Mc/s are discussed, with particular reference to the amateur channels. Certain changes directed towards the improvement of facilities for amateurs are suggested.

3667. Post-War European Broadcasting.—Brit. Rad. Equip. Manufs. Assoc. Report. (July 1945.)

A report issued by the Radio Industry Council. " Organised broadcasting started in this country twenty-two years ago. In the period since then, wavelength allocation, as it affects the European nations, has been successively an unidentified, then an imperfectly-understood, and finally a politically-obscured problem." Three principal requirements are postulated : " (1) To provide for every country one " national " programme (and preferably two of them) which can be received on a normal wireless set in any part of the country served. To these must be added a system of localised programmes to suit the special needs of any important regions or language groups in each country. (2) To arrange wavelengths in relation to the location and power of transmitters, so as to minimise interference between any two stations, and to permit reasonable quality or reproduction from receivers in all parts of the service area of each station. Power as well as wavelength would have to be specified in order to ensure good service over each area, while still avoiding serious interference with other transmitters. (3) To plan the entire system to give every listener easy reception of foreign stations, as an adjunct to the domestic service." The report gives a fully detailed frequency allocation, in accordance with the above requirements, covering Europe and European Russia, for the bands 150–432 kc/s & 550–1550 kc/s, with an 11 kc/s separation.

3668. The Industry's Plan for Broadcasting.—(*Wireless World*, Sept. 1945, Vol. 51, No. 9, p. 257.)

Editorial comment on 3667.

3669. Plan for Europe.—(*Wireless World*, Sept. 1945, Vol. 51, No. 9, pp. 258–262.)

Long summary and discussion of 3667.

3670. The 1945 Programme of Work for French Broadcasting.—(*Génie Civil*, 15th March 1945, Vol. 122, No. 6, p. 45.)

3671. N.Y., N.H. & H. Tests 3-Way Communications on New Haven to Danbury Line.—(*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, p. 22.)

Communication was satisfactory between a fixed station and trains 10 miles away or between trains 5 miles apart.

3672. Union Pacific Secures Authority for Nine Experimental Radio Stations [for Communication on Trains].—(*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, p. 14.)

3673. Railroads Allotted Double Space in HF Spectrum [FCC Frequency Allocations, May 17].—(*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, p. 31.)

3674. Denver and Rio Grande Western [Railroad] 118 Mc F-M System [for Cab-to-Caboose Communication].—A. B. Cavendish. (*Communications*, May 1945, Vol. 25, No. 5, pp. 72–74.)

A 15 watt transmitter (Motorola P-8161), and a 30-40 Mc/s F-M receiver (Motorola P-8160) with a converter (Motorola P-8162) for use at 118 Mc/s. Unusual terrain difficulties had to be catered for.

3675. Communications' Rôle in Electric Utility Systems.—S. J. Combs. (*Communications*, May 1945, Vol. 25, No. 5, pp. 43–45, 81.)

A description of the uses that can be made of portable and fixed communication equipment, radio relay, remote control, selective calling, facsimile, and multiplex circuits by electric power companies.

3676. HIGH-SPEED RADIOTELEGRAPHY.—T. Roddam. (*Wireless World*, Sept. 1945, Vol. 51, No. 9, pp. 283–284.)

A letter referring to 2816 of August. " A system which gets more words per channel at the cost of fewer channels per band and with low economic conversion efficiency . . . is not a useful system."

3677. PULSE TIME MODULATION.—E. M. Deloraine & E. Labin. (*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, pp. 18–19.)

With certain approximations the number of channels, N, that can be operated can be calculated in terms of the total frequency band, F, and the frequency band of the signal f. For pulse time modulation $N_{TM} \simeq .15$ F/f, for amplitude modulation $N_{AM} \simeq .75$ F/f, for frequency modulation $N_{FM} \simeq .35$ F/f.

In practice only N_{TM} can be fully realised owing to non-linear distortions that occur in AM & FM circuits.

See also 1947 of June and 2803 of August.

3678. RADIO-RELAY COMMUNICATION SYSTEMS IN THE UNITED STATES ARMY.—W. S. Marks, Jr., O. D. Perkins & W. R. Clark. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, pp. 502–522.)

Authors' summary :—" This paper describes the use of frequency-modulated, very high frequency radio sets in place of wire lines in Army tactical communication circuits. . . . [Early in the war] standard police-type frequency-modulation sets were adapted for use . . . By the use of radio-repeater or relay stations these [principally simplex teletype] circuits were extended several hundred miles. Representative circuits are illustrated. . . . A broad-band frequency-modulated very high frequency set designated AN/TRC–1 was developed for use in conjunction with voice-frequency-carrier equipment CF–1 and CF–2 to provide multichannel voice and teletype circuits over a single radio frequency. This has met with great success . . . marking the first real marriage of wire and radio in the Army. . . The advantages of a radio system over conventional wire lines under certain conditions are pointed out. . . . Expanding and wider application of the principle is indicated."

