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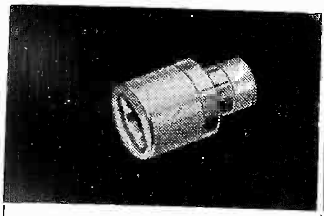

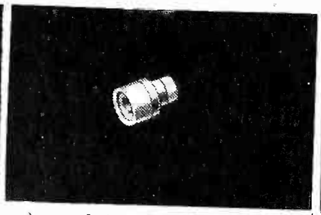
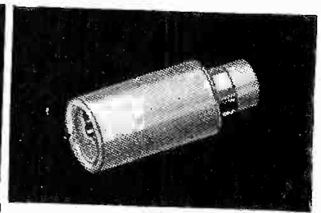

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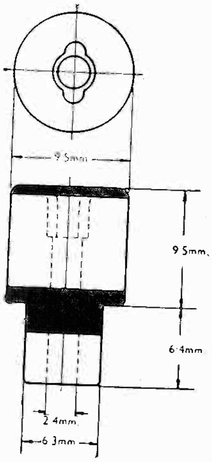

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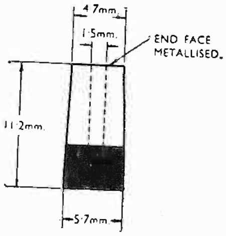

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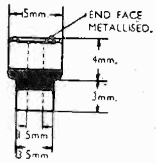

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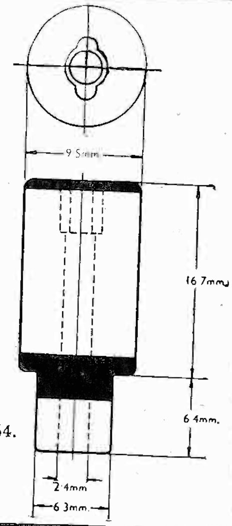

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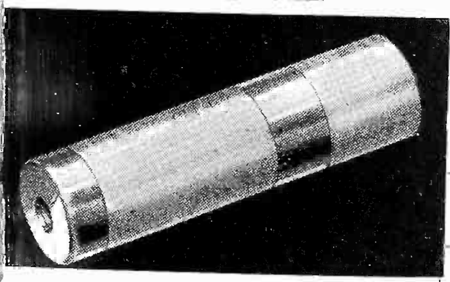

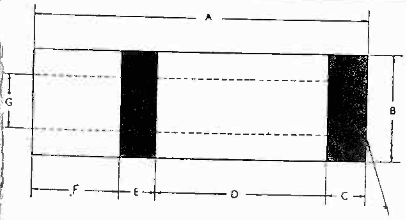

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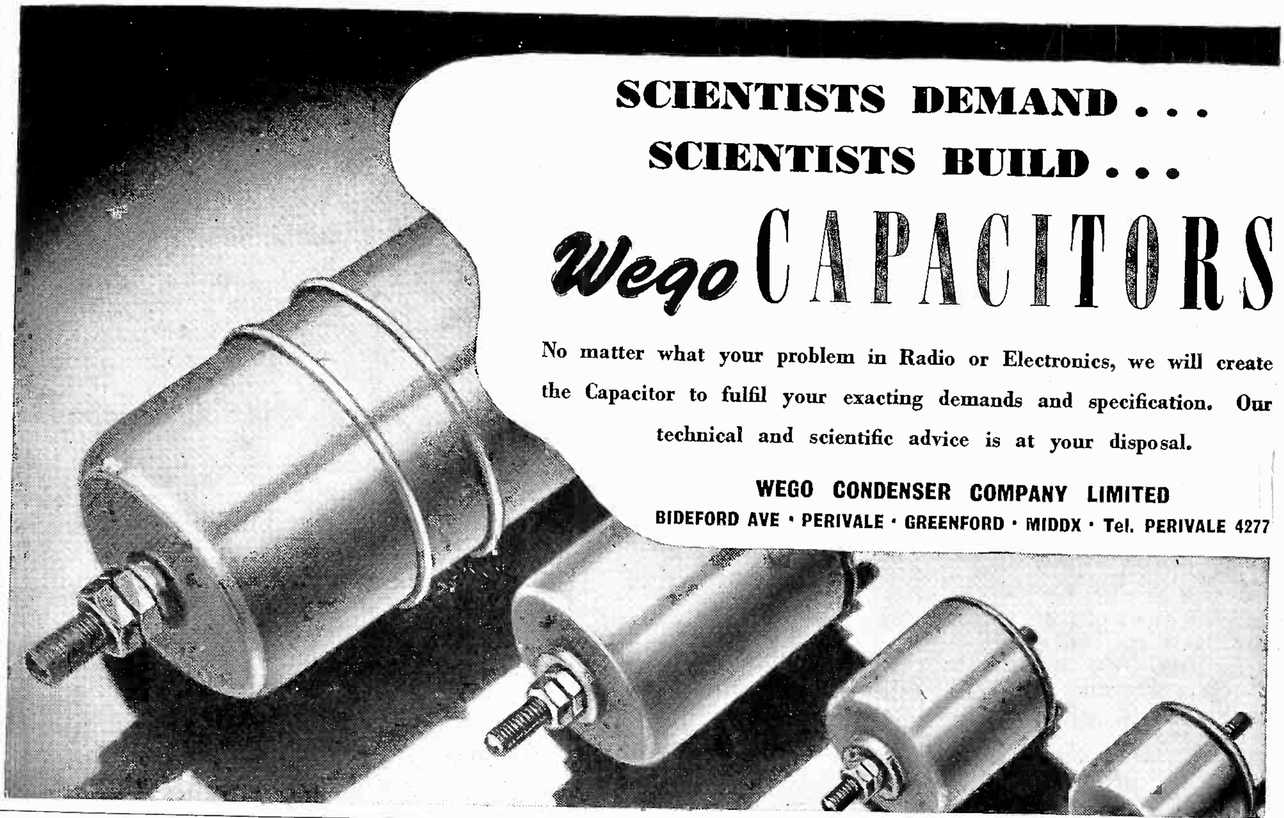


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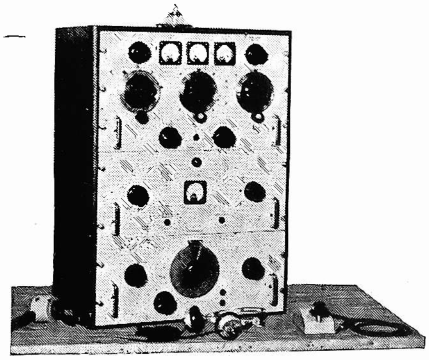

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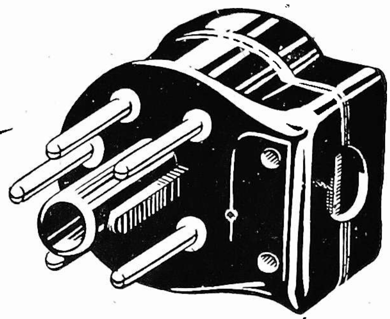

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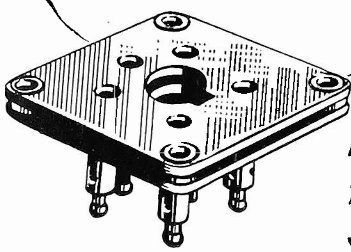

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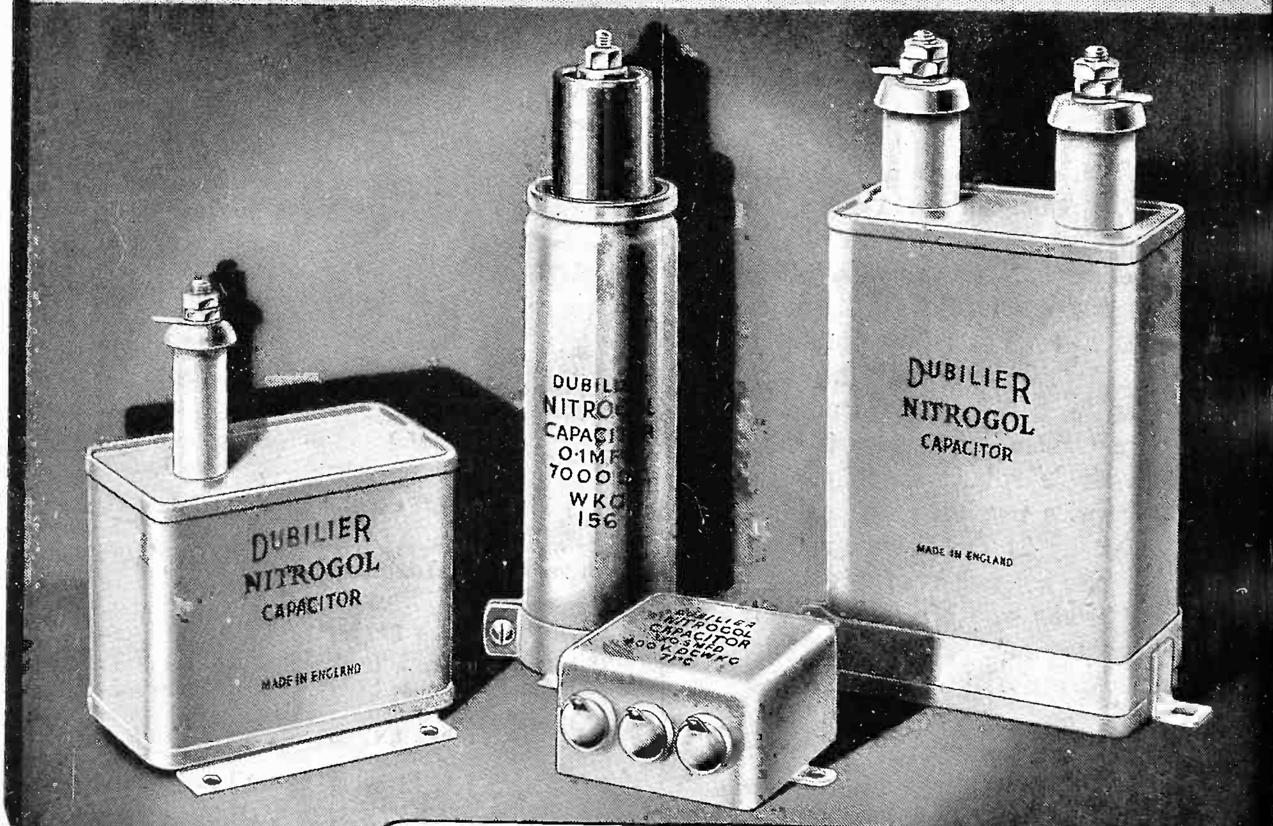

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OCTOBER 1946

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W. T. COCKING, M.I.E.E.

Managing Editor
HUGH S. POCOCK, M.I.E.E.

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

EDITORIAL

Is Rotation Relative or Absolute?

IN going over some letters of 1935 we came across one referring to an article on "The Magnetic Field" in *Electrical Review*. The writer said: "With most of what you say I am in full agreement, but I am not happy about . . . where you say that the 'rotation is not relative to anything else, not even to the observer.' Surely, the point is that the rotation is *relative to the observer*."

This raises a very interesting point. A cylinder rotating about its axis is shown in Fig. 1. If the observer at P be at rest, *i.e.* relatively to the centre of the cylinder, he will observe that the point A has a velocity v in one direction, whereas the point B has an equal velocity v in the opposite direction. He will conclude that the cylinder is rotating with an angular velocity $\omega = 2v/AB$. One may feel tempted to regard this rotation as only relative to the stationary observer, but this is not so, for let us now assume that the observer is also rotating with the cylinder so that he is always close to the point A on the cylinder. What will he now report concerning the movement of the cylinder? He will observe that the point A is at rest but that the opposite point B is moving with a velocity $2v$, and he will therefore conclude that the cylinder is rotating with the same angular velocity as before, viz. $2v/AB$. To rotate about the centre the observer P must be attached to some arm, or subjected to some mechanical restraint, otherwise he would shoot off at a tangent.* The same result would, of course, be obtained by an observer on the cylinder, say at A. The cylinder is not at rest relatively to an observer on the cylinder, as he would soon discover as the speed was increased. Whatever may be the movement of the observer, whether linear or rotational, he observes the same angular velocity of the cylinder. If the rotation is the same relative to everything in the universe, it is surely absolute. If the cylinder is surrounded by another cylinder and they both rotate with the same angular velocity, one is again tempted to say that one is not rotating relatively to the other, but this is surely a dangerous use of the word "relatively." An observer on either cylinder would report that the other one was rotating, and at the

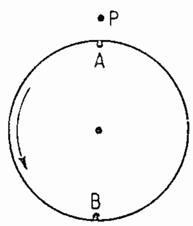

Fig. 1.

* It has been suggested to us that the observer rotating with the cylinder might keep his eyes fixed on the axis and conclude that the cylinder was not rotating at all, but that the rest of the universe was rotating around it. The force which he would experience would be a mystery to him. In the above we have ruled out such an observer and assumed one who did not rotate about his own axis, but kept his eyes fixed on some distant point. There is some ambiguity in describing the motion of such an observer for, although every part of him is rotating about the axis of the cylinder, he himself is not rotating, since he is always looking in the same direction.

same angular velocity as the one on which he was situated. The two cylinders are rotating absolutely at the same angular velocity and there is nothing relative about it.

If the inner cylinder were at rest whilst the outer one continued to rotate and an observer situated on the outer cylinder were asked whether the inner cylinder was rotating or not, he would reply that the inner cylinder was moving with a velocity v relatively to him but, since every point on it had the same velocity, it was certainly not rotating, although the centre of it appeared to be rotating about him with the same angular velocity as that of the outer ring. If he were a very intelligent observer he might notice that the velocity v corresponded to his own observed angular velocity and conclude that the inner cylinder was not only not rotating but was at rest.

We need hardly explain that this all arose out of the hoary old question of the rotating cylindrical bar magnet. Unnecessary difficulties are introduced by failure to realize the absolute nature of rotation. If one says that the magnet is rotating it is meaningless to ask, relatively to what? It is rotating in the unchanging magnetic field produced by the magnet itself, and electromotive forces are therefore induced in it with consequent movement of electrons until the distribution of charge sets up electric forces which counteract at every point inside the magnet those induced by the rotation. Any translational movement of the magnet can have no electromagnetic effect on the magnet itself.

A stationary charge near the rotating magnet is situated in an unchanging magnetic field but also in the electric field due to the charges on the magnet and it will experience a force due to this electric field. If the magnet be at rest and the charge be rotated around it, the charge will experience a mechanical force due to its rotation in the magnetic field. If both magnet and charge rotate at the same angular velocity the two forces on the charge will be equal and opposite and the charge will therefore experience no force. This does not alter the fact that both magnet and charge are rotating in an unchanging magnetic field.

In the letter to which we referred above, the writer expresses the belief that the phenomena would appear exactly the same to the observer armed with an electric charge whether he were at rest and the magnet rotating or vice-versa. This opinion seems to be based on the assumption that rotation is purely relative. We have seen that the observer can decide definitely which of the two is rotating. If he finds that he is at rest and the magnet rotating, he is surely justified in applying the ordinary laws of electromagnetic induction to the rotating mass of the magnet which will explain the distribution of charges upon it and the electric field thereby set up. If, however, he finds that the magnet is at rest but that he himself is rotating, he will not credit the magnet with anything beyond the production of the magnetic field in which he is rotating; he will find that the charge that he is carrying will experience the same force as before, but due surely to his rotation in the magnetic field.

A satisfactory explanation of the various phenomena is hardly possible unless one realises the absolute nature of rotation. Although one may feel justified in saying that the two cylinders in Fig. 2 are not rotating relatively to one another, it must always be borne in mind that an observer on either cylinder would report that the other one was rotating, and that if one cylinder is at rest, an observer on either can say quite definitely which one is at rest and which rotating. What we said in 1935 about the rotation of the magnet not being relative to anything else, "not even to the observer" would have been more correctly expressed if we had said that the rotation was relative to everything else irrespective of the observer.

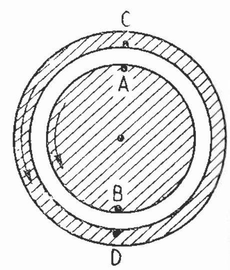

Fig. 2.

G. W. O. H.

MOTOR-CAR IGNITION INTERFERENCE*

The Impulsive Radiated Field

By C. C. Eaglesfield

SUMMARY.—A simple theory is given of the mechanism of motor-car ignition interference. Each spark gives a radiated field of the form of an impulse of easily estimated area and extremely short duration. A car gives a train of such impulses for each nominal spark. The theory seems to fit the known facts.

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1. Introduction

MOTOR-CAR ignition can be an important source of interference with radio reception, in particular of television, where it is familiar as spots on the picture and a kind of machine-gun fire from the loudspeaker.

The mechanism by which the interference is caused does not seem to have been very well understood. The usual explanation, as implied for instance by Gill and Whitehead[1] seems to be that the spark causes oscillatory currents in the ignition lead, covering a spectrum of frequencies. This spectrum is then propagated from the ignition lead, considered as an aerial, and the receiver picks out those frequencies which lie within its pass-band.

This picture is hardly satisfactory, since it is known that the spectrum involved is enormously wide, and without gaps. It therefore seems necessary to imagine that the ignition lead has a very large number of resonances, very closely spaced.

A different picture is presented here, very simply derived, which gives a result which seems to fit the facts. The inference is that the radiated field is an impulse, short compared to the period of the carrier frequency up to frequencies of hundreds of Mc/s. Thus what comes from the receiver is the impulse response of the receiving aerial and the receiver.

Since, in general terms, the impulse response is much more connected with the "bandwidth" than with the carrier frequency, it is easy to see how receivers tuned to a wide variety of carrier frequencies are all subject to the interference.

With this simple picture, we need not consider, until we come to the effect on the receiver, things which are characteristic of the receiver and not of the interfering source, namely carrier frequency, type of modulation, etc.

The application of this theory is not limited to motor-car ignition, but applies to all forms of interference caused by sparks. However it is particularly suited to the motor-car, which is a compact, self-contained unit.

The details are given in the next section, ending in a simple formula for the impulsive field, in terms of easily estimated factors. In Sections 3 and 4 the magnitude and waveform of the field as given by the theory are checked against experimental evidence.

Section 5 is devoted to some experiments with cars, the main interest of which is that cars give a train of impulses for each nominal spark.* It seems that each nominal spark is in reality a train of sparks, the number of

* MS. accepted by the Editor, March 1946.

* Professor Howe has kindly sent me a paper—I. "The Efficiency of Generation of High-Frequency Oscillations by means of an Induction Coil and Ordinary Spark-Gap." II. "An Oscillographic Study of some Induction Coil Phenomena," by Professor Howe and J. D. Peattie. *Proceedings of the Physical Society of London*, Vol. 24, Part 5, p. 317, Aug. 15th, 1912, in which there is a description of a similar phenomenon, and a spark photograph (Fig. 24) showing consistently 4 or 5 sparks per break.

sparks in the train and its duration being connected with the oscillatory nature of the ignition systems in use.

The experiments show that the impulse train is a very variable thing; however, they give an indication of the magnitude of the effect, which can greatly modify the annoyance caused by the interference.

2. A Simple Theory

The radiated field from an idealized system will now be calculated. To do this a number of assumptions will be made: the sparking plug will be replaced by a switch; the radiating part of the ignition system will be taken as a small loop having small inductance; and this loop will be supposed to lie in a vertical plane and be very close to the plane of the earth.

The purpose is merely to obtain a first approximation to the radiated field.

The method is to calculate the initial current in the loop by means of the assumption that the plug is a switch; the radiated field is then calculated from the standard formulae for an ideal magnetic dipole.

This treatment leads to the result that the field is an impulse, and the area of the impulse is given by a simple formula.

An impulse is an abstraction: its time of duration is vanishingly small and its amplitude is infinite. In practice the radiated field can only approximate to an impulse, that is, be a pulse of short but finite duration.

It is necessary to keep this point in mind, and have some estimate of the likely duration of the pulse.

Spark Gap as Switch

When the voltage across a gap is gradually increased a critical voltage will be reached at which the gap breaks down. In a very short space of time the gap changes from almost a perfect insulator to almost a perfect conductor.

There is, therefore, no difficulty in replacing it by a switch which is supposed to close when the voltage exceeds a critical value. The only point to be settled is the order of the time interval between the state of non-conduction and the state of conduction.

This interval is certainly very short: the reader is referred to Wheatcroft[2] for a discussion of what happens in the gap during the change.

Fig. 1 is a reproduction of his Fig. 43, which shows a typical curve of the voltage across a gap. The point A is where the change of state occurs; on the left of A the gap is non-conductive, and on the right it is conductive. An abrupt discontinuity of slope at A would indicate zero transition time; actually there is a large localized

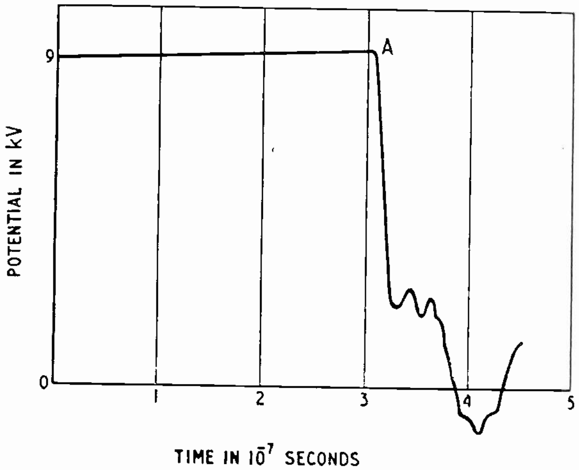


Fig. 1. *Reproduction of Fig. 43 of Wheatcroft, "Gaseous Electrical Conductors," which itself was reproduced from Rogowski and Klemperer, "Arch. f. Elekt.," Vol. 24 (1930).*

curvature, suggesting a very short transition time.

While it is evident from Fig. 1 that the transition time is much less than 10^{-7} sec, it is better to consider the mechanism of the spark for a closer estimate. This does not appear to be fully understood, but the probable course of events seems to be that in the critical condition a small number of electrons leave the cathode and proceed towards the anode, splitting off electrons from the molecules of gas as they go; the released electrons also move towards the anode and split up more molecules; so that an avalanche of electrons descends on the anode.

Until the crest of the avalanche reaches the anode the external current is very small; when the crest arrives the current is very large.

It is known that between the application of a voltage, greater than critical, and conduction a time elapses of the order of the electron transit time across the gap, i.e. about 10^{-8} sec. The application of the voltage presumably corresponds to the electrons leaving the cathode. Thus the transition time between non-conduction and conduction must surely be small compared to the electron transit time.

It can hardly be greater than 10^{-9} sec.

The Initial Current

Now consider the circuit of Fig. 2 (*a*). The inductance L is supposed to reside in the ignition lead of the car between the sparking plug and say the terminal of the magneto or sparking coil. At that point one can imagine an effective lumped capacitance completing the circuit.