3679. EMERGENCY F-M SYSTEM IN TORONTO.—(*Communications*, June 1945, Vol. 25, No. 6, pp. 60–61.)

A central 400 W 36.3 Mc/s F-M transmitter communicating with truck and car fleet. Three paragraphs and photographs only.

3680. ARGENTINA TO INSTALL 176 RADIO STATIONS [for Communications by Travellers & Residents].—(*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, p. 19.)

3681. RADIOTELEPHONE SERVICE TO AUTOS, TRUCKS AND OTHER MOBILE UNITS PLANNED BY AT & T [For Two-Way Communication with Drivers: Applications Filed with F.C.C. for Thirteen Cities].—(*Telegr. & Teleph. Age*, July 1945, Vol. 63, No. 8, pp. 16–17.)

3682. AT & T ANNOUNCES PLANS FOR TWO-WAY VEHICULAR TELEPHONE SERVICE [for Communication between any Telephone Subscriber and a Radio-Equipped Vehicle].—(*Bell Lab. Record*, Aug. 1945, Vol. 23, No. 8, pp. 293–295.)

3683. AT & T RUSHES INSTALLATION OF NATION-WIDE COAXIAL CABLE COMMUNICATIONS NETWORK.—(*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, p. 20.)

3684. 8-CHANNEL CARRIER SYSTEMS FOR UNLOADED CABLES [Loaded Cables, after Unloading, made available for Carrier Operation at Frequencies up to 60 kc/s].—S. Janson. (*Ericsson Review*, 1945, No. 1, pp. 11–18.)

3685. CARRIER TELEPHONY IN WAR [Description of British Army Set giving One Audio and Four Carrier Channels on Single Pair].—R. W. Hallows. (*Telegr. & Teleph. Age*, July 1945, Vol. 63, No. 7, pp. 6–10, 31–32.)

3686. SOME ENGINEERING ASPECTS OF AUDIO FREQUENCY WIRE BROADCASTING IN GREAT BRITAIN.—P. Adorjan. (*Journ. British I.R.E.*, Jan./Feb. 1945, Vol. 5, No. 1, pp. 28–39. Discussion pp. 39–44.)

3687. NEW MULTIPLEX RADIOTELEGRAPH SYSTEM OPENS EIGHT CHANNELS FOR USE BY SINGLE TRANSMITTER [between New York and London].—(*Telegr. & Teleph. Age*, July 1945, Vol. 63, No. 7, pp. 20–21.)

An application of time-division methods giving a total of 488 words per minute in each direction simultaneously. Each letter consists of three marking impulses and four spacing impulses. If any letter is mutilated in transmission a warning bell rings at the printer and a maltese cross is printed, so facilitating correction.

3688. REMOTE-CONTROL OF OUTPUT LEVEL [in Broadcasting or Commercial Systems to provide Effective Dynamic Range Control].—R. P. Aylor, Jr. (*Communications*, July 1945, Vol. 25, No. 7, pp. 49, 81–84.)

Two circuits are described, one using variable voltage feedback, and the other using a variable H-pad.

3689. COMMUNICATIONS SYSTEM ABOARD DC-3 [Transport] AIRCRAFT.—R. G. Peters. (*Communications*, July 1945, Vol. 25, No. 7, pp. 36–38, 85.)

3690. GERMAN AND JAPANESE [Portable] COMMUNICATIONS EQUIPMENT.—(*Communications*, May 1945, Vol. 25, No. 5, p. 60.)

Four photographs with very brief descriptions.

3691. FCC EXPECTS RADIO TO SECURE LATEST IMPROVEMENTS [enabling Reduced Channel Widths to be used].—(*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, p. 31.)

GENERAL PHYSICAL ARTICLES

3692. SOLAR RADIATION.—(*Wireless World*, Sept. 1945, Vol. 51, No. 9, p. 268.)

Comment on 398 of 1944 and a summary of 3474.

3693. A SIMPLE METHOD OF MEASURING SECONDARY ELECTRONS EXCITED BY BETA-RAYS AND THE INFLUENCE OF THESE ELECTRONS ON THE INVESTIGATION OF PRIMARY BETA-RAY SPECTRA.—L. Meitner. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 1st Nov. 1943, Vol. 29, Part 3, Section A, No. 17, 14 pp. : in German.)

3694. ON THE CONDUCTIVITY OF A METAL IN A MAGNETIC FIELD.—I. Waller. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 25th Nov. 1942, Vol. 28, Part 4, Section B, No. 15, 7 pp. : in English.)

Author's summary :—" A proof is given of the constancy of the ratio between the tensors of electric and heat conductivity of a metal in a magnetic field. New formulae are derived for the change of resistance in a magnetic field."

3695. A MODEL OF THE POINT ELECTRON II.—E. C. G. Stueckelberg. (*Helvet. Phys. Acta*, 29th Feb. 1944, Vol. 17, No. 1, pp. 3–26 : in French.)

Author's summary :—" A model of a point electron more general than the model proposed in Part I is discussed. The electron only reacts with the Maxwell field. In classical theory, its motion much resembles that of the extended electron of Lorentz. By a correspondence principle the model can be transcribed into a quantum theory, without the appearance of discrepancies. The formulae thus obtained show close analogy with those obtained by Heisenberg in his recent theory."

Part I (*Helvet. Phys. Acta*, 1941, Vol. 14, p. 51) is noted in 285 of 1942.

3696. ON THE THEORY OF MAGNETICALLY CHARGED PARTICLES [in Quantum Theory].—M. Fierz. (*Helvet. Phys. Acta*, 29th Feb. 1944, Vol. 17, No. 1, pp. 27–34 : in German.)

3697. REFRACTION EFFECTS IN ELECTRON DIFFRACTION.—L. Sturkey & L. K. Frevel. (*Phys. Review*, 1st/15th July 1945, Vol. 68, Nos. 1/2, pp. 56–57.)

Some unexpected patterns were obtained when MgO smoke was used as a calibration specimen. It was thought that these were due to refraction at the crystal faces. Some experiments with CdO smoke, ZnO smoke and larger particles of MgO tended to confirm this.

3698. THE DETERMINATION OF REFRACTIVE INDICES OF COLLOIDAL PARTICLES BY MEANS OF A NEW MIXTURE RULE OR FROM MEASUREMENTS OF LIGHT SCATTERING.—W. Heller. (*Phys. Review*, 1st/15th July 1945, Vol. 68, Nos. 1/2, pp. 5–10.)

A new theoretical rule is developed for use with differential refractometric measurements. This rule gives better results than older rules for small differences in refractive index. For larger differences, but less than 0.7, the results are still correct to the third or fourth decimal if a correction equation is used. For opaque solutions a light scattering measurement can be used.

3699. ELECTRON TEMPERATURES IN ELECTRICAL DISCHARGES [Some Measurements for Cold-Cathode Glow Discharge in Air and Carbon Monoxide at Pressures of 0.06–1.2 mm. Hg.].—K. T. Chao & T. Y. Tang. (*Phys. Review*, 1st/15th July 1945, Vol. 68, Nos. 1/2, pp. 30–39.)

3700. A PRINCIPLE CONNECTING THE THEORY OF RELATIVITY AND THE QUANTUM THEORY.—E. C. G. Stueckelberg. (*Helvet. Phys. Acta*, 12th April 1943, Vol. 16, No. 2, pp. 173–202 : in French.)

3701. ON THE PROBLEM OF HEAT CONDUCTION IN A SEMI-INFINITE RADIATING WIRE.—A. N. Lowan. (*Quart. Applied Math.*, April 1945, Vol. 3, No. 1, pp. 84–87.)

" R. V. Churchill derives the solution of the problem of heat conduction in a semi-infinite radiating wire when the initial temperature is zero, and the boundary temperature is a constant. It is the object of this paper to derive the general solution corresponding to an arbitrary initial temperature distribution when the boundary temperature is a prescribed function of time."

3702. THE ELECTROMAGNETIC SYSTEM IS NOT COHERENT [Criticism and Reformulation of the Biot-Savart Law of Electromagnetic Force].—J. Villey. (*Génie Civil*, 15th March 1945, Vol. 122, No. 6, p. 44.)

MISCELLANEOUS

3703. NOTES ON THE EVALUATION OF ZEROS AND TURNING VALUES OF BESSEL FUNCTIONS. IV.—A NEW EXPANSION. V.—CHECKS.—J. C. P. Miller, C. W. Jones, W. G. Bickley. (*Phil. Mag.*, March 1945, Vol. 36, No. 254, pp. 200–210.)

(*See* 3397 and 3398 of October for previous parts.)

3704. ON THE STABILITY OF A CERTAIN CLASS OF LINEAR DIFFERENTIAL EQUATIONS.—G. Borg. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 28th Dec. 1944, Vol. 31, Part 1, Section A, No. 1, 31 pp. : in German.)

The class is

$$y'' + [\alpha + \beta\psi(x)]\, y = 0$$

where $\psi(x)$ is periodic with period π. " Stability " implies undamped periodic solutions.

3705. ON A SYSTEM OF DIFFERENTIAL EQUATIONS STUDIED BY C. STÖRMER.—J. Malmquist. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 26th Jan. 1944, Vol. 30, Part 1, Section A, No. 5, 8 pp. : in French.)

The equations refer to the trajectories of electrified corpuscles under the influence of an elementary magnet.