The voltage is supposed to rise comparatively slowly to the critical value V, when the switch closes. At this instant the voltage V is applied across the inductance L and the current, until then zero, rises. The voltage will be considered to remain constant during the initial rise of current.

Immediately after breakdown the current s

$$i = \frac{V}{L} t$$

vhere t is the time measured from the instant of breakdown. The current is thus as shown

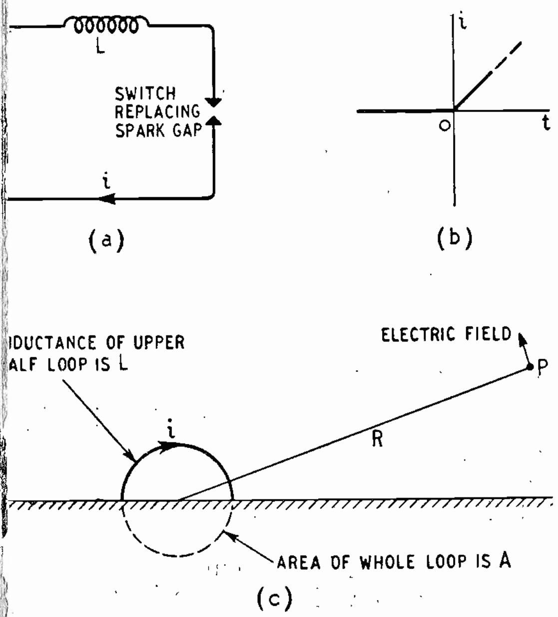


Fig. 2. (*a*) *The equivalent circuit of the spark gap*, (*b*) *the current near breakdown at* $t = 0$, (*c*) *diagram illustrating the propagation.*

n Fig. 2(*b*), and can be expressed as

$$i = \frac{V}{Lp} \mathbf{1} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

here $\mathbf{1}$ is the Heaviside step operator, and is the differential operator d/dt.

The Radiated Field

The next step is to consider the propagation between a car and a receiving aerial. We can imagine the ignition lead as a vertical loop, returned to the engine as described, by the plug at one end and the lumped capacitance at the other. If we then consider the engine as part of an infinite conducting plane representing the earth, the situation is as shown in Fig. 2(*c*), where the image of the ignition lead is shown dotted. We now have a closed loop, and for calculation of the field above earth we can consider the whole loop as a magnetic dipole.

Taking the area of the whole loop as A, the magnetic moment is :—

$$m = Ai \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where i is given by equation (1).

The field around a magnetic dipole is given in textbooks on electromagnetic theory, for instance, Stratton[3]; (the formulae as given by Stratton are for a source varying sinusoidally with time).

Referring to Fig. 2 (*c*), the electric field at a point P at a distance R from the loop and in the same plane (R very large) is in the direction shown and is given by :—

$$\frac{\mu}{4\pi cR} \cdot \frac{d^2 m}{dt^2} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

where c is the velocity of propagation ($= 3 \times 10^8$ metres/sec) and μ is the permeability ($= 4\pi \times 10^{-7}$ henry/metre).

Combining equations (1), (2) and (3) we get for the electric field :—

$$\frac{\mu}{4\pi c} \cdot \frac{AV}{LR} p\mathbf{1} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Since $p\mathbf{1}$ is a unit impulse, the electric field is an impulse of area :—

$$\frac{\mu}{4\pi c} \cdot \frac{AV}{LR} \frac{\text{volt}}{\text{metre}} \text{sec} \quad \ldots \quad \ldots \quad (5)$$

Duration of Pulse

In an actual case the radiated field will be a pulse rather than an impulse. The two factors that seem most likely to lengthen the pulse are lack of instantaneity in the switch action of the sparking plug and the finite length of the ignition lead.

The transition time in the plug has been estimated to be of the order of 10^{-9} sec.

The length of the ignition lead divided by "c" seems an appropriate measure of the effect of the lead: this would be of the order of 10^{-9} sec.

A reasonable estimate of the duration of the pulse in practice would therefore seem to be of the order of 10^{-9} sec.

3. The Magnitude of the Radiated Field

It is interesting to compare the magnitude of the radiated field as given by equation (5) with published measurements of motor-car interference.

Such results have been given by George.[4] He measured the peak output from a receiver for a number of cars and treated the figures statistically. From a knowledge of the gain of the receiver and aerial he deduced a figure for the peak field strength corresponding to his measured peak output. The receiver was tuned to a number of frequencies in turn, the extreme frequencies being 40 and 450 Mc/s.

To make a comparison with George's figures it is necessary to estimate the impulse response of a receiver. This will be done in such a way that an equivalent field strength is obtained which can be compared directly with George's peak field strength.

Then suitable numerical values must be assigned to the quantities in equation (5).

Some remarks will be added regarding the validity of the comparison.

Receiver Impulse Response

The impulse response of a network can only be rigorously calculated if the network is completely specified, either by its physical components or by its amplitude and phase characteristics.

The impulse response is likely to be a pulse, and if the network has a fairly definite pass-band, it is possible to estimate the peak value of the pulse in terms of the "bandwidth" of the network. This is often justified mathematically by considering a network with arbitrary ideal characteristics, for example see Guillemin.[5] But since the assumed characteristics are mathematically incompatible, it is better to regard the formula obtained as empirical and justified by experience.

There can be little objection to using such a formula here, considering the number of approximations already made.

The method is to multiply the impulse area of equation (5) by the receiver bandwidth, and so obtain an equivalent sinusoidal field strength which gives the same peak output from the receiver.

Doing this, we have:—

Equivalent electric field

$$= \frac{\mu}{4\pi c} \cdot \frac{AVB}{LR} \text{ volts/metre} \quad \ldots \quad (6)$$

where B is the bandwidth of the receiver.

Equation (6) then gives a figure which can be compared directly with George's figures.

Numerical Values

We now need numerical values for A, V, L.

Suppose that the ignition lead is a semicircle of diameter 12 inches and wire diameter 0.04 inch; these figures seem reasonable for actual cars.

The area of the whole loop of Fig. 2 (*c*) is then $A = 0.073$ sq. metre.

The inductance of the half-loop can be estimated approximately by taking half the inductance of the whole loop, for which there is a well-known formula (e.g. see Terman[6]).

Then $L = 0.55 \times 10^{-6}$ henry.

The breakdown voltage V, under the conditions in the engine cylinder, is probably about 5000 volts.

And for the conditions of George's measurements.

$R = 33$ metres
$B = 10^4$ c/s

Substituting these figures in equation (6):—

Equivalent electric field

$$= 67 \text{ microvolts/metre} \quad \ldots \quad (7)$$

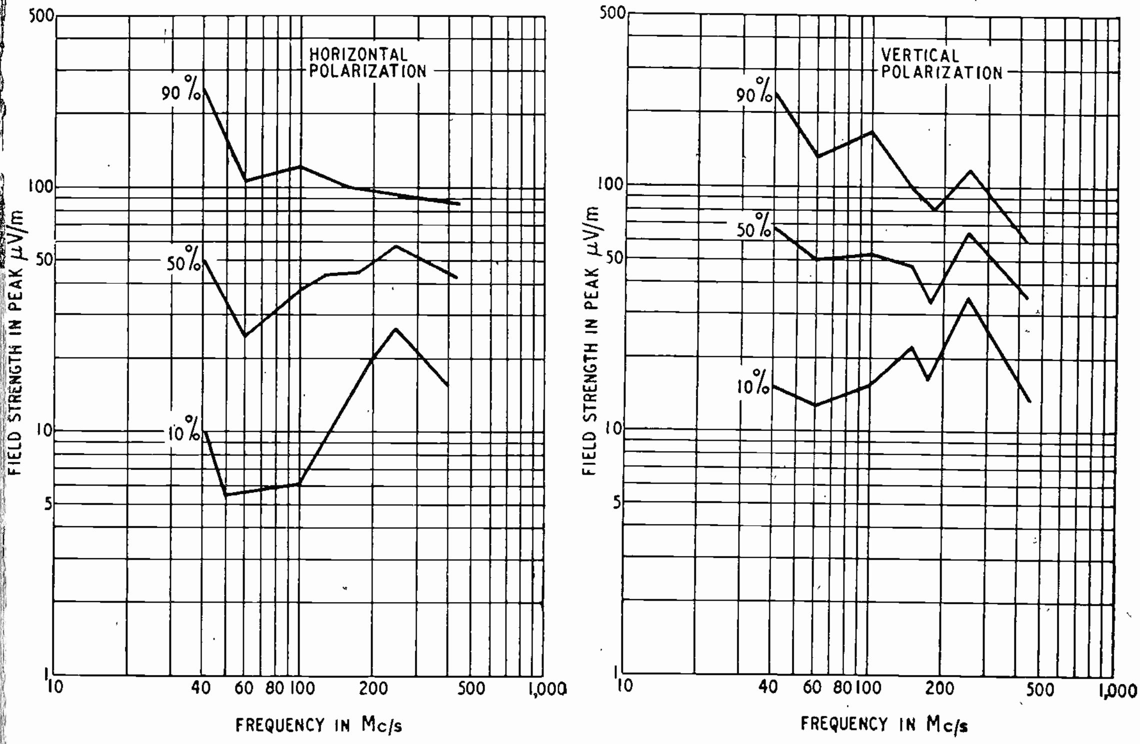
Comparison with Measurements

George's results are summarized in Figs. 3 and 4.* It will be seen that the calculated figure of 67 microvolts/metre lies in the middle of his measured values.

It will be noticed that his results are substantially independent of the carrier frequency to which the receiver is tuned. This is in agreement with the theory, which leads to an equation that does not contain the carrier frequency, that is equation (6), and seems to justify the treatment of the radiated field as an impulse even when the receiver has such a high carrier frequency as here, namely 440 Mc/s.

* These are his Figs. 2 and 3 reproduced by permission of the Institute of Radio Engineers.

There is a complication about the polarization. The theory implies vertical polarization of the field whereas George's results show that the field is not vertically polarized. The plane of the ignition lead was taken as vertical because that simplified the calculation of the radiated field. In practice, of course, the plane would probably be different for the several plugs of one car, and certainly different for different cars. It is therefore



Figs. 3 and 4. *Motor-car ignition radiation, horizontal polarization (left) and vertical polarization (right). Peak field strength versus frequency for a 10-kc/s band.* 90, 50 *and* 10 *per cent of all cars and trucks produce less than the field strength indicated by the curves. Receiving aerial* 35 *feet high and* 100 *feet from road.*

ery unlikely that a definite polarization ould be observed when a number of cars ere tested.

There are two other points about this omparison. The screening effect of the onnet, etc., of the car has not been taken nto account. Also, as will be shown in he next section, one nominal spark is ctually a train of sparks. This would not ffect the argument if the receiver bandidth were great enough to keep the effects f the sparks separate. But it is probable hat with the bandwidth of George's easurements the several pulses in the train ould be amalgamated into a large pulse reater than the response to a single impulse.

These two effects would tend to oppose each other.

On the whole it may be said that the agreement between the theory and the measurements is satisfactory.

4. The Waveform of the Radiated Field

The comparison of the last section has shown that the theory gives the correct order of magnitude of the radiated field. It remains to verify the waveform.

It is clearly not possible to exhibit on an oscillograph a pulse of the anticipated order of length (10^{-9} sec). The best that can be done is to examine the output from a wideband receiver: if the output corresponds to the estimated impulse response of the receiver, that is strong confirmation, but not proof, that the input is an impulse. The difficulty is that the receiver impulse response is so much longer than the supposed input pulse.

An experiment was made to test this point by putting a sparking plug near a television receiver, and observing the effect on the raster. The receiver was a conventional one, being tuned to 45 Mc/s and having an impulse response of about 0.5×10^{-6} sec.

The plug was connected as in Fig. 5, the capacitance C being charged from a source of high voltage through the resistance R. When the voltage across C reaches the breakdown voltage of the plug, C is discharged and the cycle repeats. The leads connecting C to the plug were very short.

The effect of these sparks was to produce small intense spots on the raster, one spot for each spark.

The size of each spot corresponded to the estimated impulse response of the receiver.

While, as already remarked, this experiment does not prove that the radiated field from the plug is an impulse, it does at any rate show that the effect on the receiver is the same as if it were.

5. The Impulse Train

With the simple arrangement described in the last section it was found that each spark produced one impulse.

Experiments were next made with actual cars. It was found that the interference from a car was more complicated: each nominal spark (each firing of an engine cylinder) gave rise to a train of pulses in the receiver output.

It seems extremely probable that the effect is caused by multiple sparks taking place for each nominal spark, presumably due to oscillations in the sparking coil or magneto; actual ignition systems being of course much more complicated than the simple system of Fig. 5, and having probably several resonant frequencies. The spacing of the plug points may be an important factor, since if the available voltage from the ignition system

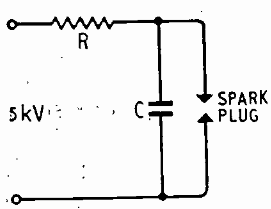


Fig. 5. *A simple circuit for producing sparks.*

does not greatly exceed the breakdown voltage of the plug, multiple sparks are less likely.

A faulty capacitor across the make-and-break contacts might aggravate the effect, but this capacitor was not faulty on the car giving the most pronounced train (car A). The same car was tried with the petrol supply cut off and the engine rotated by the self-starter (itself not a cause of interference): the result was much the same, so the explosion of the petrol does not seem to be involved.

It was found that the length of the train and the number of pulses in it varied from car to car, from plug to plug of the same car, and even on the same plug.

Each individual pulse seemed to approximate to the impulse response of the receiver.

Only one method of obtaining information about the pulse train was found practicable: to isolate a train and record it photographically.

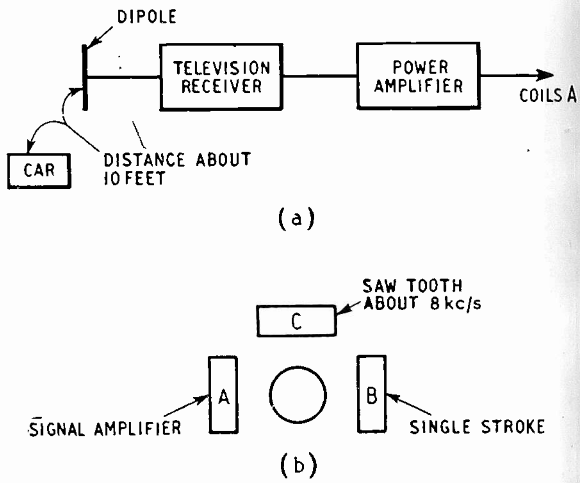


Fig. 6. (*a*) *General arrangement for investigating the pulse train,* (*b*) *the arrangement of the deflecting coils.*

The arrangement of the experiment is shown in Fig. 6 (*a*), the radiation from the car under test being picked up by a television receiver (45 Mc/s), the output of which, when amplified, caused a deflection on a second cathode-ray tube, from which the photographs were taken.

The short distance between the car and the aerial did not modify the results, and helped to reduce the effect of other casual interference.

The arrangement of the deflecting coils on the second cathode-ray tube (the tube in the television receiver was used only as a monitor) is shown in Fig. 6 (b). Coil C was connected to a saw-tooth source (about 8 kc/s); this made the spot oscillate continuously in a horizontal direction. Coil B was used to move the spot from off the screen at the top to off the screen at the bottom at more or less uniform speed. This operation was controlled by a manual switch, the effect being a single stroke raster, on to which vertical deflection from coil A was superimposed.

The car engine was run at a fairly high speed, about 1000 r.p.m., so that at least raster. Since the exposure was timed by the manual switch, the shutter was left open and the camera was placed in a tunnel facing the cathode-ray tube. The camera used was a Rolleicord with double proxar lenses,

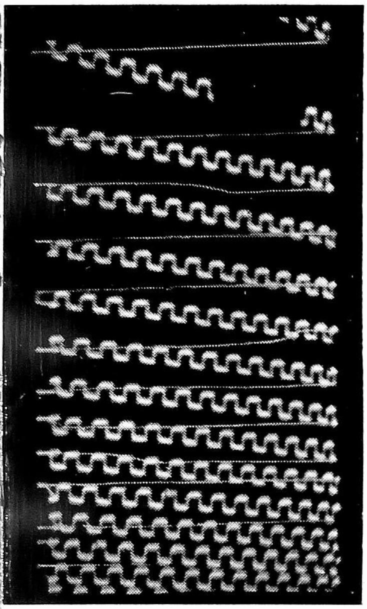


Fig. 7. *Record showing the response of the apparatus to a square wave* (100 *kc/s*).

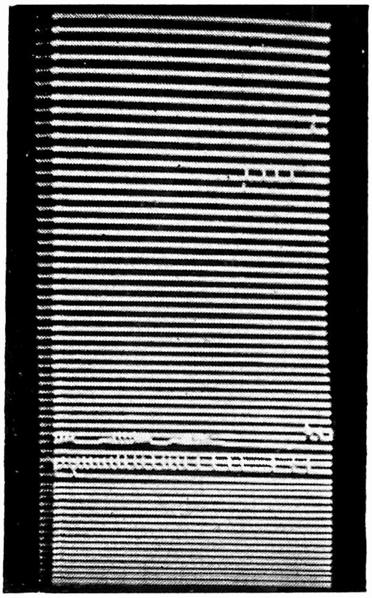


Fig. 8. *A typical record from car A, showing two separate pulse trains.*

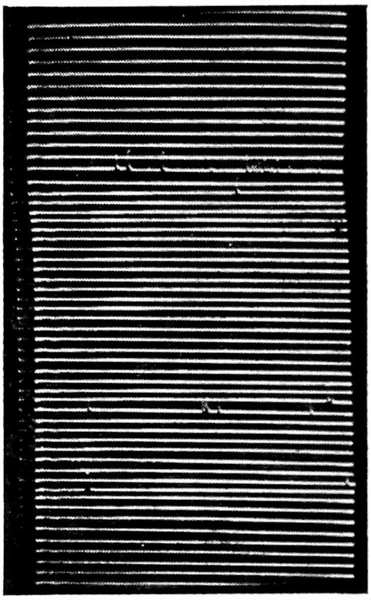


Fig. 9. *A typical record from car C showing two separate pulse trains.*

one pulse train was caught during each arbitrarily started exposure.

Valuable hints on this type of photography are given by Hendry[7] and Nethercott[8]. The first reference also described the single stroke

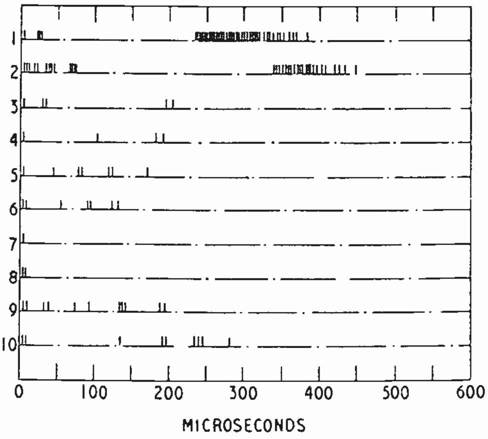


Fig. 10. *A transcription of some of the records, showing the spacing in time of the pulse trains, but not the relative amplitudes of the pulses,* 1, 2 *from car A;* 3, 4 *from car B;* 5, 6 *from car C;* 7, 8 *from car D;* 9, 10 *from car E.*

the tube was a 9-in television tube with a white screen (5 kV on the final anode) and the film was Selo HP3 (Hypersensitive panchromatic).

The response of the system to a square wave (100 kc/s) is shown by Fig. 7; this also serves as a time calibration.

Typical records from cars are shown in Figs. 8 and 9, which each contain two separate pulse trains.

As suggested by Hendry[7] it was found better to use a not so bright but well focussed spot on the cathode-ray tube and intensify the negative after development. This can be seen by comparing Fig. 9 which was intensified with Figs. 7 and 8 which were not.

Due to overloading in the amplifier, the amplitudes of the pulses in the records are not reliable. The difficulty was to put a large enough current into the deflection coil, which had to be made of few turns to retain definition.

Typical records from five cars have been transposed to a linear time scale in Fig. 10. This shows the spacing in time of the pulse trains, no account being taken of amplitude.

The following table of results gives an idea of the kind of pulse train that can be expected.

Car	No. of Trains recorded	Average No. of pulses per train	Average duration of train
A. Morris 8 ..	6	50	500 sec.
B. Hillman 10..	5	3	100 ,,
C. Vauxhall 10	8	10	125 ,,
D. Hillman 10 ..	4	5	50 ,,
E. Ford 10 ..	9	10	200 ,,
Average ..		15	200 ,,

Conclusions

A simple theory of the impulsive radiated field of motor-car ignition has been given by considering the sparking plug as a switch and then calculating the current and th radiated field and estimating the likel duration of the pulse ; the magnitude of th radiated field has been compared wit published measurements by estimating th receiver impulse response and inserting likel numerical values in the theoretical formula and the waveform checked by experiment Experiments with cars have shown tha they give an impulse train.

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DESIGN OF ATTENUATION EQUALIZERS*

Generalized Performance Equations

By H. N. Wroe, B.Sc., Ph.D.

(Assistant Engineer, Department of Post and Telegraphs, Eire)

SUMMARY.—From theoretical considerations a method of accurately calculating the performance of a given equalizer is deduced. This is utilized and exemplified in the design of equalizers which, because they are not constructed on conventional lines, do not lend themselves to customary methods of design calculation.

Introduction

In reaction, as it were, from the complexity of earlier expositions of the principles governing equalization in which the subject was presented in a generalized form rather unsuitable for practical application, later treatments have tended to concentrate on particular types of equalizer having special internal arrangements—usually the constant impedance (resistance) form—which for the very reason that they simplify mathematical considerations, mask the general factors on which equalization depends. A further consequence is that information on the prediction of the performance and on the design of very simple equalizers is lacking because they do not possess the internal arrangement normally assumed. In spite of their simplicity, therefore, such equalizers are usually not at all the easiest to deal with.

Such considerations may not be of great moment to the specialist in network design who, backed by the resources of a great manufacturing corporation which will provide almost any components he may desire, is occupied almost entirely with the attainment of first-class transmission quality. To the ordinary communications engineer, however, the following of conventional designs frequently becomes difficult, if not impossible. Despite frequent assumptions to the contrary, he is often called upon to provide transmission networks in circumstances where considerations of cost or of supply are the

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determining factors, and where the use of the minimum of standard components or, perhaps, of whatever is to hand, is necessary. For instance, he may design a constant-impedance equalizer only to find that the components available have, either nominally or owing to manufacturing tolerances, values appreciably different from those which the design demands. A method of predicting whether, despite this, the resulting quality of transmission will be of sufficiently high standard for the required purpose, or whether it can be made so by alterations, would be very useful. Or again, a small amount of equalization which could readily be provided by a very elementary form of equalizer, may be required; the difficulty is to work out a basis for design, or if recourse be had to trial and error, to calculate the performance of any given assumed network.