3706. ON THE SUMMATION OF CERTAIN TRIGONOMETRIC SERIES.—L. S. Goddard. (*Proc. Cambridge Phil. Soc.*, Aug. 1945, Vol. 41, Part 2, pp. 145–160.)

Introductory to 3483.

3707. HOW TO SAY " NO " IN MATHEMATICS.—J. J. Smith. (*Journ. Franklin Inst.*, Aug. 1945, Vol. 240, No. 2, pp. 113–122.)

The ability of certain functions to say " No " enables the discontinuous phenomena encountered in the solution of many problems to be represented by a single expression without ambiguity. The unit function, $H(xx_1)$, and the impulse function which is the time differential of this, are discussed.

3708. Determination of the Maximum Deviation from the Gaussian Law.—C. G. Esseen. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 1st Nov. 1943, Vol. 29, Part 3, Section A, No. 20, 10 pp. : in English.)

3709. Quantitative Interpretation of Maps of Magnetic and Gravitational Anomalies by Mathematical Methods.—E. G. Kogbetliantz. (*Quart. Applied Math.*, April 1945, Vol. 3, No. 1, pp. 55–75.)

Development of a mathematical method for interpreting gravitational and magnetic anomalies observed in geophysical prospecting for oil and other minerals. The method is applicable to simple anomalies, complex anomalies due to the coexistence of different geological phenomena being first resolved by methods devised by the same author but not included in this paper.

3710. On Improving the Equations of Electromagnetic Field.—P. L. Kalantarov. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 28th Feb. 1945, Vol. 46, No. 6, pp. 224–226.)

The practical difficulties of changing units as suggested by Heaviside or in the manner agreed upon by the Measuring Units' Committee of the Academy of Sciences of the U.S.S.R. are pointed out, and it is suggested that it would " suffice to change the notions of the . . . six quantities [contained in the electromagnetic field equations] instead of . . . the units adopted for their measurement. Namely magnetic permeability & magnetic pole strength can be taken to be magnitudes 4π times greater than is generally agreed upon now, while dielectric constant, magnetic force, reluctance & magnetomotive force can be understood to mean 4π times smaller quantities. . . ."

3711. A Method for Computing the Resonant Wavelength of a Type of Cavity Resonator.—Goddard. (*See* 3483.)

3712. " Waveform Analysis " [Book Review].—R. G. Manley. (*Wireless World*, Sept. 1945, Vol. 51, No. 9, p. 278.)

" . . . an excellent guide to the interpretation of periodic waves."

3713. On Parametric Excitation.—N. Minorsky. (*Journ. Franklin Inst.*, July 1945, Vol. 240, No. 1, pp. 25–46.)

Parametric excitation refers to the disturbance of an electrical or mechanical system by a variation—generally periodic—of certain of its parameters. One relevant differential equation is that of Hill $\ddot{x} + F(t)x = 0$, where $F(t)$ is periodic. If $F(t)$ takes the form of a rectangular ripple the Hill-Meissner equation results. Parametric excitation of a non-dissipative LC circuit with square and sinusoidal capacitance variation is considered together with the topology of the Hill-Meissner equation. The effects of variations in ripple frequency and phase angle are discussed. The paper concludes with an account of parametric excitation of a dissipative circuit by capacitance and inductance ripples, and the relation of the processes discussed to the Mathieu equation.

3714. On a Degenerate Case of the General Problem of Direct Control [particularly of Temperature and Pressure: Mathematical Analysis].—A. Andronow & N. Bautin. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 10th March 1945, Vol. 46, No. 7, pp. 277–279 : in French.)

3715. Ten Two-Dimensional Electrostatic Problems.—N. Davy. (*Phil. Mag.*, March 1945, Vol. 36, No. 254, pp. 153–169.)

Author's summary :—" Ten different two-dimensional electrostatic problems, seven of which involve semi-infinite rectangular electrodes, are solved. The Schwarz-Christoffel method is used in all cases except the last. Only the results, with the necessary explanations, are given. These results include (1) the transformations, (2) the field strengths, (3) the surface densities at points on electrodes, (4) the total charges on parts of electrodes, (5) the capacities between parts of electrodes, and (6) expressions proportional to the forces on small para or diamagnetic bodies at any point in the field. Elliptic functions are used in seven cases. Diagrams showing equi-potentials obtained experimentally are shown. As usual, the results apply to magnetism, hydrodynamics, heat flow, electric current flow, and other branches of physics."

3716. Early Electrical Discoveries by Benjamin Franklin & His Contemporaries.—M. MacLaren. (*Journ. Franklin Inst.*, July 1945, Vol. 240, No. 1, pp. 1–4.)

3717. The Amateur in the Post-War Period.—R. A. Lynch. (*Revista Telegrafica*, June 1945, No. 393, p. 384.)

3718. Dielectric Heating by the Radio Frequency Method.—L. Grinstead. (*Journ. British I.R.E.*, May/July 1945, Vol. 5, No. 3, pp. 128–145. Discussion pp. 145–151.)