It is to deal with the deficiencies outlined above, and to meet in a general way the needs of the non-specialist, that this paper has been written. It is felt that an exposition of the general principles determining equalizer performance illustrated in their application to telephone cables will be of some value.

As the limits for good quality transmission over the important portion of the frequency range are narrow, the methods of calculation must avoid all but really negligible approximations. This involves additional labour in computation, but if it enables calculation at the desk to replace trial and error adjustments in the field, or even if it only provides a guide to these, it will be well worth while.

General Considerations

As is well known, it is characteristic of practical transmission lines that their transmission losses vary with frequency, the losses generally increasing with frequency. In telecommunication circuits, where the signals extend over a band of frequencies, this means that the relative magnitudes of signals (and of signal components) having different frequencies are altered during the passage of the signals along the line, the result being a mutilation known as frequency distortion. For faithful reproduction of the original signals at the receiving terminal it is necessary to correct for this distortion by the process known as equalization. This consists of connecting in the circuit a correcting network, or equalizer, the function of which is to make the resultant overall loss invariable with frequency over the frequency band required.

In order that this object be attained the loss-frequency characteristic of the equalizer must be inverse to that of the line; that is, the transmission loss of the equalizer must fall with frequency. Clearly, then, the basic circuit of the equalizing network will take the form of a four-terminal network having as series arm a capacitor, and as shunt arm an inductor. In designing the equalizer the primary aim is to arrange that its transmission losses at all points within the frequency range to be covered are such that when combined with the corresponding line losses the total loss is independent of frequency.

The general practice now is to connect the equalizer at the receiving terminal of the line; i.e., to employ post-equalization.

Performance Equation

The theoretical treatment given below is based on the following premises:

1. Only frequency distortion is to be eliminated.

2. Only distortion produced by the communication circuit itself is to be considered—the transmitter and receiver, or their equivalent in the form of repeaters (valve amplifiers), being regarded as ideal.

3. Insertion loss measurements are a reasonable criterion of transmission quality.

4. Post-equalization only is employed.

5. Transmission through the equalizer is unidirectional. This assumption is made mainly for convenience.

The elements of a generalized unidirectional communication circuit are shown in

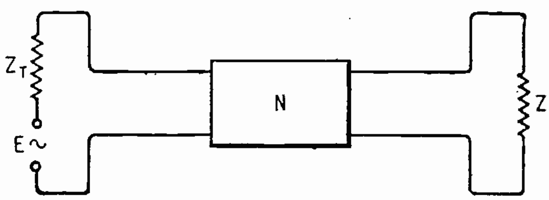


Fig. 1. *Generalized communication circuit N connected between impedances Z_T and Z_R.*

Fig. 1, where the circuit is represented by an equivalent network N, working between a transmitter of impedance Z_T, and a receiver of impedance Z_R. Usually in transmission measurements $Z_T = Z_R = R\,\underline{/\,0}$, the latter normally being 600 $\underline{/0}$ ohms. Repeaters are generally constructed to act as transmitters and receivers operating under this condition.

If the curve AB of Fig. 2 represents the insertion loss characteristic of network N alone (measured for terminating impedances Z_T, Z_R) the circuit loss curve CD may, roughly speaking, be taken as the ideal goal of equalization, the point D being fixed by f_c, the maximum frequency in the range over which equalization is desired. On this basis, at any frequency within this range the equalizer must introduce into the circuit a loss x which, added to the network loss w, gives the quantity y. In practice the resultant characteristic will have the form of the curve EF, the overall insertion loss of the equalized circuit at any frequency f, being denoted by A_0. What is needed is an equation enabling the value of A_0 to be calculated at any frequency. This will be required, firstly, in determining the magnitude of the equalizer components (when A_0 will be assumed to coincide with y), and secondly in predicting the overall circuit quality these will produce.

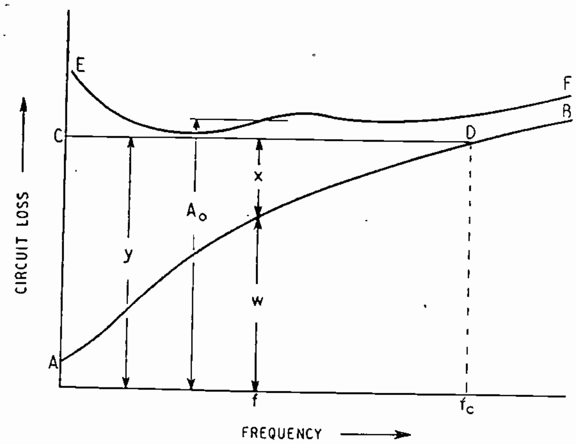


Fig. 2. *The network loss is represented by AB and the desired performance by CD; a practical resultant is more in the nature of EF.*

Referring to Fig. 3 let

E = sinusoidal transmitter e.m.f.

Z_I', Z_I'' = image impedances of network N.

θ = transfer constant of network $N = \alpha + j\beta$.

Z_E = impedance presented to N by the equalizer terminated in Z_R.

I_1 = current to Z_R when directl connected to Z_T without an intervening circuit.

I_2 = current to Z_R.

I_3 = current to equalizer.

$K = \dfrac{I_3}{I_2}$ where K is, in general complex

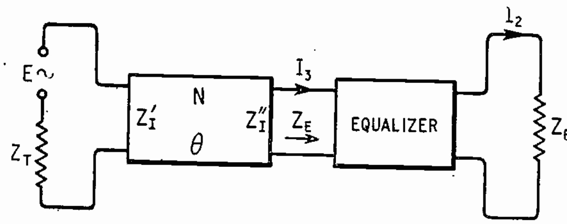


Fig. 3. *Generalized communication circuit including an equalizer.*

Any network worth equalizing will almos invariably (at any rate for the importan frequencies) be electrically "long", so tha interaction loss may be neglected.* Regard-ing Z_E for the moment as a receiver, th following relationship, which may be found in several textbooks on transmission, ther holds:

$$I_3 = \frac{E}{Z_T + Z_E} \times \frac{Z_T + Z_E}{\sqrt{4Z_TZ_E}} \times \frac{\sqrt{4Z_TZ_I'}}{Z_T + Z_I'} \times \frac{\sqrt{4Z_EZ_I''}}{Z_E + Z_I''} \times e^{-\theta} \quad \ldots \quad (1)$$

We have also

$$I_3 = KI_2 \quad \ldots \quad (2)$$

$$I_1 = \frac{E}{Z_T + Z_R} \quad \ldots \quad (3)$$

Substituting (2) and (3) in (1) we obtain the insertion loss of the network N plus the equalizer (i.e., A_0) as

$$A_0\,(\text{db}) = 20\log_{10}\frac{I_1}{I_2}$$

$$= 20\log_{10}\left|\frac{Z_T + Z_E}{Z_T + Z_R}\right| - 20\log_{10}\left|\frac{Z_T + Z_E}{\sqrt{4Z_TZ_E}}\right| + 20\log_{10}\left|\frac{Z_T + Z_I'}{\sqrt{4Z_TZ_I'}}\right| + 20\log_{10}\left|\frac{Z_E + Z_I''}{\sqrt{4Z_EZ_I''}}\right| + 20\log_{10}|e^{\theta}| + 20\log_{10}|K| \quad \ldots \quad (4)$$

From this equation the overall performance of the equalizer represented by A_0 may

* See Appendix.

be calculated. It is seen to depend not only upon the current-changing property of the equalizer (represented by K), which may be termed the "potentiometer" effect, and on that denoted by θ, but also on several other components of a more or less complex nature—reflection losses at the network terminals, and losses produced by inequalities between Z_T, Z_R, and Z_E.

Uniform Lines

With uniform transmission lines such as telephone cable circuits,† we have

$$Z_I' = Z_I'' = Z_0,$$

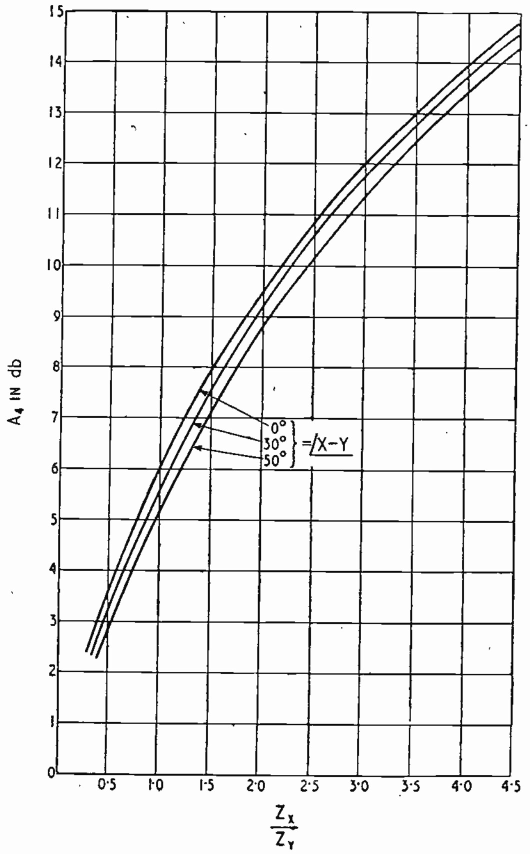


Fig. 4. *Curves expressing the quantity*

$$20 \; log_{10} \left| 1 + \frac{Z_x/x}{Z_y/y} \right|$$

where the latter is the line characteristic impedance, and θ, α, and β, now become the well-known propagation, attenuation, and phase constants respectively (for the whole line, not per unit length). If in addition, as is almost invariably the case, $Z_T = Z_R = R\,/\underline{0}$ (4) becomes

$$A_0 = \underbrace{20 \log_{10}|e^{\alpha}|}_{A_1} + \underbrace{20 \log_{10}|K|}_{A_2} + \underbrace{20 \log_{10}\left|\frac{(R + Z_0)^2}{4RZ_0}\right|}_{A_3} + \underbrace{20 \log_{10}\left|\frac{Z_0 + Z_E}{Z_0 + R}\right|}_{A_4} \quad \ldots \quad (5)$$

Now $A_1 + A_3 =$ the insertion loss of the line for terminating impedances $R\,/\underline{0}$, and is equal to w (Fig. 2), A_3 being the sum of the terminal reflection losses.

Hence

$$A_0 = w + A_2 + A_4$$
$$= w + 20 \log_{10}|K| + 20 \log_{10}\left|\frac{Z_0 + Z_E}{Z_0 + R}\right| \quad \ldots \quad (6)$$

Thus for a given line and given terminating impedances the equalizer performance depends upon two quantities, K and Z_E, and can be calculated by means of (6) without making conventional assumptions as to the internal structure of the equalizer. Much labour in computation can be saved by treating A_4 as follows :—

Write $\dfrac{Z_0 + Z_E}{Z_0 + R} = \dfrac{1 + Z_E/Z_0}{1 + R/Z_0}$

Then

$$A_4 = 20 \log_{10}|1 + Z_E/Z_0| - 20 \log_{10}|1 + R/Z_0|$$

These two quantities can be read off from the curves of Fig. 4, in which the quantity $20 \log_{10}\left|1 + \frac{Z_X/x}{Z_Y/y}\right|$ is plotted against Z_X/Z_Y for different values of $/\underline{x - y}$.

Design

The general method may be illustrated by taking the simple ladder type of equalizer sketched in Fig. 5. The treatment falls naturally under two headings :

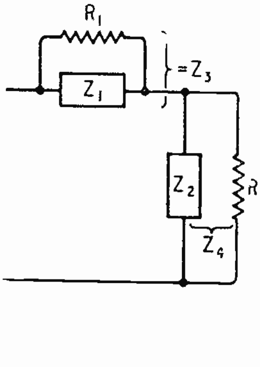


Fig. 5. *Simple ladder-type equalizer.*

† The theoretical treatment given here applies, of course, to uniform lines in general; but cable circuits are particularly considered because practical data for them are available in this paper.

1. Constant-Impedance Equalizers

These have been the subject of considerable notice during the past few years, and consequently will be considered here in bare outline only. The characteristic property is $Z_E = R/0$ at all frequencies, and inserting this in (6) it will be found that A_4 vanishes, and we obtain

$$A_0 = w + 20 \log_{10}|K| \quad \ldots \quad \ldots \quad (8)$$

Here we want $A_0 = y$ (Fig. 1) and so

$$20 \log_{10}|K| = y - w = x,$$

or $$|K| = \text{antilog}_{10}\, x/20 \quad \ldots \quad \ldots \quad (9)$$

K having been determined, Z_2 can be found from the relation

$$\frac{R + Z_2}{Z_2} = K \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

Z_1 then follows from the constant-impedance condition

$$\left.\begin{array}{r} Z_1Z_2 = R^2 \\ R_1 = R \end{array}\right\} \quad \ldots \quad \ldots \quad (11)$$

It will be seen that the constant-impedance relation produces not inconsiderable simplification in the mathematics which is one—though not the only one—of the advantages of equalizers of this type.

2. Inconstant-Impedance Equalizers

Here A_4 remains in (6) and we are presented with two unknowns, K and Z_E. A separation can, however, be achieved as follows :—

A_3 is independent of the length of the line, is relatively small, and depends upon relationships between impedances. A_1 varies with the length of the line and is by far the more important. Let the latter, then, be equalized by A_2 alone, and the former by A_4 which resembles it in composition. Proceeding on this basis we may, for the purposes of convenience and illustration, suppose the curve AB (Fig. 2) to be a graph of A_1, and putting x', y', w', for x, y, w, on our new curve, we have

$$20 \log_{10}|K| = x' \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

From this K and Z_2 follow as before.

It remains to determine Z_E. We might plot a curve of A_3 against frequency and proceed as before, putting A_4 equal to the loss required for equalization at any given frequency, but another and more convenient plan which has proved itself in practice is open to us.

The reflection loss term A_3 would be equalized when

$$\frac{(Z_0 + R)^2}{4RZ_0} \times \frac{Z_E + Z_0}{R + Z_0} = \text{a constant.}$$

Now this constant could have any one of an infinite number of values ; but a convenient value would be unity, for then there would be no resultant loss.

Hence writing

$$\frac{(Z_0 + R)^2}{4RZ_0} \times \frac{Z_E + Z_0}{R + Z_0} = 1$$

we obtain

$$Z_E = \frac{Z_0 (3R - Z_0)}{R + Z_0} \quad \ldots \quad \ldots \quad (13)$$

Since Z_2 is known, Z_4 (combination of R and Z_2 is parallel) can be calculated, and Z_3 then follows from

$$Z_3 = Z_E - Z_4 \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

A knowledge of Z_3 enables R_1 and Z_1 to be determined as will be shown later in discussing particular configurations of ladder-type equalizers.

It might appear, at first sight, that the method for dealing with the second class of equalizer involves an unusual amount of laborious calculation, and consequently the following observations may be pertinent :—

1. In any form of network design the values of components can scarcely ever be determined by a single calculation. A compromise between optimum values for different frequencies has to be struck, and several trials made before a working solution is reached. Subsequently " trimming " operations will follow, and altogether a not inconsiderable amount of computation is required.

2. Preliminary calculations of values of components need be made at two or three frequencies only, a check of performance over the whole frequency range being necessary only when these have been determined.

3. The effect of variations in the impedances composing A_4 (Eqn. 5) is relatively small, so that Z_0 and Z_E are not required with great accuracy. As standard values of Z_0 for the type of cable used are sufficient,

impedance measurements on the line actually being equalized are unnecessary.

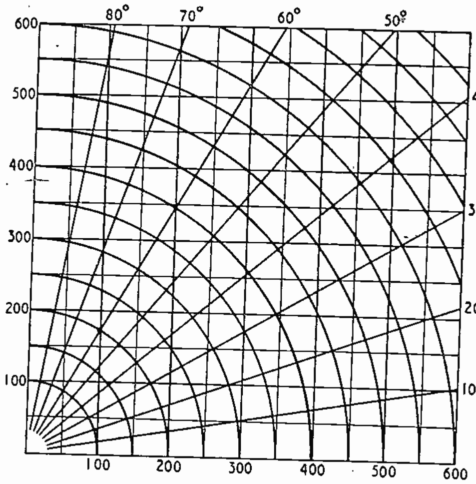


Fig. 6. *Diagram for transposing polar and Cartesian coordinates.*

Similar considerations apply to reflection losses, and it follows that once the frequency—insertion loss characteristic of the line to be equalized has been obtained the calculation of A_1 (Eqn. 5) is a simple matter.

Since Z_E need not be obtained with great precision, the calculations leading up to its determination may be much shortened by the use of a graph of the form shown in Fig. 6, which enables the transformation of impedances from polar to rectangular co-ordinates, and vice versa, to be made very readily.

The calculation of A_2 can be simplified by the use of Fig. 7 where A_2 is plotted against $|Z_2/R|$. Reference has already been made to the use of curves for determining A_4.

4. It will usually be found that several of the quantities calculated at one stage of the design reappear at another. This factor makes for further labour saving, a point which is borne out in the mathematical treatment of two forms of equalizer which are considered below as examples. For reasons already given constant-impedance conditions are ignored.

Practically speaking the simpler the equalizer the cheaper it becomes. Normally, the components must include at least one inductor, and this is by far the most expensive item. The very simple equalizer will, therefore, contain but one of the latter, and the types now to be discussed and sketched in Figs. 8 and 9 are constructed on this basis.

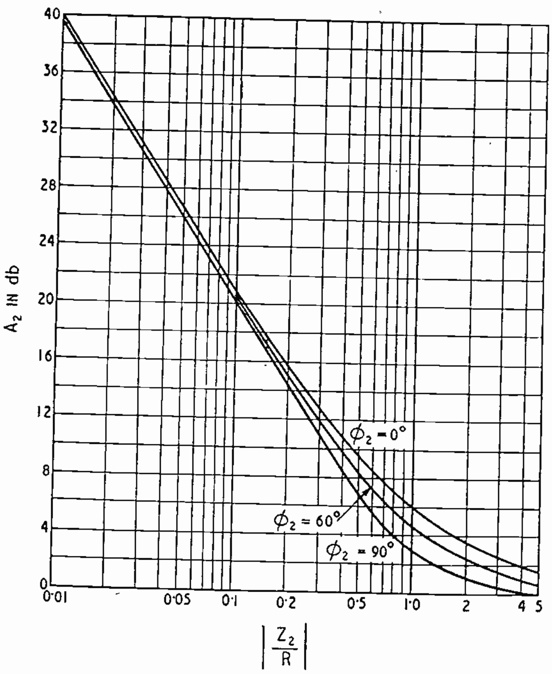


Fig. 7. *The value of A_2 in terms of $|Z_2/R|$; $Z_2 = |Z_2|\underline{/\phi_2}$.*

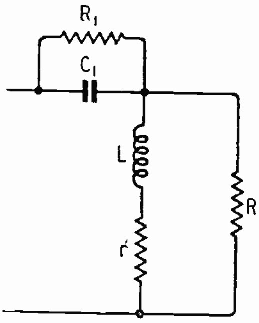


Fig. 8. *Type I equalizer.*

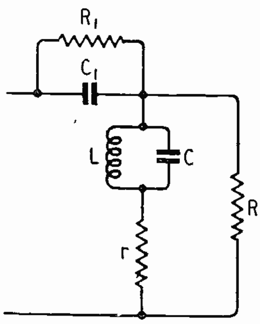


Fig. 9. *Type II equalizer.*

Type I

Here A_2 (Eqn. 5) will not be zero at f_c, so that a quantity, h (= say, 2 or 3 db) must be added to x'.

We then have

$$10 \log_{10}|K|^2 = x' + h$$

or

$$|K|^2 = \text{antilog}\frac{x' + h}{10}$$

$$= \text{M, say} \quad \ldots \quad \ldots \quad (15)$$

Again

$$K = \frac{R + Z_2}{Z_2} = 1 + \frac{R}{Z_2}$$

$$= 1 + \frac{R}{r + j\omega L} \quad [\omega = 2\pi f]$$

Hence

$$|K|^2 = \frac{(R+r)^2 + \omega^2 L^2}{r^2 + \omega^2 L^2} = M \quad .. \quad (16)$$

In this equation there are two unknowns. To effect a separation, take a very low frequency, i.e., put $\omega = 0$, and let M_0 be the corresponding valve of M.

Then $\frac{(R+r)^2}{r^2} = M_0$

and $$r = \frac{R}{\sqrt{M_0} - 1} \quad .. \quad .. \quad .. \quad (17)$$

Hence r is obtained. It includes any resistance possessed by L, though this is usually negligible in modern inductors for these networks.

L can now be calculated from (16) which gives us

$$L = \frac{\sqrt{(R+r)^2 - Mr^2}}{\omega\sqrt{M-1}} \quad .. \quad .. \quad (18)$$

Z_E is found from (13).

$$Z_4 = \frac{RZ_2}{R+Z_2} = \frac{R(r+j\omega L)}{R+r+j\omega L}$$

$$= \frac{R\sqrt{r^2+\omega^2 L^2}\ \underline{/\delta}}{\sqrt{(R+r)^2+\omega^2 L^2}\ \underline{/\gamma}} \quad \begin{array}{l}\delta = \tan^{-1}\frac{\omega L}{r} \\ \gamma = \tan^{-1}\frac{\omega L}{R+r}\end{array}$$

$$= \frac{R}{|K|}\ \underline{/\delta - \gamma} \quad .. \quad .. \quad .. \quad (19)$$

Z_3 then follows from (14)

Now $$Z_3 = \frac{R_1 \times 1/j\omega C_1}{R_1 + 1/j\omega C_1} = \frac{R_1}{1 + j\omega C_1 R_1}$$

$$= \frac{R_1}{\sqrt{1+\omega^2 C_1^2 R_1^2}}\ \overline{\diagdown \nu} \qquad \nu = \tan^{-1}\omega C_1 R_1$$

$$= R_1 \cos\nu\ \overline{\diagdown \nu} \quad .. \quad .. \quad .. \quad (20)$$

From this R_1, ν, and hence C_1 can be obtained.

If at the commencement it is clear that r will be small compared with ωL, it may be neglected in determining L which may then be found by means of Fig. 7, the curve for $\phi = 90°$ being employed, and L being calculated from the value of Z_2 ($=\omega L$ here) read off for the required value of A_2.

Type II

This is more suitable for equalizing long lines than is Type I. Moreover, with the latter A_2 can never be zero and, generally speaking, its value at f_c represents an inefficiency in the equalizer which is important in cases where the loss of the equalized circuit approaches the maximum gain of the repeaters employed. In Type II equalizers this is avoided by making L and C resonate at f_c. We then have

$$\omega_c L = 1/\omega_c C \qquad \text{where } \omega_c = 2\pi f_c$$

$$\therefore \quad C = 1/\omega_c^2 L \quad .. \quad .. \quad .. \quad (21)$$

The impedance Z_5 of L and C in parallel is

$$\frac{j\omega L \times 1/j\omega C}{j\omega L + 1/j\omega C} = \frac{j\omega L}{1-\omega^2 LC} = \frac{j\omega L}{1-\omega^2/\omega_c^2}$$

$$= j\omega L/\eta \qquad \text{where } \eta = 1 - \omega^2/\omega_c^2$$

$$= j\omega L' \quad .. \quad .. \quad .. \quad .. \quad (22)$$

where $L' = L/\eta$

Thus the LC combination can, for frequencies up to f_c, be regarded as an inductance L' which varies with frequency. From this point the mathematical treatment is as for Type I, L' taking the place of L. The resistance of the inductor is taken as negligible.

It will be noticed that here a complete break with the constant-impedance type of equalizer has been made, for in this instance the latter demands a second inductor in the series arm.

Trimming

The components lending themselves most readily to trimming alterations are, of course, r and R_1. At low frequencies the influence of the latter predominates over that of L while at higher frequencies the reverse is true so that r can be used to readjust the performance characteristic at low frequencies without appreciably affecting it at higher values, particularly in Type II equalizers. It should be noticed that increasing r does not necessarily make for a reduction in A_2 (Eqn. 5).

Increasing R_1 frequently produces a general flattening of the equalization characteristic.

With Type II equalizers better quality can often be obtained by arranging L and C to resonate at a frequency considerably in excess of f_c. This naturally tends to increase the overall circuit loss, though not to any great extent, and the problem becomes one of balancing this increase against the improvement in quality.

Practical Examples

In Figs. 10 to 12 will be found a number of measured quality curves for experimental audio circuits incorporating equalizers (shown inset in the Figs.) designed on the lines described above. In none is the constant

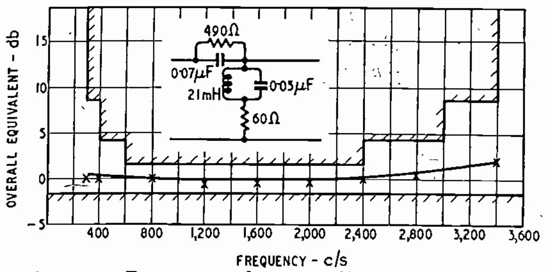


Fig. 10. *Response of* 12.7 *miles of* 20-*lb cable with the equalizer shown ;* ———— *measured,* x——x——x *calculated.*

impedance condition employed. *R* was taken as 600 /0 ohms so that the overall circuit insertion loss is here the overall equivalent. The latter has been plotted with its value at 800 c/s taken as zero, and the points indicate calculated values. In working out the designs the object was to obtain good transmission quality without excessive losses in the equalizers themselves, and with an eye to keeping the overall equivalent within normal repeater gains.

It is not to be supposed that the results are necessarily the best that could have been achieved. They are given mainly to demonstrate that the predicted quality is close to the measured values, and also to indicate the sort of quality which may be expected from very simple equalizers. The size of cable is

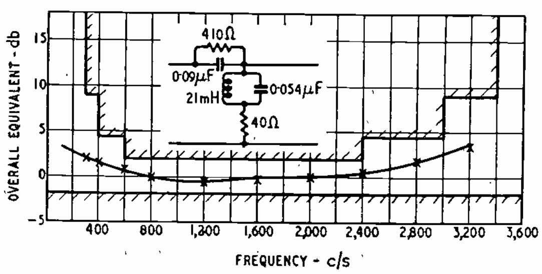


Fig. 11. *Response of* 8.85 *miles of* 10-*lb cable equalized ;* ———— *measured,* x——x——x *calculated.*

given in terms of the weight of one mile of single conductor.

Ideal equalization being impossible of attainment some practical criterion is necessary, and the quality limits of the C.C.I.F. for international 4-wire circuits suggest themselves as a convenient widely recognized standard. They are, however, not now representative of the very best practice, and in Figs. 10 to 12 the proposed new values of these limits are indicated by the shaded lines.

Fig. 14 shows the overall equivalent for an experimental equalized music circuit, the shaded lines indicating the C.C.I.F. limits for international music circuits. The circuit of the equalizer employed is shown inset.

Conclusion

It has been shown that the foregoing theoretical treatment enables an accurate prediction of equalizer performance to be made without the assumption of particular forms of equalizer being necessary, and from it a method of designing simple types of equalizer which have no special internal arrangement has been deduced. Equations

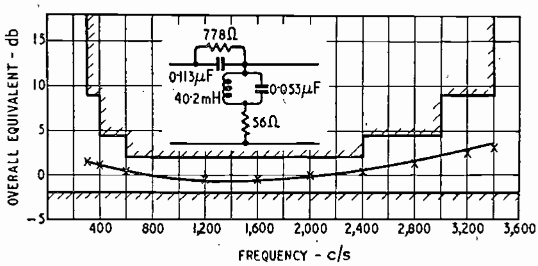


Fig. 12. 19.92 *miles of* 40-*lb cable and the equalizer ;* ———— *measured,* x——x——x *calculated.*

4 and 5 are quite general and enable the estimation of the effect of such extreme forms of equalizing network as a single capacitor or inductor connected in series or in shunt at the circuit terminal to be made, and the not uncommon simple " rejector " type of equalizer to be handled in calculations of performance. There does not appear to be any reason why they should not be applicable to other than audio and music circuits.

Equation (29)—see Appendix—is of particular interest for electrically short lines and in cases where discontinuities in the uniform distribution of electrical line constants arise.

The Author's thanks are due to the Engineer-in-Chief, Department of Posts and Telegraphs, Eire, for permission to publish this paper. He desires also to express his acknowledgements to Mr. B .O'Mongain, A.R.C.Sc.I., B.Sc., for pointing out the deduction of equation (29).

APPENDIX

Importance of Interaction Loss

Since interaction loss is a complex quantity depending on a diversity of factors, a rigorous demonstration that it is, in general, negligible for circuits requiring equalization is not possible. What can be done is to indicate general tendencies, to appeal to experience, and to cite practical examples.

Thus, if for uniform lines interaction loss is to be included, equation (5) contains an additional term, viz. :—

$$A_5 = 20 \log_{10}\left|1 - \left(\frac{Z_0 - R}{Z_0 + R}\right)\left(\frac{Z_0 - Z_E}{Z_0 + Z_E}\right)e^{-2\theta}\right|$$
$$= 20 \log_{10}|1 - W| \quad .. \quad .. \quad .. \quad (23)$$

where

$$W = \left(\frac{Z_0 - R}{Z_0 + R}\right)\left(\frac{Z_0 - Z_E}{Z_0 + Z_E}\right)e^{-2\theta}$$

Now A_5 will be negligible if W is small, and this means, in the first place, that the differences $(Z_0 - R)$, $(Z_0 - Z_E)$ must not be excessive. For several transmission reasons Z_0 and R are of the same order of magnitude, while it will be found that, in general, Z_E does not differ (or can be made not to differ) greatly from Z_0. Thus the product

$$\left(\frac{Z_0 - R}{Z_0 + R}\right)\left(\frac{Z_0 - Z_E}{Z_0 + Z_E}\right)$$

is not large.

The remaining factor is $e^{-2\theta}$ and this quantity decreases rapidly with θ; i.e., with the length of the line. In practice, for any but electrically short lines $e^{-2\theta}$ is such as to reduce W to negligible proportions.

In order to give actual figures the interaction loss of an extreme case has been calculated, and is shown plotted against frequency in Fig. 13. It is for 3 miles of 20-lb cable, which for audio circuits is on the borderline for worth-while equalizing. Values of Z_E have had to be assumed ; and since the phase angle of this quantity is usually small for the equalizers discussed above, it has been taken to be zero. R has been assumed to be $600 \underline{/0}$ ohms.

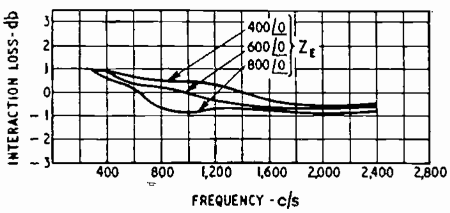


Fig. 13. *Interaction loss for several values of* Z_E.

It will be seen that even in this instance, allowance being made for variations in Z_E with frequency —normally not large—and for the fact that it is relative loss which is of importance, the effect of interaction loss on equalization is not great ; and that, if anything, it is of assistance. Moreover with short lines the total amount of equalization required is small so that adjustments to allow for interaction loss can readily be arranged. Thus even with these lines it is reasonable to design on the basis of neglecting the latter, and then, if necessary, to check back and make any alterations which calculations of interaction loss (a rather laborious process) may indicate as being desirable.

There is, however, an alternative line of attack. Referring to Fig. 3 and to the definition of terms preceding (2), let E_0 be the open-circuit voltage at the receiving end of the network N when the equalizer is disconnected, and let Z_B be the impedance looking back into the network at this point.

Then by Thévenin's Theorem

$$E_0 = I_3(Z_E + Z_B) \quad .. \quad .. \quad .. \quad (24)$$

If the network be now terminated in Z_R, the current, I_4, to the latter is

$$I_4 = \frac{E_0}{Z_R + Z_B} \quad .. \quad .. \quad .. \quad .. \quad (25)$$

Combining (24) and (25) we have

$$I_3 = I_4 \cdot \frac{Z_R + Z_B}{Z_E + Z_B} \quad .. \quad .. \quad .. \quad (26)$$

whence

$$I_2 = \frac{I_4}{K} \cdot \frac{Z_R + Z_B}{Z_E + Z_B} \quad .. \quad .. \quad .. \quad (27)$$

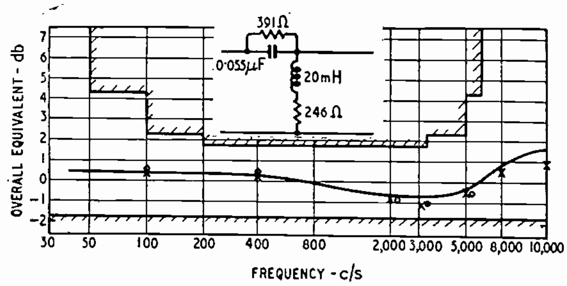


Fig. 14. *Performance of* 1.88 *miles of equalized* 10-lb *cable ;*
——— *measured,*
×——×——× *calculated A,*
⊙——⊙——⊙ *calculated B.*

The overall insertion loss of the equalized circuit is given by

$$20 \log_{10}\left|\frac{I_1}{I_2}\right| = 20 \log_{10}\left|\frac{I_1}{I_4} \cdot K \cdot \frac{Z_E + Z_B}{Z_R + Z_B}\right| \quad (28)$$

Now $20 \log_{10}\left|\frac{I_1}{I_4}\right|$ is the insertion loss of the network N for impedances Z_T, Z_R, and is therefore w (Fig. 2).

Hence

$$20 \log_{10}\left|\frac{I_1}{I_2}\right| = w + 20 \log_{10}|K| + 20 \log_{10}\left|\frac{Z_E + Z_B}{Z_R + Z_B}\right| \quad .. \quad .. \quad (29)$$

This equation is similar to (6), Z_B replacing Z_0 in the latter ; but does not require any assumption as to the magnitude of interaction loss. In (6), however, Z_0 is a quantity which, as we have already seen, can be regarded as standard for the type of line employed, whereas Z_B must be measured over the frequency range required for each particular case ; but for very short lines where interaction loss is considered to be of importance the additional labour may be worth while, and the overall performance can then readily be calculated by means of (29).

For the circuit of Fig. 14 the design was based on (29) owing to the electrical "shortness" of the line. The predicted performance as given by the latter are indicated by the points A.

As a matter of comparison the performance was also calculated by (6), the results being given by points B. It is evident that here the effect of interaction loss is inappreciable.

It is interesting to note that unlike (6) (29) does not depend upon the assumption of uniformly distributed line constants, so that it remains valid for circuits possessing discontinuities such as those produced by the insertion at intermediate points of filters and the like, or by the utilization of a combination of cable and open-wire line, etc., and is therefore of special importance in these cases.

LINEAR FREQUENCY DISCRIMINATOR*

By J. R. Tillman, Ph.D., A.R.C.S.

Introduction

IN a transmission system using frequency modulation (f.m.), the frequency of a carrier wave is modulated by the primary signal, e.g. speech, in such a manner that (a) the rate of change of frequency of the transmitted signal corresponds to the frequency of the primary signal and (b) the instantaneous carrier frequency differs from its unmodulated value (the centre frequency) by an amount proportional to the instantaneous amplitude of the primary signal. The reverse effect, the conversion of frequency- to amplitude-modulation, in the receiver of such a system, is usually carried out by means of a frequency discriminator. Among the important requirements of this section of the receiver are a conversion ratio which is high over the important range of frequencies, and low outside it, and a high degree of linearity of conversion.

The simplest frequency discriminators do not meet one or more of these requirements and are rarely used. Of the more satisfactory designs an early one has two parallel-resonant circuits, *A* and *B*, with resonant frequencies f_A and f_B so chosen that $\sqrt{f_A . f_B}$ is the centre frequency of the f.m. signals, and with equal impedances at resonance. The signals are fed to both these circuits and each is connected separately to a diode detector and d.c. load resistor. The resistors are so connected that the rectified voltages are in series opposition. The relationships between frequency and output voltage for each resonant circuit, and between frequency and net rectified output voltage, will then be as shown in Fig. 1, provided a certain calculable relationship between the magnifications (Q) of the tuned circuits and $(f_B - f_A)/\sqrt{f_A . f_B}$ has been satisfied. The central portion of the lower curve is substantially linear and when f_A and f_B are correctly chosen this linear range just embraces all the frequencies which comprise the f.m. signal.

Later designs of discriminator[1] have usually aimed at satisfying more effectively one or other of the requirements already stated. All such designs known to the author have made use of capacitance, resistance and inductance.

Because of the inclusion of inductors, the instability of the characteristics of these discriminators with changes of temperature and ageing is excessive for some purposes unless great care is taken with the design and manufacture of these particular components. The temperature coefficient of inductance of the cheaper commercial types of inductor is often as high as 2.10^{-4}/°C and is somewhat indeterminate. Moreover, the resistive components of the impedances of the inductors play a considerable part in the performance of these discriminators.

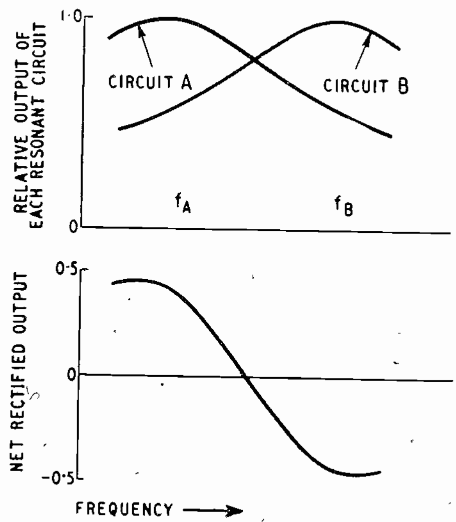


Fig. 1. *Characteristics of the discriminator based on two resonant circuits with staggered frequencies of resonance.*

That fraction of this component which is due to the copper losses has a high temperature coefficient, though the degradation of "Q," which is in some cases permissible and in others desirable, can be carried out with materials having a small and, to some extent, compensating temperature coefficient of resistance. Where the frequencies involved are low, say below 10 kc/s, iron-cored inductors are usually necessary; a new factor, the non-linearity of the in-

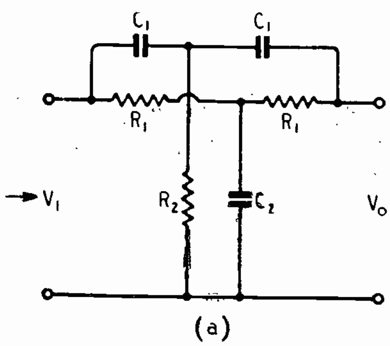
* MS accepted by the Editor, February 1946.

ductance of such components, must now be considered unless the signal level is kept very low.

A need thus exists for a discriminator which does not require the use of inductors.

Resistance-Capacitance Discriminator

Whereas the performance of the simple discriminator mentioned above is based on the shape of the response curve of a tuned



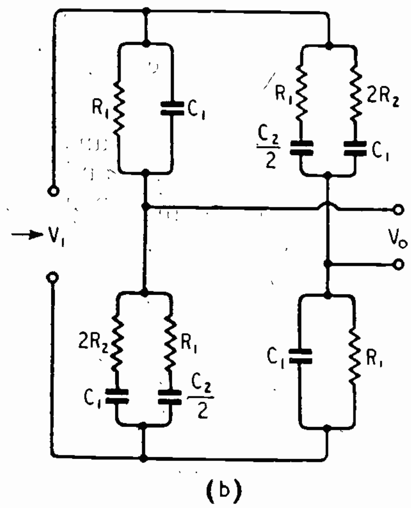


Fig. 2. *The twin-T network considered is shown at (a) and its bridge equivalent at (b).*

circuit at and near resonance, the present design[2] is based on the output *v.* frequency characteristic of the Wien bridge near the balance frequency. In this paper, however, consideration will be given primarily not to the Wien bridge but to the twin-T network of Fig. 2 (a), to which the bridge is related. The bridge equivalent of this twin-T network is given in Fig. 2 (b). This more elaborate bridge or the twin-T network can have greater sensitivity than the Wien bridge when used as a frequency bridge or meter.

The analysis of the twin-T network is simple and need not be given in full here. The conditions for balance, i.e. $V_0 = 0$ for a finite value of V_1 at a frequency $f_0\left(=\dfrac{\omega_0}{2\pi}\right)$, are given by the relationships

$$2R_1R_2\omega_0^2C_1^2 = 1 \quad \text{and} \quad \omega_0^2C_1C_2R_1^2 = 2.$$

If $R_1 = nR_2$, $C_1 = \dfrac{n}{4}C_2$. Now in practice the generator feeding the network may well have a low value of internal impedance and the detector or output voltmeter a high value. Under such conditions the output voltage at a frequency $f\left(=\dfrac{\omega}{2\pi}\right)$ is proportional to $\dfrac{\sqrt{n}}{(n+2)}$, which has a maximum value when $n = 2$*. Adopting this value of n, $R_1 = 2R_2$, $C_2 = 2C_1$ and the out-of-balance voltage V_0 at this frequency f is $\dfrac{(x^2-1)V_1}{(x^2-1)-4jx}$ where $x = f/f_0$. The modulus of this out-of-balance voltage is $+\sqrt{\dfrac{(x^2-1)^2V_1^2}{x^4+14x^2+1}}$. $V_0(x)$, $[= V_0(1/x)]$, has been evaluated (see Table) for some values of x from 0.6 to 1.66.

When $n = 2$, the four-element arms of the bridge of Fig. 2 reduce to two-element arms as shown in Fig. 3.

Electrical Properties of the Discriminator

The discriminator consists of two such twin-T networks having approximately equal values of R_1 and suitably staggered balance frequencies. The two outputs obtained after rectification, and separate and equal amplification if necessary, are qualitatively as shown in Fig. 4. Here f_1 is the centre

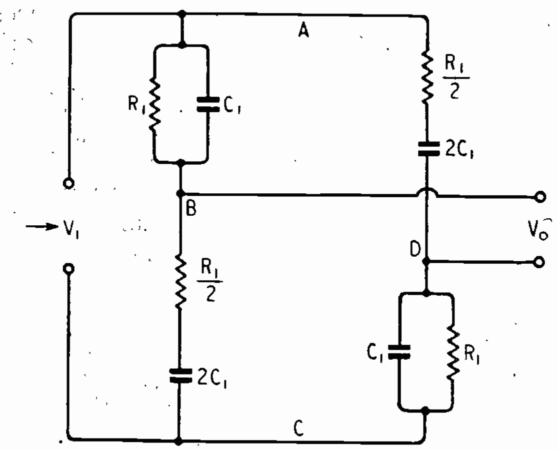


Fig. 3. *When $n = 2$, the bridge of Fig. 2 (b) reduces to this form.*

* For other conditions 2 may still be the value of n which gives a maximum value of V_0, but the expressions now quoted for V_0 no longer hold exactly.

frequency and f_1/m_0 and $m_0 f_1$ are the balance frequencies of the two networks, so chosen that the range between them is the required overall frequency band. If these outputs are placed in opposition the relationship between the differential rectified voltage, V_{DR}, and frequency is given by the full lines of Figs. 5 and 6. The scale of ordinates

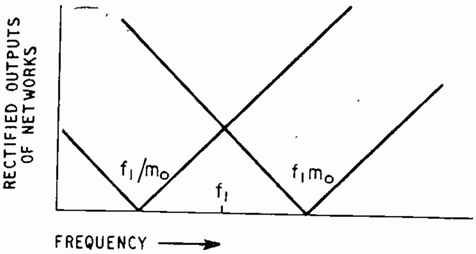
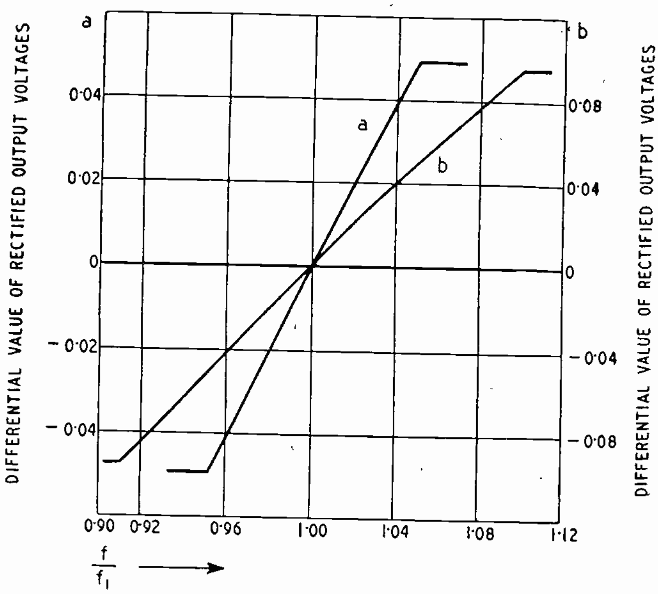


Fig. 4 (above). *Characteristics, in the form of the rectified outputs* v. *frequency, of the two twin-T networks with staggered balanced frequencies.*

Fig. 5 (right). *Output voltage* v. *frequency, response of discriminator having (a)* $m_0 = 1.05$, *(b)* $m_0 = 1.10$.



is in terms of V_1 and assumes both that an input of V_0 volts a.c. to either rectifier produces an output of V_0 volts d.c., and unity amplification. These curves express the relationship

$$V_{DR} = \left| V_0\left(\frac{m_0 f}{f_1}\right) \right| - \left| V_0\left(\frac{f}{m_0 f_1}\right) \right| .$$

The values of m_0 shown were selected arbitrarily ; their range covers most applications. The sensitivity in terms of volts output per volt input is approximately $1/f_1$ per c/s ; it is nearly independent of m_0. An inspection of the curves of Fig. 4 in the regions of $f > m_0 f_1$ and $f < f_1/m_0$ will provide the reasons for the substantial constancy of V_{DR} outside the important band.