Author's summary:—" After a brief reference to some of the applications of radio-frequency energy to the heating of dielectric materials, the general theory of the method is outlined.

" The heat and power relations governing all such uses are discussed in some detail with special reference to sources of electrical and thermal loss in the generator and the work. It is shown that, for minimum losses and a reasonably good temperature distribution, fast heating is desirable. A family of curves is included enabling relative performances of various generators in terms of power and time to be rapidly determined.

" The basic circuits for dielectric heating equipments are briefly reviewed and the need for correct loading of the transmitting valves is explained.

" Two of the more usual load coupling circuits are analysed so that the effects on loading and efficiency of varying circuit parameters may be studied. It is shown that the series-capacitance type of circuit can, under certain conditions, maintain nearly constant power in the work during a heating cycle. For transformer circuits, the conclusions reached show that a proper value of coupling coefficient is desirable in the interest of circuit efficiency."

3719. Longitudinal or Transverse Heating? [Their Relative Efficiencies in the Gluing of Wood].—D. I. Lawson. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, pp. 646–647.)

" The method to be recommended depends on the ratio of the dielectric constants of the wood and glue. If $\epsilon_g > \epsilon_w$ longitudinal heating would be preferred and *vice versa*." In an example using a synthetic resin glue, longitudinal heating is 13 times more efficient than transverse heating.

3720. POWER VALVES FOR H.F. HEATING EQUIPMENT.—F. E. Henderson. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, pp. 643–645.)

Discussion of choice of oscillator valve for specific applications.

3721. INDUCTION HEATING IN RADIO TUBE MANUFACTURE.—E. E. Spitzer. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 640.)

Paragraph on degassing and getter flashing quoted from *Trans. Electrochem. Soc.*, 1944.

3722. AUTOMATIC H.F. HEATING CONTROL.—(*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 640.)

Short summary of a paper by W. M. Roberds ". . . small thyratrons and a reversible motor are used to provide continuous automatic tuning of an electronic power generator. . . . These so control the oscillator that any predetermined power can be fed to the work continuously, regardless of changes in the electrical properties of the work material produced by heating. . . ."

3723. A NEW INDUCTION HEATING EQUIPMENT.—(*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 634.)

Type T.10 of the Electric Furnace Co., Ltd., 500 kc/s, dissipates 4½ kW in the valve.

3724. CALCULATIONS FOR DIELECTRIC HEATING BY HIGH FREQUENCY CURRENTS.—A. J. Maddock. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, pp. 635–639.)

Fundamental formulae, design charts, data for typical materials, and worked examples.

3725. A 1/4-kW H.F. [30 Mc/s] GENERATOR [for Heating]. — Rediffusion Ltd. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 633.)

Two paragraphs.

3726. RADIO HEATING AND MASS PRODUCTION SOLDERING.—C. E. Tibbs. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, pp. 631–633.)

Describes the soldering of the ends onto tinplate cans at the rate of 1200 per hour, by passing them on a conveyor belt over the coil of an eddy-current heater.

3727. A BIBLIOGRAPHY OF H.F. HEATING.—(*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, pp. 629–630.)

About 100 items under the headings: General; Seam Welding, Spot Welding, Spot Gluing, Soldering; Moulding; Timber Section; and Food Section.

3728. HIGH FREQUENCY DIELECTRIC HEATING.—A. E. L. Jervis. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, pp. 624–628.)

A general account of the subject, showing simple calculation of heating per unit volume of a typical substance (laminated wood).

See also J. P. Taylor, *Trans. A.S.M.E.*, April 1943, p. 201.

3729. A LABORATORY VACUUM INDUCTION FURNACE USING PENTODE RADIO-FREQUENCY AMPLIFIERS.—G. J. Aitchison & J. Crouchley. (*Journ. of Scient. Instr.*, Sept. 1945, Vol. 22, No. 9, pp. 176–178.)

Frequency of operation 170 kc/s. Time to melt 300 g of iron, 8 min, with 3.7 kW D.C. plate input to the pentodes. Time to melt 300 g of copper, 25 min, with 4.1 kW D.C. input.

3730. "CAREERS IN SCIENCE" [Book Review].—P. Pollack. (*Journ. Franklin Inst.*, July 1945, Vol. 240, No. 1, p. 65.)

"This volume will serve as an excellent survey for the young person interested in a scientific career."

3731. SOME AIDS TO FACILITATE THE ENGINEER'S ACADEMIC TRAINING.—B. Dudley. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, pp. 499–502.)

The importance of adequate mathematical teaching methods is discussed in relation to the "rapidly increasing complexity of radio engineering practice and the employment of very high frequencies". "The judicious use of animated motion pictures, models and more effective textbook illustrations" is recommended. The use of isometric drawings giving the illusion of three-dimensional representation on a sheet of paper is discussed. These are useful in cases ". . . in which a family of curves connecting three variables may be used to represent quantitative relationships".