The input impedance Z of a twin-T network, for which $n = 2$, at a frequency f is given by the expression

$$\frac{x(x^2 + 3) - j(3x^2 + 1)}{2x(x^2 + 1)} R_2.$$

For $x = 1$ this reduces to $R_2 - jR_2$. For $x = 2/3$, $Z = (1.19 - 1.21j) R_2$ and for $x = 1.5$, $Z = (0.81 - 0.79j)R_2$.

Thus Z varies only slowly with x, and the two twin-T networks of a discriminator connected, as they should be, in parallel and having a common value of R_2 present an impedance which changes only very slightly over practical ranges of f_1/m_0 to $f_1 m_0$. If for any reason the reactive component of

VALUES OF $V_0(x) = V_0(1/x)$

x	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80
$1/x$	1.667	1.613	1.563	1.515	1.471	1.429	1.389	1.351	1.316	1.282	1.25
V_0/V_1	0.258	0.241	0.225	0.209	0.194	0.179	0.165	0.151	0.138	0.125	0.112

x	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	
$1/x$	1.220	1.191	1.163	1.136	1.111	1.087	1.064	1.042	1.020	1.00	
V_0/V_1	0.099	0.087	0.075	0.064	0.053	0.042	0.031	0.020	0.010	0	

the impedance presented to the source of power must be kept small, the value of the inductance of the primary winding of the transformer or of the choke coupling the source to the load should so be chosen as to effect considerable neutralization of this otherwise large capacitive component.

A Refinement

The universal requirement of the discriminator of any f.m. receiver is that its output signal should reproduce faithfully the signal which modulates the f.m. oscillator of the transmitting station. If this latter unit generates an instantaneous frequency whose deviation from the centre frequency is strictly proportional to the instantaneous magnitude of the applied signal, the discriminator should, ideally, give an output whose magnitude is strictly linear with frequency. The characteristics represented by the full lines of Figs. 5 and 6 are more nearly linear with log f than with f, a feature which is perhaps more evident with large values of $(m_0 - 1)$. If simple additional networks are used, however, the linearity against f can be vastly improved. When the arrangement of Fig. 7 is used and the

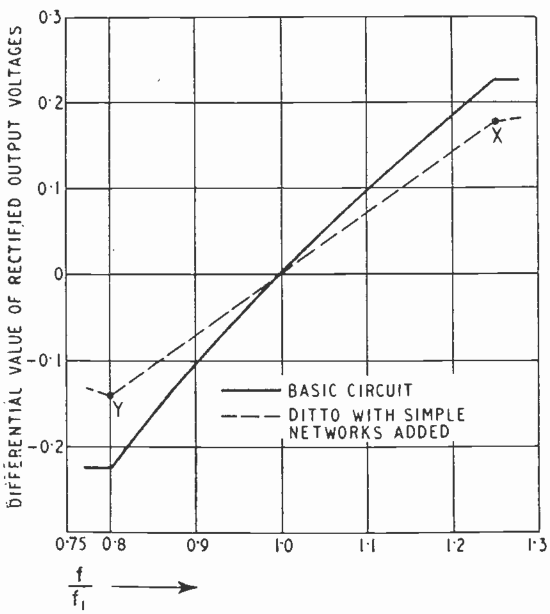


Fig. 6. *Response of discriminator having* $m_0 = 1.25$.

relationships $R_3 \gg R_1$ (of the main networks) and $2\pi f_1 R_3 C_3 = 1$ are satisfied, the broken curve of Fig. 6 can be obtained. The section of this curve between X and Y nowhere departs from the straight line joining X and Y by more than 0.4 per cent of the vertical ordinate at X. It will be seen that the sensitivity is reduced by about 30 per cent for this value, 0.25, of $(m_0 - 1)$. It is not

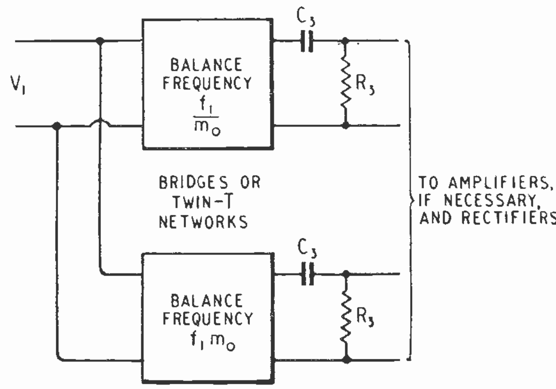


Fig. 7. *The linearity is improved by using the additional networks* R_3C_3.

apparent from a casual inspection of the relationship which this curve represents, namely

$$V_{DR} = \frac{|V_0(m_0 f/f_1)| - |V_0(f/m_0 f_1)|}{\{1 + (f_1/f)^2\}^{\frac{1}{2}}},$$

that such a high degree of linearity will result. But if, in the expression for V_0, $4.05\,x$ is substituted for $\sqrt{x^4 + 14x^2 + 1}$ which it equals to within ± 1.2 per cent over the range $x = 0.64$ to 1.56 concerned here, the expression

$$4.05\,V_{DR} = \frac{\left\{\dfrac{(m_0 f/f_1)^2 - 1}{m_0 f/f_1} - \dfrac{1 - (f/m_0 f_1)^2}{f/m_0 f_1}\right\}}{\{1 + (f_1/f)^2\}^{\frac{1}{2}}} V_1$$

is obtained. From this it can be deduced that

$$V_{DR} \propto (f/f_1 - 1)\sqrt{\frac{f/f_1 + \frac{1}{4}(f/f_1 - 1)^2}{f/f_1 + \frac{1}{2}(f/f_1 - 1)^2}}.$$

The term involving the square-root sign differs from unity by less than 0.7 per cent for any value of f/f_1 between 0.8 and 1.25.

The same high degree of linearity results from the use of one such additional network suitably fitted to the input circuit common to the two main networks. High linearity can also be obtained if one twin-T network is followed by a CR network (connected similarly to Fig. 7), for which now $2\pi f_1 C_3 R_3$ should be $\ll 1$, and the other twin-T network by a high value resistive potentiometer which reduces the output at all relevant frequencies, in the ratio $1 : 2\pi f_1 C_3 R_3$. The sensitivity is clearly much reduced in this case, however.

If the relationship between the instantaneous frequency of the f.m. oscillator and the input level is other than a linear one, the departure from linearity being known, high fidelity may still be possible with the use of other correcting networks.

Practical Details

The RC discriminator presents few problems in practice. The resistive components of the impedance of the capacitors and the reactive components of that of the resistors are normally negligible. Stray capacitances from the junction of C_1 and R_2 to earth (see Fig. 2 (a)) should be kept to a minimum: their presence involves slight changes in the values of R_2 and C_2 required to ensure balance at the calculated frequency f_1/m_0 or $m_0 f_1$ and modifies slightly the relationships connecting V_0 and f. The values of R_2 and C_2 should be controllable over small ranges.

Maintenance is simple. Initially and at long intervals R_2 and C_2 of each network should be adjusted so that zero output is obtained from the network concerned at the appropriate balance frequency. The gain of the amplifier following one network should then be adjusted to make V_{DR} zero at f_1. For normal maintenance this latter adjustment is all that is needed. For, besides dealing with changes of amplifier gain, it can be used to counteract any small change of the frequency at which $V_{DR} = 0$ resulting from small changes of either balance frequency. The change of the slope of the characteristic which accompanies this counteraction is small.

Discussion

The output-frequency characteristic of this discriminator does not show any falling off outside the wanted range; this deficiency should be rectified by the fitting of a suitable filter network to the input circuit to the discriminator.

The sensitivity is low, particularly for small values of $(m_0 - 1)$; additional amplification will overcome this defect.

To offset these disadvantages the discriminator has the following important advantages. The upper limit of V_1 is set only by the permissible rise of temperature of the resistors R_1 and R_2 or the breakdown voltages of the capacitors C_1 and C_2. Power inputs of 0.1 — 1.0 W, such as are obtainable from small receiving valves, are usually permissible; with such power inputs the final output V_{DR} may be adequate without the additional amplification suggested in the previous paragraph. Levels of input as high as these are not normally practicable with discriminators using iron-cored inductors; indeed 1 mW may then be the maximum permissible, consistent with a performance which is independent of level.

The linearity is good over the whole required range of frequency. The use of simple additional networks makes this characteristic excellent even for wide-band units.

There are good prospects of making the performance substantially independent of temperature (T). Because each network consists of several components, there are numerous relationships between the temperature coefficients of the important characteristics of these individual components which will ensure that the balance frequency of such a network is independent of T; i.e., $\dfrac{\delta f_0}{\delta T} = 0$. The easiest to aim at is probably

$$\frac{\delta C_1}{\delta T} = \frac{\delta C_2}{\delta T} = -\frac{\delta R_1}{\delta T} = -\frac{\delta R_2}{\delta T}.$$

To-day this can be done to such an extent that the magnitude of $\dfrac{\delta f_0}{f_0 \,.\, \delta T}$ need be $\not> 4.10^{-5}/°C$, without recourse to other than mass produced components. Moreover the physical sizes and the thermal capacities of these components are small.

Nearly all that has been said of the twin-T network with $n = 2$ applies to the equivalent bridge (Fig. 3). The main exception concerns the points of the networks from which stray capacitance to earth should be minimized and stabilized. Referring to Fig. 3, the point D should be earthed and earth capacitance to A kept at a low value. R_1 and C_1 in the arm CD should be made controllable. A transformer having two separate equal secondary windings, each screened and balanced with respect to earth should be used to connect the source of signals to the two bridges involved.

Since analysing and testing these types of discriminator and writing this description, I have noted that the Philco Radio and Television Corporation of the U.S.A. and Albright have patented [3] various discriminators primarily connected with the bridge-T network having for its shunt arm an inductor of high "Q". Such a network has high sensitivity near its balance frequency. A subsidiary claim covers the network of my Fig. 2 (a), with $n = 2$; its use cannot therefore here be claimed to be novel. The patent specification includes little description of the discriminator using this RC network beyond the statements that the sensitivity is rather low and the components inexpensive.

REFERENCES

[1] Sturley gives some examples in *Journ. I.E.E.*, Vol. 92, p. 197 (1945); Hazeltine Corp. and H. A. Wheeler, Brit. Pat. 507,619; R. O. Carter, Brit. Pat. 570,478.

[2] Brit. Prov. Pat. Spec. 30477/45 and 2800/46.

[3] Brit. Pat. 571,314.

CORRESPONDENCE

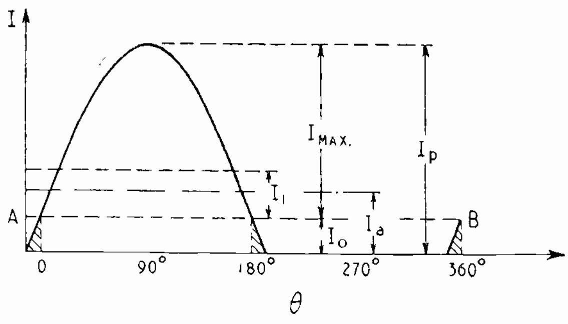
Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Peak Pulse Currents in Class B Amplifiers

To the Editor, "Wireless Engineer"

SIR,—In Class B operation it is often necessary to estimate the peak pulse anode current taken by the valve. If it is assumed that the $I_a V_g$ characteristic of the valve (or valves) is linear and that the latter is biased to zero anode current, the peak pulse anode current is simply π times the direct anode current when sinusoidal excitation is applied to the grid, because the anode current waveform is that of a half-sine wave. This ignores the "standing feed" always present in the practical case. It is, of course, possible to obtain a more accurate result by assuming a "standing feed" and employing Fourier analysis of the resultant wave. A simpler method, only slightly less accurate than the Fourier analysis for normal practical cases, where the peak pulse anode current is much greater than the standing feed, was developed by the writer and it may be of interest to others engaged upon Class B problems.

Let us consider a Class B stage having a valve (or valves; two in push-pull are necessary for a.f. but not for r.f. amplification) with linear $I_a V_g$ characteristics and a standing feed of I_0 amps. The wave shape of the resultant current pulse for sinusoidal excitation is slightly greater than a half-sine wave as shown in Fig. 1. The following components of the anode current wave are important:



I_{max} = peak value of the current pulse above the standing feed value I_0; i.e., the peak value of the half-sine wave part of the current pulse.

I_a = direct current taken by the valve when supplying the current pulse.

I_1 = direct current corresponding to the half-sine wave of current above AB.

I_p = peak pulse current value $= I_0 + I_{max}$.

Since the wave above AB is a half-sine wave

$$I_1 = \frac{I_{max}}{\pi}$$

If the shaded area outside the 0° and 180° positions of the wave is neglected (this assumes that I_p is large compared with I_0) the d.c. component contributed over a complete cycle by the standing feed is $\frac{1}{2}I_0$, and the total current $I_a = I_1 + \frac{1}{2}I_0$

$$= \frac{I_{max}}{\pi} + \tfrac{1}{2} I_0$$

or $I_{max} = \pi(I_a - 0.5\, I_0)$

The peak value of the anode current pulse

$$I_p = \pi(I_a - 0.5\, I_0) + I_0$$
$$= 3.14\, I_a - 0.57\, I_0.$$

Evesham. K. R. STURLEY.

Time-base Converter and Frequency-divider

To the Editor, "Wireless Engineer"

SIR,—In his letter published in the May 1946 issue of *Wireless Engineer*, Dr. Moss calls for an explanation of what he is pleased to describe as the discrepancy between theoretical reasoning and the results shown in the photographs published by us indicating the high degree of linearity obtainable by using the signal converter as the time-base valve in an oscillograph.

The explanation is that there is, in fact, no such discrepancy, except in so far as Dr. Moss made an error in his theoretical reasoning. It is true that, if a resistance of ten megohms is placed parallel to the deflector plates of the c.r. tube and the capacitor across which the time-base potentials are produced, then, assuming a constant charging current (signal-converter output-electrode current) of 50 μA, and a time-base output potential of 200 volts, the linearity error is 20 per cent.

However, the internal "leak" of a c.r. tube is not a pure ohmic load shunting the deflector plates. Dr. Moss makes a mistake when he thus refers to the deflector-plate characteristic in *Wireless Engineer*, August 1941, Fig. 1, because this characteristic shows that the leak due to secondary electrons increases relatively slowly when the potential of the deflector plate is increased above +10 volts relative to the final-anode potential. Thus, although the effective impedance of the tube for which these characteristics are given is less than 10 megohms when the deflector plate is 10 volts positive to final anode, it is evidently greater than 10 megohms when the deflector plate is 100 volts positive.

Now linearity of a time base means the constancy of the time-base velocity, which is proportional to the charging current. Thus, if the charging current is, say, 50 μA, and the "leak" is 1 μA, the linearity error is 2 per cent. The tube for which the characteristics are given in Fig. 1 of the article by Dr. Moss in the August 1941 issue is much inferior to the tubes which are obtainable at the present time. We are employing in our oscillograph a commercial tube (VCR 112 or CV 1112) wherein no special screens or other precautions are employed for the collection of secondary or stray primary electrons. Nevertheless, we found that the current collected by the X-deflector plates (nearest the fluorescent screen), even when 100 volts positive relative to final anode, is less than 1 per cent of the beam current, or about 0.25 μA, when the beam current is 30 μA. This gives a maximum linearity error of 0.5 per cent in our time base due to this cause.

Also a signal converter negative output electrode current of 50 μA is the lowest limit: at the usual beam current value, 0.5 mA, the error of linearity is only 0.05 per cent.

Our calculations in Appendix I in the September 1945 issue of *Wireless Engineer*, naturally refer only to leaks which have an ohmic character.

The false conception of Dr. Moss is mainly due to the blind acceptance of the "axiom of cathode-ray tube work that the deflector-plate driving-source impedance should be kept low." This is an established principle (but by no means a self-evident truth) because, when conventional valves are used, it is not possible to eliminate ohmic resistances of the order of 1 megohm shunting the time-base capacitor.

The necessity for a low-impedance time-base generator input is very real in the case of the split-deflector plate double-beam c.r. tube to which Dr. Moss refers in the latter part of his August 1941 article, as the leakages are considerable due to the interception of the primaries by the splitter plate. A superior solution is the employment of two separate gun systems, as the interaction of the two deflection systems is hardly avoidable in the split type, unless the parallel impedances are very low, with proportional increase of the wattage requirements.

The fact that the load of the signal converter can be wholly reactive is a major advantage, not a "drawback." As we were at pains to explain in our previous publications, the ideal time base *requires* a pure reactive load; only then can true linearity be achieved at high time-base frequencies. This is why the 200 kc/s time-base trace, reproduced in Dr. Moss's letter, shows a linearity error of 30 per cent.

Regarding our previous statement that "When the frequency is such that the capacitances are of the order of the resistances, synchronization is unreliable and the linearity of the scan is destroyed," we agree that the word "synchronization" was inaccurate. We had the "semi-direct driven" time base in mind, which we employ in the oscillograph described in the September and October 1945 issues of *Wireless Engineer*.

Our previous statement that "the signal converter is superior to conventional valves because two parameters are available—the intensity of the beam current and the position of the beam," Dr. Moss considers a doubtful advantage. Surely, if there is no interaction between the various networks which control the modulation of the beam intensity and the various deflector plates, the greater range of application is an advantage without drawbacks. In the conventional intensity-modulated valve, interaction between the control grids is unavoidable; this is not the case in a deflection-modulated cathode-ray valve.

It is not for us to state whether we have "succeeded in establishing any great superiority in time-base technique as a result of the use of the signal converter." But we should like to say that some impartial opinions are more encouraging than those of Dr. Moss.

We quite agree that the huge list of valve types at present in use should be reduced. Ultimately, perhaps, a score of intensity-modulated valves, a score of deflection-modulated types, and some velocity-modulation types, etc., should satisfy the optimum requirements of the circuit engineer.

London, W.1. P. NAGY
M. J. GODDARD

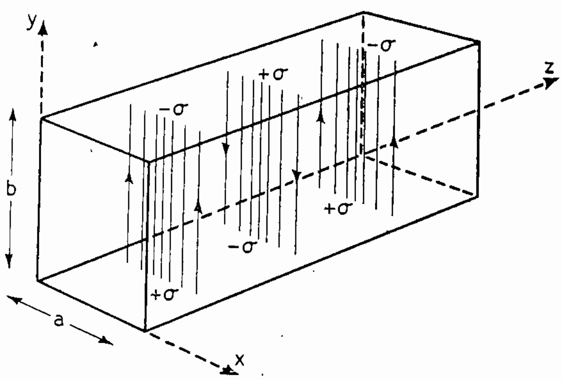
Anomalous Attenuation in Waveguides

To the Editor, The Wireless Engineer

SIR,—In reading Mr. Kemp's interesting paper in your August issue, I was struck by a passage which, if torn from its context, might appear very anomalous. It is on p. 213:—

"The first term is due to currents induced in the top and bottom walls by the tangential magnetic intensities H_x and H_z. . . . currents induced in the side walls. These are due to the longitudinal magnetic field H_z only; for H_x, being perpendicular to the side walls, is prevented from setting up currents in them."

Now all our experience of purely magnetic fields (e.g., the consideration of eddy-currents in the core of an iron-cored transformer) is exactly the reverse of the above, namely that the current in a conductor is proportional to the component of magnetic flux perpendicular to the plane in which the current flows, and some explanation is therefore needed of the different phenomenon occurring in the wave-



guide. The easy answer is to refer to the equations of the *electromagnetic field* (not to components of magnetic intensity) and correct mathematics will then give the correct answer. But there are advantages in a "pictorial" type of presentation, and the writer would therefore like to ask whether there are any fallacies in the following qualitative explanation, or alternatively whether this method can be worked out quantitatively.

First, we can dispose of the magnetic field perpendicular to the side walls by pointing out that at the boundary surface the field is always tangential: at the cut-off frequency (Fig. 6 of the paper) this is obviously so, and at higher frequencies (Fig. 5) the component H_x curves round and becomes H_z before reaching the boundary surface. Then we proceed to deduce the electric currents in terms of the *electric* component of the electromagnetic field. The lines of electric intensity, which form " cores " to the rings of magnetic flux, will in the mode under consideration form a pattern of the type shown in the accompanying figure. (The electric field does, of course, extend over appreciable distances along the Z axis, but for the sake of clarity only sections through the planes of maximum electric intensity have been drawn in the figure.) These lines of electric intensity must terminate, both at the top and the bottom, in surface charges $\pm\,\sigma$ on the boundary conductors, and as the field reverses cyclically so these charges must reverse in polarity. Clearly this can be effected by interchange of charges both between adjacent positive and negative areas on the same surface and between positive and negative areas on the two boundaries at opposite ends of a given group of lines of electric intensity. The first interchange requires currents in the top and bottom walls only, and the second currents in the side walls, each with accompanying energy dissipation.

The magnitude of the surface charges depends only on the magnitude of the component E_y, but the current involved in the movement of these charges is inversely proportional to the time available for the interchange ($i = dq/dt$) and therefore directly proportional to the frequency; and on this account the dissipation, i^2R, would tend to increase with the square of the frequency. However, at frequencies far above the cut-off frequency the wavelength is approximately inversely proportional to the frequency, so that the separation between adjacent charges of opposite sign (and therefore the path of the current) in the top and bottom walls is decreasing with increasing frequency. Hence the component of energy loss due to eddy currents in the top and bottom walls is, so far, increasing less rapidly than the square of the frequency. But in the meantime, the shortening of the current paths in the top and bottom walls will tend to cause a greater proportion of the interchange of charges to take place along the top and bottom, and less along the side walls in which the path length is independent of frequency. Hence the losses in the side walls will decrease with rising frequency, although in a guide of fixed dimensions the rate of increase of total attenuation is of the order of proportionality to the square of the frequency.

It follows that at infinite frequency all the losses would be in the top and bottom walls, but they would be eliminated if one could avoid terminating the component E_y in surface charges on a conducting boundary. The obvious method of doing this is to extend the dimension b very greatly, and then curve the cross-section into an annulus so that the original E_y becomes a continuous circumferential component, and one can then derive the circular guide by letting the inner radius of the annulus tend to zero.

D. A. Bell

London, N.21.

Pulse Modulation

To the Editor, " Wireless Engineer."

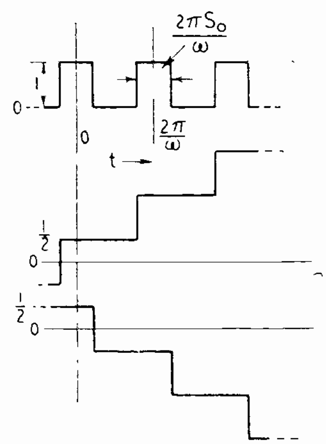
SIR,—In spite of the discussion on this subject in your correspondence columns since the article by Roberts and Simmonds in November 1945, there appears to be still some doubt as to the formulae for the various types of modulated pulse waveforms. Apart from the confusion of definitions for the different types of modulation, there are discrepancies between the " exact " formulae produced by different writers.

The purpose of this note is to point out that all types of modulated pulse trains with constant amplitude pulses can be represented by a single general formula, from which formulae for particular types of modulation can easily be derived as special cases.

Modulated pulse trains differ from unmodulated trains in the positions, in time, of the leading or trailing edges, or both, of the pulses. Usually the time displacements of the leading and trailing edges are related in a simple way, but it is convenient to consider the general case in which the modulations of leading and trailing edges are unrelated.

Any pulse train, modulated or unmodulated, consisting of constant amplitude pulses with vertical sides (it is convenient to take the amplitude as unity), may be regarded as the sum of two stepped waves or staircases, the first of which is a positive or ascending staircase, with positive steps of unit height occurring at the positions of the leading edges of the pulses; while the other staircase has negative steps, also of unit height occurring at the positions of the trailing edges of the pulses.

Consider an unmodulated pulse train with a repetition frequency $\omega/2\pi$ per second, and pulse width $2\pi S_0/\omega$. The zero of the time scale, which is arbitrary, may be taken at the centre of a pulse. The ascending staircase corresponding to the leading edges may have the arbitrary value $\frac{1}{2}$ at $t = 0$ and increase by 1 at the times $2\pi/\omega - \pi S_0/\omega$, $4\pi/\omega - \pi S_0/\omega$, etc., remaining constant between steps, while the descending staircase, corresponding to the trailing edges, is equal to $\frac{1}{2}$ at $t = 0$ and decreases by 1 at the times $\pi S_0/\omega$, $2\pi/\omega + \pi S_0/\omega$, etc. It is easily shown that the equation to the ascending staircase is



$$\frac{S_0}{2} + \frac{\omega t}{2\pi} + \sum_{k=1}^{\infty} \frac{1}{\pi k} \sin k\,(\omega t + \pi S_0) \qquad \ldots \quad (1)$$

Suppose now that the positions of the leading edges, and thus of the staircase steps, are modulated by a signal $f_1(t)$ in such a way that the time displacements of the edges from their unmodulated positions are proportional to the values of $f_1(t)$ at the times at which the steps take place; e.g., a step which in the absence of modulation occurs at time t_1 now occurs at $t = t_1 - \delta t$, where $\delta t = \phi_{max} f_1(t)/\omega$, ϕ_{max} being the phase deviation and ϕ_{max}/ω the time deviation when $f_1(t) = 1$. The equation to the modulated staircase is then obtained by writing $t + \phi_{max} f_1(t)/\omega$ in place of t in expression (1), and it can be seen that this transformation satisfies the condition for the position of the pulse edges, laid down in the previous sentence, at every step in the staircase, and also, of course, gives a constant value to the staircase between steps.

The equation to the unmodulated descending staircase is

$$\frac{S_0}{2} - \frac{\omega t}{2\pi} - \sum_{k=1}^{\infty} \frac{1}{\pi k} \sin k (\omega t - \pi S_0)$$

If the trailing edges are modulated by a different signal $f_2(t)$ so that the time displacements are equal to $\phi_{max} f_2(t)/\omega$, then the equation to the modulated staircase is obtained by writing $t + \phi_{max} f_2(t)/\omega$ for t. The equation to the complete pulse train, obtained by adding the expressions for the two modulated staircases, is

$$S_0 [1 + A \{f_1(t) - f_2(t)\}/2]$$
$$+ \sum_{k=1}^{\infty} \frac{2}{\pi k} \sin k\pi S_0 [1 + A \{f_1(t) - f_2(t)\}/2] \cos k [\omega t + \pi A S_0 \{f_1(t) + f_2(t)\}/2]$$

in which $A = \phi_{max}/\pi S_0$. . .. . (2)

From this general formula the equation for any particular type of pulse modulation may be obtained by assigning appropriate values to $f_1(t)$ and $f_2(t)$.

For the type of "symmetrical" pulse-length modulation generated by the usual sliced saw-tooth type of modulator $f_2(t) = -f_1(t)$, and expression (2) becomes identical with equation (6) of Roberts and Simmonds when $f_1(t) = \cos pt$.

When the phase of the repetition frequency generator is modulated, $f_2(t) = f_1(t)$ and if $f_1(t) = \sin pt$ expression (2) becomes equal to equation (7) of Roberts and Simmonds, which, however these authors describe as "delay modulation."

For modulation of the leading pulse edges only, $f_2(t) = 0$, while for modulation of the trailing edges only, $f_1(t) = 0$. In the general case of a symmetrical pulse-length modulation $f_2(t) = -bf_1(t)$ where b is a positive constant.

An important case is that in which the time duration of each pulse is constant and equal to the unmodulated value $2\pi S_0/\omega$, and the position of the pulse is varied by the modulating signal (pulse-position modulation). In modulators producing this type of pulse train, the position of the leading edge is determined by the modulating signal, and the trailing edge is generated automatically therefrom by a pulse forming network giving a constant time delay. The condition of constant pulse length is obtained by writing

$$f_2(t) = f_1(t - 2\pi S_0/\omega)$$

A more convenient expression is obtained by assuming that the positions of the pulse centres are modulated by $f(t)$ and that

$$f_1(t) = f(t + \pi S_0/\omega) \qquad f_2(t) = f(t - \pi S_0/\omega)$$

This is equivalent to the trivial change of imposing a time advance of $\pi S_0/\omega$ on the modulating wave.

On substituting these values for $f_1(t)$ and $f_2(t)$ in the general formula, and writing $f(t) = \sin pt$, the expression for the pulse train becomes, after expansion in terms of Bessel functions,

$$S_0 + \frac{\phi_{max}}{\pi} \sin (\pi S_0 p/\omega) \cos pt$$
$$+ \sum_{k=1}^{\infty} \sum_{n=-\infty}^{\infty} \frac{2}{\pi k} J_n (k\,\phi_{max}) \sin \pi S_0 (k + np/\omega) \cos (k\omega + np)t$$

In this particular example the calculation is most conveniently carried out by resolving the general formula back into its two staircase components.

On comparing this expression with that given by Mr. Fitch in your August issue, there is seen to be agreement between the first two terms, but a considerable discrepancy in the last group of terms. It is difficult to say at what point the difference arises, since Mr. Fitch does not explain how his formula is derived or on what assumptions the derivation is based. No doubt the matter will become clearer when Mr. Fitch's full analysis is published.

Research Laboratories of the General Electric Co., Ltd., Wembley. A. S. GLADWIN

[Mr. Gladwin asks us to add that since the above was written his attention has been drawn to reports by Dr. A. Bloch on various types of pulse modulation in which a formula similar to (2) was deduced by another method, which also used the argument of a transformation of the time scale.—ED.]

To the Editor, "Wireless Engineer."

SIR,—In reviewing my letter in the August issue, I noticed the following omission :

The letter ν should multiply the quantity πS in the last two equations given in the appendix. These equations should therefore read

$$e = S + 2/\pi \sum_{v=1}^{\infty} \left[1/\nu \sin (\nu\pi S) \right] \cos \nu\omega t$$

and

$$e(S, \theta) = S + 2/\pi \sum_{\nu=1}^{\infty} \left[1/v \sin (\nu\pi S) \right] \cos \nu\theta.$$

Although this error is unfortunate, it does not affect the arguments or results of my previous communication in any way.

E. R. KRETZMER.
Massachusetts Institute of Technology,
Cambridge, Mass., U.S.A.

BOOKS RECEIVED

An Index of Mathematical Tables by A. Fletcher, M.A., Ph.D., J. C. P. Miller, M.A., Ph.D., and L. Rosenhead, Ph.D., D.Sc. Published by Scientific Computing Service Ltd., 23, Bedford Sq., London, W.C.1. Pp. 450 + viii. Price 75s.

CORRECTION

In "Anomalous Attenuation in Waveguides," which appeared in *Wireless Engineer* for August 1946, p. 211, the drawings of Figs. 8 and 11 were interchanged. The captions are correct for the figure numbers, but not for the drawings above them. In addition, the symbol θ on both drawings should be ϕ.

WIRELESS PATENTS

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

576 197.—Arrangement of spaced microphones for indicating the level of volume and reverberation in an auditorium, particularly for monitoring the reproduction of sound films.

H. W. Hastings-Hodgkin and Tickford Ltd. Application date 25th April, 1944.

576 322.—Flexible rod-aerial for a motor-car, arranged to be operative either when the free end is erect, or when it is anchored to lie parallel with the roof of the car.

A. F. Burgess (communicated by Zenith Radio Corp.). Application date 21st February, 1944.

576 344.—Circuit for detecting the presence of conducting bodies in an opaque mass of insulation, or any asymmetry of the coaxial wire relatively to its sheath in a cable.

Marconi Instruments Ltd., W. B. Bartley and C. F. Brockelsby. Application date 17th January, 1944.

576 349.—Magnetic system forming a gap of inverted-T shape for minimizing distortion in a gramophone pick-up of the moving-coil type.

Radio Gramophone Development Co. Ltd. and S. T. Bolus. Application date 7th February, 1944.

AERIAL AND AERIAL SYSTEMS

576 159.—Directive aerial of the helical type, wherein the wire forming the larger helix is first wound into a spiral of smaller diameter and pitch [addition to 573 896].

Marconi's W.T. Co. Ltd. and C. S. Franklin. Application date 4th December, 1942.

576 360.—Highly-aperiodic short-wave aerial comprising two parallel strips of metal, connected to form a narrow loop by parabolic end-pieces, the feed-line being connected to a centre gap in one of the strips.

Soc. Anonyme des Industries Radio-Electriques. Convention date (France) 28th March, 1941.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

576 103.—A.V.C. circuit, utilizing an amplifier as an impedance-transformer, in a receiver for pulsed signals, as used in radiolocation.

The General Electric Co. Ltd. and E. C. Cherry. Application date 18th December, 1942.

576 154.—Selecting and then permanently holding the sensitive point-contact between a catswhisker and a rectifying crystal for very-short waves.

Sperry Gyroscope Co. Inc. (assignees of F. S. Salisbury). Convention date (U.S.A.) 19th May, 1941.

576 158.—Time-base circuit for a C.R. tube designed to show two discrete traces against scanning-sweeps of different speeds.

Cinema-Television Ltd. and S. S. West. Application date 17th November, 1942.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception.

576 204.—Cathode-ray tube designed to facilitate the viewing of a televised picture at an angle to the fluorescent screen and to the main axis of the scanning stream.

Cinema-Television Ltd. and T. M. C. Lance. Application date 26th April, 1944.

576 277.—Amplifier with negative feedback for offsetting the attenuation of the higher frequencies when receiving a wide band of signals as in television.

Marconi's W.T. Co. Ltd. (assignees of O. H. Schade). Convention date (U.S.A.) 20th January, 1943.

TRANSMITTING CIRCUITS AND APPARATUS

576 145.—Variable-attenuating device for a wave-guide, consisting of a resistive septum or plate adjustably spaced from one of the longitudinal walls of the guide.

Western Electric Co. Inc. Convention date (U.S.A.) 7th May, 1943.

576 147.—Conical coupling-device for connecting two coaxial cables, of unequal outer diameters, transmitting waves of the order of 10 cm.

The General Electric Co. Ltd. and R. J. Clayton. Application date 19th April, 1941.

576 152.—Symmetrical "neutrodyning" arrangements for the electrodes and mountings of high-powered short-wave amplifiers.

Soc. Française Radio-Electrique. Convention date (France) 27th February, 1941.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

576 003.—Spacing and construction of the electrostatic lens-assembly of an electron microscope.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 1st December, 1942.

576 085.—Screw-thread type of attachment between the re-entrant glass tube and the electrode system of a thermionic valve.

The M-O. Valve Co. Ltd. and L. R. E. Windsor. Application date 12th January, 1942.

576 096.—Magnetron oscillator in which permanent magnets are arranged to allow for varying the intensity and direction of the control-field.

The General Electric Co. Ltd. and E. M. Hickin. Application date 21st September, 1942.

576 121.—Regulating the drift-time of the electrons in a velocity-modulation tube for handling centimetre waves.

B. J. Mayo. Application date 8th August, 1941.

576 126.—Arrangement of the hollow resonator and reflecting electrodes in a rhumbatron device for handling centimetre waves.

B. J. Mayo. Application date 8th August, 1941.

ABSTRACTS AND REFERENCES

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

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

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ACOUSTICS AND AUDIO FREQUENCIES

534.131 **2791**

Reflection and Refraction of Non-Stationary Elastic Waves.—Gogoladze. (*See* 2862 & 2864.)

534.131 **2792**

On Rayleigh Boundary Waves.—Gogoladze. (*See* 2863.)

534.231 **2793**

The Sound Field of Moving Sound Sources.—M. F. Shirokov. (*C. R. Acad. Sci. U.R.S.S.*, 10th Dec. 1945, Vol. 49, No. 7, pp. 494–496. In English.) An attempt to find "a new solution of the differential equations of acoustics with sources moving in the medium."

534.321.9 **2794**

On Method in Supersonic Absorption Measurements.—E. J. Pumper. (*C. R. Acad. Sci. U.R.S.S.*, 20th Dec. 1945, Vol. 49, No. 8, pp. 558–560. In English.) A new method of measurement is described in which an acoustic tone-modulated transmitter of supersonic radiation (quartz crystal) is used with a microphone membrane as receiver. The microphone output contains a modulation-frequency component, of amplitude proportional to the square of the intensity of the incident supersonic wave, which gives a measure of the absorption in the liquid or gas interposed between transmitter and receiver.

534.43 : 621.395.61 **2795**

Improved Modulated - Oscillator [gramophone] **Pickup.**—H. Kalmus. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 182..186.) Improved version of the pickup circuit described in 1154 of May (Kalmus). Audio output is increased by 15–20 db, noise is reduced in the same ratio, and microphonics are reduced by 6 db.

534.43 : 621.395.61 : 621.396.619.018.41 **2796**

Simplified Frequency Modulation [applied to gramophone pickup].—Bruck. (*See* 2853.)

534.7 : 621.395.645 **2797**

Auditory Perception.—J. D. Goodell & B. M. H. Michel. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 142–148.) An inverse volume-expansion circuit for automatic tone control is described. It compensates for changes in the response of the ear at different intensity levels. Factors affecting the design and use of various audio-frequency connecting circuits are discussed in relation to the subjective effect of the results.

534.76 **2798**

The Formation of Stereophonic Images.—K. de Boer. (*Philips tech. Rev.*, Feb. 1946, Vol. 8, No. 2, pp. 51–56.) General discussion, with particular reference to the conditions under which sound must be recorded for stereophonic effects.

534.862 + 621.397 **2799**

S.M.P.E. [Society of Motion Picture Engineers] **Spring Technical Conference** [New York, May 1946]. —(*See* 3087.)

621.317.79 : 621.395.82 : 621.395.645 **2800**

Intermodulation Testing [of audio-frequency amplifiers].—Hilliard. (*See* 2978.)

621.395.613.32 **2801**

Microphones: Part 4.—S. W. Amos & F. C. Brooker. (*Electronic Engng*, Aug. 1946, Vol. 18, No. 222, pp. 255–258.) An account of the theory and construction of the ribbon velocity-type microphone and of its performance compared with other types. Polar diagrams and response curves are given. Special B.B.C.-Marconi velocity types and combined pressure and velocity microphones are also described in detail. Conclusion of series; for previous parts see 2458 of September and back references.

621.395.623.8 **2802**

Beachmaster Announcing Equipment.—L. Vieth. (*Bell Lab. Rec.*, July 1946, Vol. 24, No. 7, pp. 261–263.) A general account. See also 532 of March (Duffield).

621.395.625 **2803**

Recording and Broadcasting of Preparations for Bikini Atom-Bomb Test.—A. A. Kees. (*Communications*, July 1946, Vol. 26, No. 7, pp. 11–13.) Outline of methods used to overcome technical difficulties of sound recording in aircraft and under difficult climatic conditions.

621.395.625.3 **2804**

Signal and Noise Levels in Magnetic Tape Recording.—D. E. Wooldridge. (*Trans. Amer. Inst. elect. Engrs*, June 1946, Vol. 65, No. 6, pp. 343–352.) Statistical variations in net flux entering the pole pieces, due to finite size of magnetic domains in the tape material, is the only source of noise completely explainable. Detailed consideration is given to hysteresis processes in the erase-record-reproduce cycle. The magnitude of overload signal is predicted in terms of the coercive force of the tape material and the reluctance of the magnetic circuit. A combination of a new vicalloy tape, the superposed h.f. method of recording, and a new unit design results in high quality recording from 100–8 000 c/s with a useful volume range of more than 50 db.

621.395.625.6 **2805**

Preliminary Sound Recording Tests with Variable-Area Dye Tracks.—R. O. Drew & S. W. Johnson. (*J. Soc. Mot. Pict. Engrs*, May 1946, Vol. 46, No. 5, pp. 387–404.) Measurements on frequency response, noise, and distortion, with photocells having various spectral response curves.

621.395.625.6 : 621.383 **2806**

Behavior of a New Blue-Sensitive Phototube [for black-and-white or colour film tracks] **in Theater Sound Equipment.**—J. D. Phyfe. (*J. Soc. Mot. Pict. Engrs*, May 1946, Vol. 46, No. 5, pp. 405–408.)

621.395.625.6 : 621.383 **2807**

A Phototube for Dye Image [colour film] **Sound Track.**—Glover & Moore. (*See* 3076.)

AERIALS AND TRANSMISSION LINES

621.315.1.056.1 **2808**

Tensions in Hanging Wires.—G. Hookham. (*Engineering, Lond.*, 17th May 1946, Vol. 161, No. 4192, p. 460.) Geometrical construction for tensions at the ends of fairly taut wires, with known sag.

621.315.21.029.5/.6 **2809**

Design Data and Characteristics of High-Frequency Cables: Parts 1 & 2.—K. Zimmermann. (*Radio, N.Y.*, May & June 1946, Vol. 30, Nos. 5 & 6, pp. 13–15 & 20 . . 34.) Cables for centimetre wavelengths require rigid mechanical and electrical specifications. Design data for obtaining a suitable characteristic impedance and attenuation with the required strength and flexibility are given for the following types: (1) Coaxial cable with stranded inner conductor and low-loss dielectric. (2) Coaxial cable, air-spaced by means of a spiral of polythene. (3) High impedance cable having a spiral inner conductor. (4) Dual coaxial for a high degree of balance. (5) Screened twin cable. (6) Twin unscreened. The second part discusses causes of attenuation, the power rating, and typical design problems.

621.315.21.029.6 : 621.317.3 **2810**

Measurement of Velocity of Propagation in Cable.—Kramer & Stolte. (*See* 2977.)

621.315.212.1.017 **2811**

Current Rating of Single-Core Paper-Insulated Power Cables.—C. C. Barnes. (*Elect. Comm.*, March 1946, Vol. 23, No. 1, pp. 70–95.) An outline of a method for computing the ratings. The effect of sheath losses, skin effect, proximity effect, and dielectric loss, are discussed in detail. Current rating for special cases of cables in water, air, and ducts, and for particular types of cables are calculated and tabulated.

621.315.221 : 669.45 **2812**

[Chemical] **Analysis of Cable Sheathing Alloys.**—Hamilton. (*See* 2947.)

621.315.229 **2813**

Jacketing Materials for High-Frequency Transmission Lines.—Warner. (*See* 2929.)

621.319.7 : 621.392 **2814**

Some Applications of Field Plotting.—E. O. Willoughby. (*J. Instn elect. Engrs*, Part III, July 1946, Vol. 93, No. 24, pp. 275–293.) "By the process of field-plotting in the cross-section of a uniform transmission line, an orthogonal field pattern of curvilinear squares satisfying the boundary conditions is obtained. If N_v is a number of voltage steps and N_f the number of electrostatic flux lines in this field plot, the characteristic impedance is given by

$$Z = 377(N_v/N_f)\sqrt{\mu/\kappa}$$

where μ is the permeability, and κ is the permittivity.

"Applications to coupling and screening are also considered.

"The use of models in an electrolytic tank for capacitance determination from field plots or direct measurement is discussed, and an axially symmetrical three-dimensional field is plotted. Mention is made of the relaxation process and rubber-sheet methods of field-plotting."

621.392 + 621.316.35.011.3 **2815**

Formulas for the Inductance of Coaxial Busses Comprised of Square Tubular Conductors.—H. P. Messinger & T. J. Higgins. (*Trans. Amer. Inst. elect. Engrs*, June 1946, Vol. 65, No. 6, pp. 328–336.)

621.392 + 621.396.11 **2816**

Propagation of Electromagnetic Waves Along a Single Wire.—Vladimirski. (*See* 3008.)

621.392 **2817**

Characteristic Impedance of Balanced Lines.—P. J. Sutro. (*Electronics*, July 1946, Vol. 19, No. 7, p. 150.) Three equations for the Z_0 of a balanced two-wire transmission line with cylindrical shield are compared, and expressions given for the errors in each equation.

621.392 **2818**

Anomalous Attenuation in Waveguides.—J. Kemp. (*Wireless Engr*, Aug. 1946, Vol. 23, No. 275, pp.

211–216.) "The puzzling phenomenon of decreasing attenuation constant with increasing frequency which occurs in a few isolated instances is here elucidated by treating the guides concerned as limiting cases of a guide of more general shape, in the interior of which the waves display the normal properties characteristic of waves in guides generally. The equations of the electromagnetic field, cut-off frequency and attenuation constant describing the isolated cases are then, in like manner, deduced as limiting cases from those appropriate to a guide of general shape. The isolated cases thus lose their character of isolation and assume that of straightforward limits instead. According to the point of view developed in the paper these limiting cases imply an electromagnetic field which extends to infinity along one of the transverse co-ordinates but, being wrapped around the axis of the guide, the field is constrained to exist in finite space where it continues to display the properties characteristic of a field of infinite extent."

621.392 : 621.396.67 2819

Aerial-to-Line Couplings.—Burgess. (*See* 2835.)

621.392.43 2820

Transmission Lines as Impedance Transformers.—L. R. Quarles. (*Communications*, July 1946, Vol. 26, No. 7, pp. 20 . . 38.) The solution of typical problems involving the quarter-wave line and open- and shorted-stub matching. The use of the circle diagram is explained. The last of a series; for previous parts see 2478 and 2480 of September.

621.396.67 2821

Aerials.—"Cathode Ray". (*Wireless World*, July 1946, Vol. 52, No. 7, pp. 223–225.) Elementary theory of radiation from current elements.