3732. THE UNIVERSITIES AND SCIENTIFIC RESEARCH.—(*Engineer*, 6th July 1945, Vol. 180, No. 4669, p. 1.)

The Association of University Teachers express need for larger peace-time grants for pure research untrammelled by external control.

3733. THE INAUGURATION OF THE ARGENTINE SCHOOL OF TELECOMMUNICATIONS [in April 1945].—(*Revista Telegrafica*, May 1945, No. 392, pp. 316–318.)

3734. THE EQUIPMENT OF THE ARGENTINE SCHOOL OF TELECOMMUNICATIONS.—(*Revista Telegrafica*, June 1945, No. 393, pp. 377–379.)

3735. THE THIRD PAN-AMERICAN CONFERENCE ON RADIOCOMMUNICATIONS [Rio de Janeiro, June 1945].—(*Revista Telegrafica*, May 1945, No. 392, pp. 292, 296.)

Representation and programme (mainly frequency allocation). *See also* 3664.

3736. A REVIEW OF THE WORK OF THE C.S.I.R. [Australia].—G. Lightfoot. (*Journ. Council for Scientific and Industrial Research*, May 1945, Vol. 18, No. 2, pp. 85–102.)

Includes short accounts of the work of the National Standards Laboratory and of the Radiophysics Laboratory.

3737. SCIENTIFIC LIAISON AND INFORMATION BUREAU.—(*Journ. Council for Scientific and Industrial Research*, May 1945, Vol. 18, No. 2, p. 168.)

A note on the incorporation of the Scientific Liaison Bureau with the Information Section of C.S.I.R. (Australia).

3738. RESEARCH AGENCY PLANNED [in U.S.A.].—(*Sci. News Letter*, 28th July 1945, Vol. 48, No. 4, pp. 51–53.)

Summary of O.S.R.D. report recommending

creation of a government agency for the encouragement and support of basic research in colleges, universities and research institutes, in response to one of President Roosevelt's "four points".

3739. The Interdepartment Radio Advisory Committee [to Assign Frequencies to U.S. Government Services and to Advise the President on Related Radio Matters]: Its History, Mode of Operation, and Relationship to Other Agencies.—E. M. Webster. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, pp. 495–499.)

3740. The Organisation of Research in the Radio Industry After the War.—W. R. Maclaurin. (*Proc. I.R.E.*, Sept. 1945, Vol. 33, No. 9, pp. 567–570.)

Between the wars, research organisation was seriously weakened by lack of incentive and bureaucratic tendencies. Men who combine thorough training with creative originality can only be produced if conditions are improved. In the past the tendency to exploit youth has been too great.

Prior to the war most companies were imitative and few had the research spirit. Major rewards went to manufacturing positions, freedom was lacking and the accent was on short-term results.

In periods of business depression small research organisations are unable to survive and some measure of protection for them is vital to the health of the radio industry.

3741. The Rôle of the Sections in the I.R.E. Program [i.e., Functions of Local Branches].—W. A. Dickinson. (*Proc. I.R.E.*, Sept. 1945, Vol. 33, No. 9, p. 565.)

3742. Report of the Standards Committee [I.R.E.] Relating to [Designation of] Standard Frequency Ranges.—(*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, p. 548.)

The spectrum is divided into decades in the manner agreed to at the C.C.I.R. conference in Bucharest. The frequency coverage, however, is extended down to 0.3 c/s and up to 300 kMc/s. The nomenclature is almost identical with that of the Bucharest convention with the addition of numerals to designate each decade. *See* 379 *and* 1681 of 1938.

3743. Patents from the Viewpoint of the Applied Physicist.—H. S. Knowles. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, p. 104.)

Very short abstract.

3744. B.S. 1219 [Printers' and Authors' Proof Corrections].—(*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 623.)

Editorial note.

3745. Exploring Magnetic Fields.—L. Shapiro. (*Bell Lab. Record*, Aug. 1945, Vol. 23, No. 8, pp. 281–283.)

Exploration of the intensity and direction of the field produced by typical cathode-ray oscillograph magnetic coil deflection systems is made by exciting the system with low-frequency alternating current and measuring the voltage induced in a very small search coil which can be located at a number of different points in the field.

3746. "Colección Telecomunicaciones" [Book Review].—(*Revista Telegrafica*, May 1945, No. 392, p. 306.)

A series of eleven books of elementary instruction for radio operators.

3747. "The Radio Amateur's Handbook" [Twenty-Second Edition: Book Review].—American Radio Relay League, Inc. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, p. 555.)

Sections have been added to this annual publication to include techniques developed during the war years; for example those dealing with microwaves.