621.396.67 2822

The Radiation Field of an Unbalanced Dipole.—W. Kelvin. (*Proc. Inst. Radio Engrs, W. & E.*, July 1946, Vol. 34, No. 7, pp. 440–444.) A method for obtaining the magnitude of the electric field in the distant zone of a symmetrical dipole with unequal branch currents is described. The result involves two functions of the vertical angle, plots of which are given for four values of h, the half-length of the dipole. Curves of the distant-zone electric field are given for values of h and of k, the ratio of the branch currents at the driving points. Experimental field patterns are plotted for several dipole lengths.

621.396.67 2823

Slotted Tubular Antenna for 88 to 108 Mc/s.—J. R. Jones. (*Communications*, July 1946, Vol. 26, No. 7, pp. 36 . . 39.) Short technical description of an aerial designed by A. Alford for horizontal polarization.

621.396.67 2824

Three New Antenna Types and Their Applications.—A. G. Kandoian. (*Elect. Comm.*, March 1946, Vol. 23, No. 1, pp. 27–34.) Reprint of 1180 of May.

621.396.67 : 538.56 2825

On the Excitation of Vibrators in Antennae.—M. A. Leontovich & M. L. Levin. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 3, pp. 156–163. In Russian.) Complete paper, of which an English summary was abstracted in 2618 of 1945.

621.396.67 : 621.397.6 2826

C.B.S. Tele Antenna.—O. J. Sather. (*Electronic Industr.*, July 1946, Vol. 5, No. 7, pp. 68–69.) Design and constructional details of a folded dipole video radiator for operation at 51.25 Mc/s. A heater is provided for removing ice.

621.396.677 2827

An Inexpensive 3-Element [rotating] **Beam** [antenna] **for 28 Mc/s.**—C. E. Nichols. (*QST*, Aug. 1946, Vol. 30, No. 8, pp. 27–31, 126.) Constructional details.

CIRCUITS

621.3.011.2 2828

Impedance Calculations.—H. Horwood. (*Elect. Rev., Lond.*, 31st May 1946, Vol. 138, No. 3575, pp. 846–847.) Graphical method for impedances in parallel.

621.3.012.3 2829

System of Graphing Capacities and Inductances.—A. S. Runciman. (*Elect. Engng, N.Y.*, June 1946, Vol. 65, No. 6, p. 300.)

621.3.012.3 2830

Nomograph Construction : Part 1 — Nomograph for Current, Voltage and Resistance.—F. Shunaman. (*Radio Craft*, June 1946, Vol. 17, No. 9, pp. 609 . . 633.)

621.314.2.029.5 : 621.396.619.018.41 2831

The Theory and Design of Intermediate-Frequency Transformers for Frequency-Modulated Signals.—H. A. Ross. (*A.W.A. tech. Rev.*, March 1946, Vol. 6, No. 8, pp. 447–471.) The design criteria are shown to be (*a*) the amount of a.m. introduced into the f.m. signal by the selective circuits, and (*b*) the linearity of the phase-angle/frequency characteristic of the secondary current. Maximum linearity is obtained when the transformers are critically coupled. The characteristic remains almost linear with a small degree of over-coupling, and the design of over-coupled transformers is discussed. Design charts are given for critically coupled transformers. The power relations in an f.m. signal which has been subjected to transmission through selective circuits are also discussed.

621.316.578.1 2832

One Tube—One Relay Multi-Time Circuits.—V. Wouk. (*Electronic Industr.*, July 1946, Vol. 5, No. 7, pp. 48–52, 98.) A single thyratron is used to perform multiple timing operations by the addition of RC combinations to the grid and anode circuits. A typical single or repeating two-interval timer provides interval ranges from 0.05 sec to 3 min and 0.07 sec to 10 sec. Details are given of multiple-interval timers.

621.385 : 621.396.822 2833

Fluctuations in Electrometer Triode Circuits.—A. van der Ziel. (*Physica, Eindhoven*, Feb. 1942, Vol. 9, No. 2, pp. 177–192. In English.) "The influence of fluctuations on the accuracy of measurement of small currents by an electrometer triode is investigated theoretically and the results compared with earlier theoretical and experimental work. Only two sources of fluctuations are important, thermal noise in the input circuit, and the shot effect of the grid current. The mean-square error is calculated for three methods of measurement: first, when the final deflexion of the galvanometer in the anode circuit is read once, second, such as the back heating of the cathode by returned electrons may contribute to the poor performance at high frequencies.

621.396.662 **2856**

The Design of Band-Spread Tuned Circuits for Broadcast Receivers.—D. H. Hughes. (*J. Instn elect. Engrs*, Part I, July 1946, Vol. 93, No. 67, pp. 317–318.) Long abstract of 1803 of July.

621.397.64 **2857**

H.F. Wideband Amplifier.—(*Radio Craft*, June 1946, Vol. 17, No. 9, p. 645.) Sylvania i.f. chassis for television using 6AK5 valves, centre frequency 60 Mc/s, bandwidth 9 Mc/s.

539.16.08 + 621.318.572 **2858**

Electron and Nuclear Counters. [Book Review] —Korff. (*See* 3081.)

621.396.61 **2859**

Théorie des Oscillateurs. [Book Review]—Y. Rocard. France, 1941, 223 pp. (*Wireless Engr*, Aug. 1946, Vol. 23, No. 275, p. 233.) "This book can be heartily recommended to anyone seriously interested in the subject of oscillations."

GENERAL PHYSICS

523.755 : 539.1 **2860**

Possibility of Emission of a Very Hard Radiation from the Solar Corona.—J. S. Shklovsky. (*Nature, Lond.*, 22nd June 1946, Vol. 157, No. 3999, p. 840.)

530.145 **2861**

An Attempt to Formulate a Divergence-Free Quantum Mechanics of Fields.—G. Rayski. (*Nature, Lond.*, 29th June 1946, Vol. 157, No. 4000, p. 873.)

534.131 **2862**

Reflection and Refraction of Non-Stationary Elastic Waves.—V. Gogoladze. (*C. R. Acad. Sci. U.R.S.S.*, 20th Nov. 1945, Vol. 49, No. 5, pp. 322–325. In English.) "The present paper and [2863 & 2864 below] . . . contain a full treatment of the elastic wave reflection and refraction problem for arbitrary elastic media that are in contact along a plane. Also a theory of Rayleigh boundary waves is developed."

534.131 **2863**

On Rayleigh Boundary Waves.—V. Gogoladze. (*C. R. Acad. Sci. U.R.S.S.*, 30th Nov. 1945, Vol. 49, No. 6, pp. 400–403. In English.) A short mathematical paper on the spectrum of free vibrations of two different solid elastic media meeting along a plane. The necessary and sufficient condition for the existence of Rayleigh's boundary wave is established.

534.131 **2864**

General Formulae for the Reflexion and Refraction of Non-Stationary Elastic Waves.—V. Gogoladze. (*C. R. Acad. Sci. U.R.S.S.*, 10th Dec. 1945, Vol. 49, No. 7, pp. 479–481. In English.) Elastic disturbances may be considered as an aggregate of longitudinal and transverse waves reflected and refracted through real and complex angles in the plane of separation between elastic media, consequently, as an aggregate of homogeneous and non-homogeneous plane waves. General formulae for these waves are given. The horizontal component of energy flow in the non-homogeneous waves has a constant direction, while the vertical component "may change its sign with time and at different points". See also 2862 above.

535.234 **2865**

Planck's Radiation Formula.—D. G. Kendall: H. Dingle. (*Nature, Lond.*, 1st June 1946, Vol. 157, No. 3996, p. 737.) Demonstration by Kendall that Planck's radiation formula is not a unique solution of the general integral equation considered by Dingle (*Nature, Lond.*, 20th April 1946, Vol. 157, No. 3990, p. 515), and reply by Dingle.

535.313.2.08 **2866**

Screen-Line Tests of Paraboloidal Reflectors.—D. H. Hamsher. (*J. opt. Soc. Amer.*, May 1946, Vol. 36, No. 5, pp. 291–295.) Theoretical and practical considerations of testing optical reflectors by photographing by reflection an illuminated screen bearing ruled lines.

535.43 **2867**

Modified Rayleigh Scattering in a Liquid.—D. H. Rank. (*J. opt. Soc. Amer.*, May 1946, Vol. 36, No. 5, pp. 299–301.) Experimental investigation of the phenomenon of scattered light of modified frequency predicted by Brillouin. The $\lambda 3650$ and $\lambda 4358$ mercury lines were used, and scattering from benzene gave wavelength shifts in close agreement with the theoretical values.

535.434 **2868**

On the Theory of the Light Field in a Scattering Medium.—A. Gershun. (*C. R. Acad. Sci. U.R.S.S.*, 20th Dec. 1945, Vol. 49, No. 8, pp. 556–557. In English.) In a turbid medium where the illumination is due to scattered light, the relative distribution of intensity may be considered uniform in all directions. This leads naturally to the exponential law of attenuation of light with increasing depth.

In sea water the attenuation of daylight with increasing depth is determined almost completely by the true absorption.

535.61–15 : 536.45 : 546.3 **2869**

Infra-Red Emissivity of Metals at High Temperatures.—D. J. Price. (*Nature, Lond.*, 8th June 1946, Vol. 157, No. 3997, p. 765.) Measured between 1 000° and 1 500° C in a specially designed furnace.

537.523.4 **2870**

Incomplete Breakdown : a Cathode De-ionization Effect.—F. L. Jones. (*Nature, Lond.*, 13th April 1946, Vol. 157, No. 3989, p. 480.) The "stepped" nature of the voltage change observed across a spark gap using very clean electrodes is discussed. Introduction of fine dust particles of certain oxides on the cathode destroys the "stepped" phenomenon and permits full breakdown of spark-gap insulation. It is concluded that, for complete breakdown, continuous electron emission at or near the cathode is required during the whole breakdown process and not merely in the initial stages.

537.525 : 538.551.25 **2871**

Characteristic Electric Oscillations of a Low Pressure Mercury Arc.—B. L. Granovsky & L. N. Bykhovskaya. (*C. R. Acad. Sci. U.R.S.S.*, 20th Nov. 1945, Vol. 49, No. 5, pp. 339–342. In English.) Short account of experiments on oscillations in the frequency range 10^3–10^6 c/s in a circuit "consisting only of a constant e.m.f., ohmic resistance and discharge gap". In these experiments the discharge gap was a mercury arc and the existence of four different types of oscillation was established, (*a*) irregular deviations of the voltage from its normal value in the case of a freely moving cathode spot, (*b*) irregular oscillations at higher frequencies in the case of an anchored cathode spot, (*c*) regular oscillations in the low r.f. range (10^4–10^5 c/s), and (*d*) regular oscillations in the range of sound frequencies (3 000–300 c/s and lower). See also 2872 below.

537.525 : 538.551.25 2872

The Generation of High-Power Electric Oscillations by a Low Pressure Discharge.—B. L. Granovsky & T. A. Suetin. (*C. R. Acad. Sci. U.R.S.S.*, 30th Nov. 1945, Vol. 49, No. 6, pp. 410–413. In English.) Brief summary of results of a study of the generation of oscillations by gas discharge tubes having a perforated diaphragm or a narrow neck dividing the anode from the cathode regions (such tubes are here given the name " stenotrones "). The form of these oscillations depends on temperature, pressure, shape of tube, nature and density of gas discharge, and upon the external circuit. Frequencies of 15–100 kc/s and useful oscillatory powers up to 1 kW were obtained. See also 2871 above.

537.533.72 + 621.385.833 2873

Focusing of Electrons in Two Dimensions by an Inhomogeneous Magnetic Field.—K. Siegbahn & N. Svartholm. (*Nature, Lond.*, 29th June 1946, Vol. 157, No. 4000, pp. 872–873.) Description of a method combining several of the useful properties of the semicircular and lens methods of focusing β rays.

537.533.72 + 621.385.833 2874

Optical Characteristics of a Two-Cylinder Electrostatic Lens.—Goddard. (*See* 2998.)

537.533.72 + 621.385.833 2875

A Note on the Petzval Field Curvature in Electron-Optical Systems.—Goddard. (*See* 2999.)

537.564 2876

Stepped Ionization of Hydrogen by Electronic Impact.—B. Yavorsky. (*C. R. Acad. Sci. U.R.S.S.*, 10th Nov. 1945, Vol. 49, No. 4, pp. 250–253. In English.) Short mathematical paper on a method of computing the cross-section for ionization of the hydrogen atom.

537.591.5 2877

Mesotron Intensity as a Function of Altitude.—P. S. Gill. (*Nature, Lond.*, 25th May 1946, Vol. 157, No. 3995, p. 691.) A slight hump (maximum) occurs in the intensity/pressure curve at 500 mb.

538.1 2878

On Certain Non-Linear Phenomena resulting from the Superposition of Mutually Perpendicular Magnetic Fields.—G. S. Gorelik. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 4, pp. 172–188. In Russian.) Complete paper, of which an English summary was abstracted in 3073 of 1945.

538.11 2879

The Unit-Pole Definition of Magnetic Field Strength.—G. W. O. H. (*Wireless Engr*, Aug. 1946, Vol. 23, No. 275, pp. 207–210.) The problem of reconciling this definition with the fact that H is not a directly measurable quantity is discussed for media of permeability other than unity.

538.31 2880

On the Parametric Vibrations of an Iron Body in an Alternating Magnetic Field.—S. M. Rytoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 3, pp. 150–155. In Russian.) Complete paper, of which an English summary was noted in 3074 of 1945. For another Russian version see 2546 of September.

538.56 : 530.12 : 531.51 2881

Radiation of Gravitational Waves by Electromagnetic Waves.—L. M. Brekhovskich. (*C. R. Acad. Sci. U.R.S.S.*, 10th Dec. 1945, Vol. 49, No. 7, pp. 482–485. In English.) The decrease in flux of electromagnetic energy due to gravitational radiation for a spherical e.m. wave is calculated for Einstein's cylindrical world and for a spherically isotropic world, and is found to be unobservable.

539.153 : 538.221 2882

Collective Electron Assemblies in a Metal with Overlapping Energy Bands: Part 1, General Theory; Part 2, The Occurrence of Ferromagnetism.—W. Band. (*Proc. Camb. Phil. Soc.*, June 1946, Vol. 42, Part 2, pp. 139–144 & 144–155.) In Part 1 it is shown that, in a metal with overlapping energy bands, one of which is nearly full and the other nearly empty, there exists a critical temperature below which spontaneous magnetization will be present. In Part 2 it is shown that this concept is useful in systematizing the Curie-point data not only for pure ferromagnetic elements but also for the ferromagnetic alloys.

541.135 : 537[.226 + .228.2 2883

On the Dielectric Property and Electrostriction of Solutions of Electrolytes.—O. K. Davtjan. (*C. R. Acad. Sci. U.R.S.S.*, 20th Dec. 1945, Vol. 49, No. 8, pp. 575–577. In English.) A theoretical paper which establishes " that the change in the dielectric constant of a polar liquid consequent upon the dissolution of an electrolyte is proportional to its electrostriction ".

A formula is derived expressing the relation between the dielectric constant and concentration of an electrolyte. Satisfactory agreement with experimental data is found.

621.317.4 : 621.318.2 2884

The Magnetic Potentiometer Study of Permanent Magnets.—Bates. (*See* 2939.)

621.384 2885

On Resonance Phenomena Associated with the Movement of a Relativistic Particle in the Cyclotron.—A. Andronov & G. Gorelik. (*C. R. Acad. Sci. U.R.S.S*, 30th Dec. 1945, Vol. 49, No. 9, pp. 640–642. In English.) A theoretical analysis of the variation of energy of a charged particle with the intensity of magnetic field in a cyclotron. A resemblance to the curve of ferro-resonance is pointed out.

537 + 538](075) 2886

Electricity and Magnetism for Students. [Book Review]—S. R. Humby. John Murray, London, 2nd edn. 1945, 6s. 6d. (*Nature, Lond.*, 1st June 1946, Vol. 157, No. 3996, p. 714.) " . . . Covers all the essential work for higher school certificate and university scholarship examinations, and treats the difficulties of electrostatic theory exceptionally well."

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.165 : 523.746 "1946.01/.02" 2887

Cosmic Rays and the Great Sunspot Group of January 29 – February 12, 1946.—A. Duperier & M. McCaig. (*Nature, Lond.*, 13th April 1946, Vol. 157, No. 3989, p. 477.) Large variations in intensity of cosmic rays were observed during the passage of a large sunspot group, a large decrease in intensity coinciding with the peak of the associated magnetic storm.

523.7 2888

Magnetism of the Sun.—K. Mital. (*Sci. Culture*, June 1946, Vol. 11, No. 12, pp. 671–677.) A discussion of present-day knowledge and theoretical explanations of observed aspects of the sun's magnetic field. The field and polarity associated with sunspots, and convection currents in the sun itself are discussed. The relation of the general magnetic field to that of a uniformly magnetized sphere is examined.

523.72 2889

Cause Radio Disturbances.—(*Sci. News Lett., Wash.*, 20th April 1946, Vol. 49, No. 16, p. 245.) Clouds of electrically charged gases reaching the earth from the sun were discovered by a pulse ranging method during recent magnetic-ionospheric storms.

523.746 2890

The Magnetic Field of the Sun Spots.—L. E. Gurevich & A. I. Lebedinsky. (*C. R. Acad. Sci. U.R.S.S.*, 20th Oct. 1945, Vol. 49, No. 2, pp. 92–94.) Explanation of the magnetic field observed in sunspots, in terms of the flow of ionized gas towards the axis of the spot. The gas, crossing the initial (weak) field of the sun, has currents induced in it, resulting in an enhanced magnetic field along the axis of the spot. The field builds up slowly in a time comparable with the life of the spot.

523.746 : 621.396.11 : 551.51.053.5 2891

Sunspots and Radio Communication.—(*See* 3015.)

523.78 : 551.51.053.5 2892

Solar Eclipses and Radio Investigations of the Ionosphere.—Ya. L. Al'pert & B. N. Gorozhankin. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 2, pp. 85–108. In Russian.) Complete paper, of which an English summary was abstracted in 2521 of 1945.

523.78"1945.07.09" : 551.51.053.5 : 621.396.11 2893

On the Results of Radio-Observations during the Solar Eclipse (Corpuscular and Ultra-Violet) of July 9, 1945.—Ya. L. Al'pert & B. N. Gorozhankin. (*C. R. Acad. Sci. U.R.S.S.*, 10th Nov. 1945, Vol. 49, No. 4, pp. 254–258. In English.) Brief account of equivalent height and azimuth measurements on 3.8 Mc/s and 6 Mc/s over a sender-receiver distance of 37 km. The azimuth observations showed marked variations during the eclipse period, and it is suggested that these were due to bending of the F_2 layer during the optical eclipse. The results in general confirm the view that solar ultra-violet light governs E-layer ionization and "that the corpuscular radiation of the sun is not the agent determining the fundamental state of ionization of any of the regions of the ionosphere and that its action is purely perturbative in nature. . . . [However,] from the results of our experiments it may be concluded that the corpuscular radiation of the sun, in particular for particles with velocities of the order of 500 km/s, affects the ionosphere."

525.24 : 523.7 2894

Persistent Solar Rotation Period of 26.875 Days and Solar-Diurnal Variation in Terrestrial Magnetism.—J. Olsen. (*Nature, Lond.*, 11th May 1946, Vol. 157, No. 3993, p. 621.) Observations of the solar-diurnal variation in the horizontal force of the terrestrial magnetic field at Godhavn, Greenland, covering the years 1926–1940 establish a definite periodicity of 26.875 days. The effect vanishes in winter and has not been observed south of the auroral zone. Probable explanations are discussed.

550.37 : 621.315.28 2895

Earth Currents in Short Submarine Cables.—D. W. Cherry & A. T. Stovold. (*Nature, Lond.*, 8th June 1946, Vol. 157, No. 3997, p. 766.) Tests on submarine cables between Great Britain and the Continent earthed at the far shore show that voltages between cable and earth vary with the same periodicity as the tides.

550.38 2896

On the Origin of Terrestrial Magnetism.—J. Frenkel. (*C. R. Acad. Sci. U.R.S.S.*, 20th Oct. 1945, Vol. 49, No. 2, pp. 98–101. In English.) An hypothesis to explain the existence and magnitude of the earth's magnetic field is given in terms of convection currents set up in the core of the earth, which is assumed to be of molten metal of relatively low viscosity. These convection currents in the presence of a weak "adventitious" field give rise to a more powerful magnetic field by a process of "self-excitation". The theory gives results which are high by a factor of 10 or even more compared with the observed values, but it is pointed out that the theory is incomplete and does not take account of many possibly important factors. See also 2890 above.

551.51.053.5 : 550.38 2897

On Currents in the Ionosphere which cause Variations in the Earth's Magnetic Field.—I. E. Tamm. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 2, pp. 30–41. In Russian.) Complete paper, of which an English summary was abstracted in 2523 of 1945.

551.51.053.5 : 550.38 2898

Two Anomalies in the Ionosphere.—E. V. Appleton. (*Nature, Lond.*, 25th May 1946, Vol. 157, No. 3995, p. 691.) Ionization in the F_2 layer is not symmetrical with respect to either geographic latitude or geographic longitude. Geomagnetic influences in the F_2 layer are suggested by the symmetry which obtains when magnetic dip is used in place of geographic latitude as a basis of comparison with F_2 ionization.

551.51.053.5 : 621.396.11 2899

Ionosphere Storm Effects in the *E* Layer.—T. W. Bennington. (*Nature, Lond.*, 13th April 1946, Vol. 157, No. 3989, pp. 477–478.) During the course of, or just prior to, an ionospheric storm, a low-pitched "rumble" is heard from high-power transmitting stations within the skip zone. From the nature of the signals it is concluded that they are due to variations in the ionic clouds in the E layer, and that these clouds are affected by the corpuscular radiation from the sun which causes the ionospheric storm.

551.51.053.5 : 621.396.11 2900
Maximum Values of Radio Field Intensity on Vertical Reflection from the Ionosphere, and an Evaluation of the Coefficient of Reflection.—Kessenikh. (*See* 3014.)

551.51.053.5 : 621.396.11 2901
On the Refractive Index of an Ionized Gas (Ionosphere).—V. L. Ginsburg. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 2, pp. 76–84. In Russian.) Complete paper, of which an English summary was abstracted in 2517 of 1945.

551.51.053.5 : 621.396.91 2902
Ionosphere Measuring Equipment.—Sulzer. (*See* 2983.)

551.57 : 621.396.82 : 629.135 2903
Flight Research on Precipitation Static.—Cleveland. (*See* 3038.)

551.594.5 : 535.33 2904
The Auroral Spectrum.—S. K. Mitra. (*Nature, Lond.*, 25th May 1946, Vol. 157, No. 3995, p. 692.) The spectra of the aurora and of the luminescent night sky are compared with those of atmospheric gases in a discharge tube. In the tube, the glass walls absorb the products of bombardment, but in the upper atmosphere, these persist and cause radiation by interaction. Differences between the auroral and night-sky spectra are due to higher collision frequency at the level of the aurora.