3748. "Introduction to Practical Radio" [Book Review].—D. J. Tucker. (*Proc. I.R.E.*, Sept. 1945, Vol. 33, No. 9, p. 632.)

3749. "Electrical Essentials of Radio" [Book Review].—M. Slurzberg & W. Osterheld. (*Communications*, May 1945, Vol. 25, No. 5, p. 95.)

An elementary text-book.

3750. "Electronics To-day and To-morrow" [Book Review].—J. Mills. (*Telegr. & Teleph. Age*, June 1945, Vol. 63, No. 6, p. 30.)

3751. "Electronic Equipment and Accessories" [Book Review].—R. C. Walker. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 653.)

"A Concise Introduction to the principles of Electronics and their Applications to Industry."

3752. Electronics.—J. Mills. (*Sci. Monthly*, June 1945, Vol. 60, No. 6, pp. 459–463.)

A broad outline is given of the fundamentals and applications of electronics including lightning discharges, vacuum tubes and the electron microscope.

3753. Growth of Electronics in the Fleet Personnel of Electronics Division Bureau of Ships.—U.S. Navy Dept. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, p. 551.)

Short description of the communication system for amphibious operations, and the associated equipment production planning.

3754. A Simplified [Mechanical] Auto-Alarm Selector.—S. Schiffer. (*Communications*, June 1945, Vol. 25, No. 6, pp. 56–59.)

A description of a device for operating a relay when a predetermined morse signal is received. Primarily intended for sounding an alarm on receipt of distress signals at sea.

3755. A Scale-of-N Counter and the Sensitiveness towards Light of a Geiger-Müller Tube.—E. Bergstrand. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 3rd Nov. 1943, Vol. 29, Part 4, Section A, No. 31, 7 pp.: in English.)

A simplified version of the condenser-charging type of dividing counter which requires only constancy of amplitude in the counted impulses.

3756. An Apparatus for Coincidence Measurements with Very High Resolving Power.—H. Bradt & P. Scherrer. (*Helvet. Phys. Acta*, 30th June 1943, Vol. 16, No. 3, pp. 251–264: in German.)

3757. "THE MEASUREMENT OF COLOUR" [Book Review].—W. D. Wright. (*Journ. Soc. Mot. Pict. Eng.*, June 1945, Vol. 44, No. 6, pp. 481–482.)

3758. PRECISION PHOTOMETRY WITH A CAESIUM CELL AND COMBINATION FILTERS.—H. König. (*Helvet. Phys. Acta*, 20th October 1943, Vol. 16, No. 5, pp. 421–422 : in German.)

Summary only.

3759. "COLOR DETECTIVE" HELPS NAVY [An Apparatus to Measure the Absorption of Red Light by Paint].—(*Gen. Elec. Review*, Aug. 1945, Vol. 48, No. 8, p. 60.)

3760. ON AN OBJECTIVE COLORIMETER [Discussion of Requirements].—H. König & F. Mäder. (*Helvet. Phys. Acta*, 20th October 1943, Vol. 16, No. 5, pp. 419–421 : in German.)

3761. ELECTRICAL MEASUREMENT OF VERY SMALL CHANGES IN ATMOSPHERIC PRESSURE.—L. Saxer & F. Dessauer. (*Helvet. Phys. Acta*, 20th October 1943, Vol. 16, No. 5, pp. 435–436 : in German.)

Summary only.

Observation of changes in capacitance between a metal membrane and a fixed electrode, by means of a Hut-Kühn circuit. A change in pressure of 10^{-3} mm of mercury gives a galvanometer deflection of 4 cms at 1 m.

3762. DYNAMIC BALANCER [for Small High-Speed Rotors].—Scophony Ltd. (*Journ. of Scient. Instr.*, Sept. 1945, Vol. 22, No. 9, pp. 178–180.)

The device comprises "electromagnetic driving means, electrostatic pick-up of the vibrations, electronic amplification and electronic [cathode-ray oscilloscope] means for continuously indicating the amount and phase of the unbalanced mass. Sensitivity is independent of the speed, and is so high that dependence is not made on the body passing through some particular resonance period". It is possible "to detect unbalance of the order of 0.0005 g.cm in gyromotors having moment of inertia 300 to 6000 g.cm² rotating at 20 000 rpm . . . the accuracy and smoothness of the balls and race set the final limit to the accuracy attainable".

3763. A DEVICE FOR INDICATING SMALL CHANGES IN ELECTROLYTIC RESISTANCE.—Blake. (*See* 3602.)

3764. HIGH-FREQUENCY LOW-TENSION [Aero Engine] IGNITION SYSTEM.—(*Engineering*, 20th July 1945, Vol. 160, No. 4149, p. 48.)

Paragraph only.

3765. "RESISTANCE WELDING CONTROL" [Set of Seven Lesson Books and One Quiz Book : Book Review].—Westinghouse Electric & Manufacturing Company. (*Proc. I.R.E.*, Aug. 1945, Vol. 33, No. 8, p. 555.)

"These eight booklets comprise a complete series of blackboard talks on the practical aspects of resistance welding control."

3766. INVESTIGATION OF RESONANCES IN FILAMENTS BY A MECHANICAL ACTUATION AND MEASUREMENT OF ELECTROMAGNETICALLY INDUCED VOLTAGES.—R. W. Carlisle & H. W. Koren. (*Journ. Acous. Soc. Am.*, July 1945, Vol. 17, No. 1, pp. 71–72.)

The mounted filament is caused to vibrate in a magnetic field, and the induced electromotive force is measured, after suitable amplification.

3767. AN INTERVAL TIMER FOR ARC DURATION [during Opening of an Electric Circuit].—(*Electrical Eng:g*, May 1945, p. 237.)

Short abstract in *Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 656.)

3768. ELECTRONIC FLAME CUTTER [a Photo-Tube Device for Guiding Cutting Torches to Follow a Contour].—(*Steel*, 28th May 1945, p. 102.)

Short abstract in *Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 656.

3769. ELECTRONIC DEVICE INDICATES PEAK TRANSIENT VOLTAGES.—(*Elec. World*, 26th May 1945, p. 80.)

Short abstract in *Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 656.

3770. THE SCOPHONY [Portable] ELECTRONIC STROBOSCOPE [for Rotating or Reciprocating Mechanisms in the Range 600–14400 rpm].—(*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 658.)

3771. PHOTO-ELECTRIC FURNACE DISCHARGE INDICATOR.—(*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 654.)

A short descriptive note.

3772. ELECTROSTATIC PRECIPITATION : THE FUNDAMENTALS AND A SIMPLE NOMOGRAPHIC METHOD OF CALCULATING EFFICIENCY.—L. R. Koller. (*Gen. Elec. Review*, Aug. 1945, Vol. 48, No. 8, pp. 13–15.)

3773. ELECTRO-DEPOSITED PAINT.—H. J. Ransberg Co. (*Electronic Eng:g*, Aug. 1945, Vol. 17, No. 210, p. 654.)

Short note. A D.C. potential difference of 100 000 V between the spray and the article to be coated is reported to halve the consumption of paint.

3774. NEW ELECTRONIC TIMER GIVES UNIFORM X-RAY EXPOSURES.—Westinghouse Electric & Manufacturing Company. (*Journ. Franklin Inst.*, July 1945, Vol. 240, No. 1, pp. 66–67.)

"The heart of the Westinghouse Phototimer is the so-called phototube camera consisting of a lens which scans the fluorescent screen [on which the X-rays cast the object image], a photoelectric multiplier tube and a condenser-thyratron-relay system. . . . The output current [from the multiplier] charges the condenser until the proper ionisation voltage is reached, when the thyratron fires actuating the relay which opens the X-ray circuit and terminates the exposure."

3775. UNIFICATION OF SCREW THREADS, PART II.—(*Engineer*, 6th July 1945, Vol. 180, No. 4669, pp. 7–9.)

Conclusions of report on I.M.E. Conference. (For Part I, *see* 3447 of October.)

3776. A NEW KIND OF H.F. DISCHARGE IN VACUUM AND ITS USE AS AN ION SOURCE.—H. Alfvén & H.-J. Cohn-Peters. (*Arkiv för Mat., Astron. och Fysik* [Stockholm], 12th Feb. 1945, Vol. 31, Part 3, Section A, No. 18, 17 pp. : in German.)

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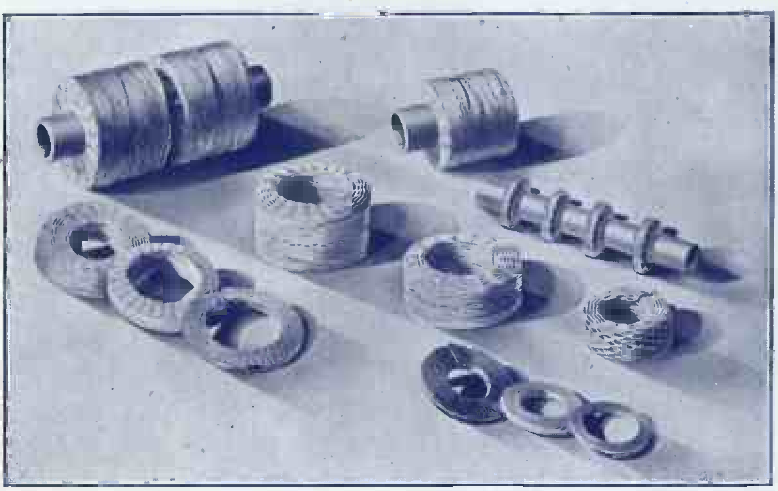

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