LOCATION AND AIDS TO NAVIGATION

519.2 2905
The General Case of Locating a Point on a Plane by Three Angle Measurements.—Yudin. (*See* 2959.)

621.3(43) 2906
German Industrial Techniques.—(*See* 2927.)

621.396.9 2907
The Military Application of Radar.—E. G. Bowen. (*Proc. Instn Radio Engrs, Aust.*, May 1946, Vol. 7, No. 5, pp. 4–10.) Lecture giving a popular description and the history of development of radar for ground, ship, and aircraft use. For report of previous lecture see 1854 of July.

621.396.9 2908
Rotary Wave Radar.—W. van B. Roberts. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 130–133.) A general description of a continuous-wave radar system using circularly polarized waves. The system has advantages in low-power applications requiring minimum weight and bulk.

621.396.9 2909
Aircraft Radar.—V. Zeluff. (*Sci. Amer.*, May 1946, Vol. 174, No. 5, pp. 204–206.) A brief general description of teleran, GCA, lanac and loran.

621.396.9 2910
Demonstration of a Marine Radar Set.—(*Engineer, Lond.*, 28th June 1946, Vol. 181, No. 4720, pp. 583–584.) Primarily for short-range navigation, and complying with British Ministry of Transport specification. The set, now in quantity production, consists of scanner, console with receiver and p.p.i. display, transmitter, and motor generator set with control board. The wavelength of the set is in the 3-cm band, and the peak power is 50 kW. Manual control of scanning is provided for, and an automatic warning unit is fitted, giving audible warning of the presence of an object in any direction within range limits 3 000–6 000 yd.

621.396.932 2911
Radio Aids to Marine Navigation.—(*Engineer, Lond.*, 10th May 1946, Vol. 181, No. 4713, pp. 425–427.) A brief description of direction-finding systems and the shipborne radar installed on H.M.S. Fleetwood for a trial blind run in the Solent.

621.396.932/.933].24 2912
Consol.—J. E. Clegg. (*Wireless World*, July 1946, Vol. 52, No. 7, pp. 233–235.) A description of a long-range radio navigational aid. Seventy-four beams are produced by three aerials on a two-mile baseline, the field being divided into areas of "dot" and "dash" modulation. The equisignal beams are rotated through about 10 degrees per minute, and the time at which the beam passes through the receiving station (measured in terms of the number of dots and dashes received since the last marking signal, a continuous tone) indicates the bearing from the transmitter. Maps and charts are provided at the receiving station for the interpretation of bearings.

The operational frequency range is 260–420 kc/s, the reliable range 1 000 miles over sea and 600 miles over land, by day, with an accuracy of about 0.3°. At night the range is increased and the accuracy reduced to 1–3°, depending on the sector. Ambiguities on bearing are normally easy to resolve by the use of other available data.

621.396.933.2 2913
Evaluation of Night Errors in Aircraft Direction Finding, 150–1 500 Kilocycles.—H. Busignies. (*Elect. Comm.*, March 1946, Vol. 23, No. 1, pp. 42–62.) Description of a method by which a pilot can determine the accuracy of night bearings obtained by aircraft radio compass and the effect of the aircraft's passing through fields resulting from reflections from the *E* layer or from mountains. Night error on the ground and at altitude is discussed, considering the simultaneous presence of the direct wave, sky wave, and sky wave reflected from the ground. All cases of polarization are examined briefly to indicate the numerous effects which may be encountered, and a number of rules are given for direction finding at night over land and sea, with diagrammatic maps showing safe and unsafe areas of operation.

621.396.933.2 2914
Discussion on "A New Type of Automatic Radio Direction Finder".—C. C. Pine: H. Busignies. (*Proc. Inst. Radio Engrs, W. & E.*, July 1946, Vol. 34, No. 7, p. 457.) Discussion of 3543 of 1945, referring to earlier patents issued to Busignies, with reply by Pine.

621.396.933.23 2915
Microwave Approach and Landing System.—W. T. Spicer. (*Electronic Industr.*, Aug. 1946, Vol. 5, No. 8, pp. 52–57.) Description of equipment for the blind landing of aircraft that carry only voice communication apparatus. It consists of two microwave radar sets: (*a*) search system on 3 000 Mc/s that gives a polar radar map of 30 miles radius, (*b*) precision system on 10 000 Mc/s that covers a sector 20° in azimuth and 7° in elevation

over the runway, with 10 miles range, and gives azimuth, elevation, and range indications. The ground observer gives verbal instructions to the aircraft.

621.396.9 **2916**

Radar — Radiolocation Simply Explained. [Book Review]—R. W. Hallows. Chapman & Hall, London, 140 pp., 59 figs., 7s. 6d. (*Elect. Rev., Lond.*, 31st May 1946, Vol. 138, No. 3575, p. 848.) ". . . not highly technical, but contains a clear exposition of the basic principles of the subject."

621.396.9 **2917**

Radar for Merchant Ships. [Book Review]—H.M. Stationery Office, 1946, 9d. (*Electrician*, 14th June 1946, Vol. 136, No. 3550, p. 1598.) Includes a specification suitable for adoption by manufacturers.

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.1 **2918**

A Knudsen Absolute Manometer.—S. E. Williams. (*J. sci. Instrum.*, July 1946, Vol. 23, No. 7, pp. 144–146.) Describes a new design. The gauge is capable of absolute measurement of pressures between 10^{-4} mm and 10^{-6} mm Hg.

531.788.6 **2919**

Thermocouple Vacuum Gage.—H. Robinson & M. C. Flanagan. (*Gen. elect. Rev.*, May 1946, Vol. 49, No. 5, pp. 42–44.) Description of the arrangement and performance of a direct-reading gauge for the 1–200 micron range.

531.788.7 **2920**

Application of the Ion Gage in High Vacuum Measurement.—H. E. Van Valkenburg. (*Gen. elect. Rev.*, June 1946, Vol. 49, No. 6, pp. 38–42.) An electronic control panel has been developed for use with the ionization gauges to give continuous and stable operation over the range 10^{-4}–10^{-8} mm Hg. Details are given of the stabilizing and protective circuits used, and practical operation is discussed.

535.215 : 546.3 **2921**

Photoelectric Properties of Metals in a Finely Divided State.—L. J. Reimert. (*J. opt. Soc. Amer.*, May 1946, Vol. 36, No. 5, pp. 278–283.) Investigation of black surfaces (produced by distillation at a pressure of several mm Hg) of Cd, Zn, Sb, over the wavelength range 0.24–0.44μ and of Na from 0.40–, 0.96μ. The dependence of the photoelectric output and the threshold on the nature of the surfaces is discussed.

535.37 **2922**

The Effect of Wave-Length Distribution on the Brightness of Phosphors.—R. T. Ellickson. (*J. opt. Soc. Amer.*, May 1946, Vol. 36, No. 5, pp. 261–264.) A simple graphical method is given for estimating the visual efficiency of the emitted light from a phosphor with an emission curve that can be represented by a Gauss error function.

535.37 **2923**

Light Sum of Phosphors under Thermal and Infra-Red Stimulation.—R. T. Ellickson. (*J. opt. Soc. Amer.*, May 1946, Vol. 36, No. 5, pp. 264–269.) Measurements show that the ratio of the light sums obtained by infra-red irradiation or by heating the phosphor can vary from 1 to 30 according to the phosphor. This effect should be taken into account in using glow curves to determine the electron trap distributions in phosphors.

538.213 : 546.74 : 538.56.029.64 **2924**

Magnetic Permeability of Nickel in the Region of Centimetre Waves.—I. Simon. (*Nature, Lond.*, 1st June 1946, Vol. 157, No. 3996, p. 735.) μ decreases from 7.7 at $\lambda = 20$ cm to 1.2 at $\lambda = 3.2$ cm as measured on films 1 000–2 000 Å thick. The static permeability was found to decrease from 22 for 2 300 Å thickness to unity at zero thickness.

546.32.85 + 546.39.85] : 537.228.1 **2925**

ADP and KDP Crystals.—W. P. Mason. (*Bell Lab. Rec.*, July 1946, Vol. 24, No. 7, pp. 257–260.) Piezoelectric crystals of ammonium dihydrogen phosphate containing no water of crystallization are recommended for use as a substitute for Rochelle salt. The isomorphous salt potassium dihydrogen phosphate has similar properties, and the crystal structure is discussed. See also 1260 of May (Mason).

549.6 : 661.312.1 : 66.083.4 **2926**

Action of Water and Potassium Solutions under Pressure on Various Kinds of Silica.—J. Wyart. (*C. R. Acad. Sci., Paris*, 4th June 1945, Vol. 220, No. 23, pp. 830–832.) A brief account of a study of the crystalline forms appearing as a result of the action of water and of 0.01 mol KOH on fused silica.

621.3(43) **2927**

German Industrial Techniques.—(*Electronics*, July 1946, Vol. 19, No. 7, pp. 200 . . 206.) Notes on a number of developments connected with wired wireless, deposition of metallic films, radar, and ceramics.

621.3.017[.143 + .39 **2928**

Several After-Effect Phenomena and Related Losses in Alternating Fields.—J. L. Snoek & F. K. du Pré. (*Philips tech. Rev.*, Feb. 1946, Vol. 8, No. 2, pp. 57–64.) A survey of the causes and effects of the phenomena in dielectrics and ferromagnetic materials.

621.315.229 **2929**

Jacketing Materials for High-Frequency Transmission Lines.—A. J. Warner. (*Elect. Comm.*, March 1946, Vol. 23, No. 1, pp. 63–69.) The relative merits of a number of plastics and other materials are discussed. Test procedures are also outlined. See also 631 of March (Warner).

621.315.3 **2930**

Methods of Removing the Insulating Film from Formex Wire.—E. J. Flynn & G. W. Young. (*Gen. elect. Rev.*, June 1946, Vol. 49, No. 6, pp. 8–15.) Tests on various types of solvent give the following results: aqueous solutions of salts and alkalis are ineffective; liquid organic mixtures with ammonium hydroxide, formic acid solutions, and certain acid pastes are rapid and do not cause corrosion, but need care in handling; immersion in certain molten compounds, *e.g.* glass or solder, is extremely rapid; of these 50–50 lead-tin solder at a temperature just over 500° C has proved most generally useful. Data and necessary precautions are stated for all the methods investigated.

621.315.61 : 546.287 **2931**

New Electrical Materials — I.—(*Electrician*, 9th Aug. 1946, Vol. 137, No. 3558, pp. 383–386.) Notes on organo-silicon compounds, including silicones.

621.315.61 : 621.396 **2932**

New Dielectric and Insulating Materials in Radio Engineering.—(*Engineer, Lond.*, 7th June 1946, Vol. 181, No. 4717, pp. 519–520.) Report of I.E.E. discussion on new r.f. insulating materials, particularly hydrocarbon plastics and ceramics. Disadvantages of the hydrocarbons are their widely varying mechanical properties and their low temperature-resistance. Progress is being made in overcoming these deficiencies. Magnesium silicate derivatives are used in ceramics, and a closer study of titanium dioxide has yielded better capacitor dielectrics. Titanates of the alkaline earth metals offer scope for development. For another account see *Electrician*, 7th June 1946, Vol. 136, No. 3549, pp. 1519–1520.

621.315.611 **2933**

The Formation of Ionized Water Films on Dielectrics under Conditions of High Humidity.—R. F. Field. (*J. appl. Phys.*, May 1946, Vol. 17, No. 5, pp. 318–325.) "When a dielectric is placed in an atmosphere of 100 per cent relative humidity, an ionized film of water forms, whose conductivity at the end of one minute is within a factor of ten of its equilibrium value, which is usually attained within an hour. This equilibrium conductivity ranges from essentially zero for certain hydrocarbon waxes, silicone resins and silicone-treated glass to 100 micromhos for ordinary glass and quartz. The ionized water film also produces interfacial polarization at its interface with the dielectric, which produces a marked increase in both capacitance and dissipation factor at audio frequencies. This polarization builds up in the same manner as the conductivity. Its relaxation frequency appears to be in the audio range."

621.315.613.1 **2934**

Physical Properties of Mica.—(*Nature, Lond.*, 22nd June 1946, Vol. 157, No. 3999, pp. 849–850.) Survey of American work leading to the conclusion that none of the species of mica has fixed and reproducible physical properties, since these are largely dependent on heat treatment, presence of impurities, and other factors. Main reference is to work of Hidnert & Dickson (1559 of June).

621.315.613.8.011.5 : 546.431.824 **2935**

Dielectric Constant of Barium Titanate as a Function of Strength of an Alternating Field.—B. M. Wul & I. M. Goldman. (*C. R. Acad. Sci. U.R.S.S.*, 30th Oct. 1945, Vol. 49, No. 3, pp. 177–180. In English.) An experimental study has established that below a critical temperature (about 80° C) the dielectric constant varies with the applied electric field. The effect is not due to the production of ionization in the air enclosed in any pores in the material, but is due to a change in the physical properties of the substance. The critical temperature, which depends somewhat on the annealing process, corresponds to the temperature at which the dielectric constant reaches a maximum. It is suggested that below the critical temperature the substance is pyroelectric. An abrupt variation in the specific heat of the substance at about 125° C has also been observed.

621.315.616 **2936**

Synthetic Rubbers and Plastics : XI. (Part 2) Water and the High Polymer.—F. T. White. (*Distrib. Elect.*, July 1946, Vol. 19, No. 163, pp. 143–145.) Further discussion of factors affecting the water affinity of high polymers, with examples of behaviour for several types of molecular structure. For Part 1 of Section XI see 1560 of June. To be continued.

621.315.616.029.64 **2937**

Dielectric Behaviour of 'Polythene' at Very High Frequencies.—J. G. Powles & W. G. Oakes. (*Nature, Lond.*, 22nd June 1946, Vol. 157, No. 3999, pp. 840–841.) The power factor decreases for wavelengths below 10 cm ; polythene may be used with confidence as a low-loss dielectric at 1 cm wavelength. A graph shows measurements of power factor versus frequency over the range 10^5–2.10^{10} c/s.

621.315.616.9 : 536.41 **2938**

Thermal Expansion and Second-Order Transition Effects in High Polymers : Part 3—Time Effects.—R. S. Spencer & R. F. Boyer. (*J. appl. Phys.*, May 1946, Vol. 17, No. 5, pp. 398–404.) The apparent second-order transition in polystyrene is shown to be a rate-effect.

"At ordinary rates of heating below the apparent transition temperature, or at more rapid rates near and above the transition temperature, polystyrene exhibits a cubical thermal expansion coefficient of about 2.7×10^{-4} per °C, and this value is not dependent on the heating rate as long as it is rapid enough. This fact suggests that two mechanisms operate in the thermal expansion of polystyrene, at markedly different rates, one resulting in almost instantaneous expansion, even at room temperature, and the other being strongly temperature dependent and contributing to the expansion under normal rates of heating only at higher temperatures."

For previous parts see 3605 of 1944 and 350 of February.

621.317.4 : 621.318.2 **2939**

The Magnetic Potentiometer Study of Permanent Magnets.—L. F. Bates. (*Phil. Mag.*, May 1945, Vol. 36, No. 256, pp. 297–318.)

621.357.7 : [621.882.2/.3 **2940**

Clearance between Nut and Screw Prior to Plating.—J. Bradshaw. (*Electronic Engng*, Aug. 1946, Vol. 18, No. 222, p. 259.) The basis for calculations, with mnemonics and a table of values for B.A. and Whitworth threads.

621.357.7 : 669.55.6 **2941**

Electrodeposition of Tin-Zinc Alloys.—R. M. Angles. (*Engineering, Lond.*, 3rd May 1946, Vol. 161, No. 4190, p. 427.) Composition of the electrolyte, and precautions in application. Reference is made to an article by Angles & Kerr (2599 of September).

621.396.6 : 551.5 : 629.135 **2942**

The Effects of Atmospheric Conditions on Aircraft Radio Equipment.—Honnor. (*See* 3143.)

621.791.3 **2943**

Soft Solders.—L. G. Earle. (*Metal Ind., Lond.*, 18th & 25th May 1945, Vol. 66, Nos. 20 & 21, pp. 308–311 & 322–325.) Determination of jointing capacity by the Kollagraph.

621.791.3 : 669.65.4 2944
An Engineering Approach to Soldering with Tin-Lead Alloys : Part 1.—A. Z. Mample. (*Metals and Alloys*, March 1945, Vol. 21, No. 3, pp. 702–707.)

621.793 2945
Metal Coatings on Ceramics.—E. Rosenthal. (*Electronic Engng*, Aug. 1946, Vol. 18, No. 222, pp. 241–242, 262.) A review of methods used, with special reference to the advantages of the method of firing on a paint consisting of a mixture of precious-metal oxides (which reduce on heating) with a ceramic flux. See also 2613 of September (Wein).

668.31(213) 2946
Fortified Glues.—(*Sci. Amer.*, May 1946, Vol. 174, No. 5, p. 203.) Resistant to tropical conditions.

669.45 : 621.315.221 2947
[Chemical] **Analysis of Cable Sheathing Alloys.**—G. M. Hamilton. (*Nature, Lond.*, 29th June 1946, Vol. 157, No. 4000, p. 875.) A method of dissolving lead alloy (sheathing) containing up to 2% tin, 0.8% antimony and 0.25% cadmium, with a solution of 30% hydrogen peroxide and glacial acetic acid.

679.5 2948
Development of Industrial Plastics.—(*S. Afr. Engng*, June 1946, Vol. 57, No. 6, pp. 132–133.) A history of the development of plastics with brief notes on the properties of some of the more recent melamine resins.

679.8.053 2949
A Simple Saw for Hard Materials [quartz etc.].—W. A. Wooster. (*J. sci. Instrum.*, June 1946, Vol. 23, No. 6, p. 131.)

539.23 2950
Thin Films and Surfaces. [Book Review]—W. Lewis. English Univ. Press, London, 70 pp., 15s. (*J. sci. Instrum.*, July 1946, Vol. 23, No. 7, p. 163.)

621.396.611.21 : 549.514.1 2951
Quartz Crystals. [Book Review]—R. A. Heising (Ed.). D. Van Nostrand, New York, 563 pp., $6.50. (*Electronic Industr.*, July 1946, Vol. 5, No. 7, pp. 110, 112.) Seventeen chapters by members of the Bell Telephone Laboratories. " . . . complete to the point of being exhaustive . . a valuable compendium of quartz crystal information."

679.5 : 621.3 2952
Plastics for Electrical and Radio Engineers. [Book Review]—W. J. Tucker & R. S. Roberts. Technical Press, Kingston, Surrey, 12s. (*Engineering, Lond.*, 24th May 1946, Vol. 161, No. 4193, p. 482.) Written with "informed judgment" and a "wide knowledge of the requirements of electronic equipment". A very favourable review. See also 1896 of July.

MATHEMATICS

517.512.4 : 621.392.41.015.3 2953
On Transients in Homogeneous Ladder Networks of Finite Length.—W. Nijenhuis. (*Physica, Eindhoven*, Sept. 1942, Vol. 9, No. 8, pp. 817–831. In English.) See 2836 above. Contains a sine series expansion for Bessel functions.

517.9 2954
On the Stability of Systems of Differential Equations.—R. Bellman. (*Proc. nat. Acad. Sci., Wash.*, June 1946, Vol. 32, No. 6, pp. 190–193.)

518.5 2955
Slide-Disk Calculator.—G. S. Merrill. (*Gen. elect. Rev.*, June 1946, Vol. 49, No. 6, pp. 30–33.) The most efficient measure of the dispersion of a set of measurements is given by the root-mean-square deviation from the arithmetic mean. The calculator, based on the theorem of Pythagoras, affords a quick and simple means of obtaining this result. See also 2956 below.

518.5 2956
A Circular Slide Rule.—J. R. Dempster. (*Science*, 19th April 1946, Vol. 103, No. 2677, p. 488.) For root-mean-square operations. See also 2616 of September (Morrell), and 2955 above.

518.5 : 517.512.2 2957
A Machine for the Summation of Fourier Series.—G. Hägg & T. Laurent. (*J. sci. Instrum.*, July 1946, Vol. 23, No. 7, pp. 155–158.) Principally for Fourier synthesis in X-ray crystallography.

518.5 : 621.38 2958
Super Electronic Computing Machine.—Burks. (*See* 2995.)

519.2 2959
The General Case of Locating a Point on a Plane by Three Angle Measurements.—M. I. Yudin. (*C. R. Acad. Sci. U.R.S.S.*, 10th Dec. 1945, Vol. 49, No. 7, pp. 472–475. In English.) An extension of the author's paper (*Bull. Acad. Sci. U.R.S.S., sér. géogr. et géophys.*, 1944, Vol. 8, Nos. 2/3, p. 96 on. In Russian.) to a case where the errors in angular measurement are not independent. Formulae are given which determine the position of the most probable point and the accuracy achieved. Aero-dynamical and aural direction-finding applications are mentioned.

519.251.8 2960
Linear 'Curves of Best Fit'.—A. E. W. Austen & H. Pelzer. (*Nature, Lond.*, 25th May 1946, Vol. 157, No. 3995, pp. 693–694.) Applicable when both parameters are subject to errors of measurement.

621.392 2961
On Approximate Integration of van der Pol's Equation.—Kazakevich. (*See* 2834.)

621.395.4 2962
The Probability Distributions of Sinusoidal Oscillations Combined in Random Phase.—M. Slack. (*J. Instn elect. Engrs*, Part I, June 1946, Vol. 93, No. 66, p. 278.) Abstract of 1908 of July.

MEASUREMENTS AND TEST GEAR

621.317.3.029.63/.64 2963
Radio Measurements in the Decimetre and Centimetre Wavebands.—R. J. Clayton, J. E. Houldin, H. R. L. Lamont & W. E. Willshaw. (*J. Instn elect. Engrs*, Part I, June 1946, Vol. 93, No. 66, pp. 279–282.) Long abstract of 1914 of July.

621.317.32 : 621.3.015.33 **2964**

The Influence of Irradiation on the Measurement of Impulse Voltages with Sphere-Gaps.—J. M. Meek. (*J. Instn elect. Engrs*, Part I, July 1946, Vol. 93, No. 67, pp. 318–319.) Long abstract of 2624 of September.

621.317.35 **2965**

Non-Inductive Wave Analyser Circuits of Constant Q.—H. G. Yates. (*Engineer, Lond.*, 7th June 1946, Vol. 181, No. 4717, pp. 515–516.) Vibration problems in engineering require a wave analyser to track the component vibrations to their sources, and use is made of an amplifier and resistance-capacity feedback bridge. Various modifications of this arrangement are dealt with briefly.

621.317.35 **2966**

Complex Waveforms.—H. Moss. (*Electronic Engng*, Aug. 1946, Vol. 18, No. 222, pp. 243–250.) The general method of harmonic analysis is discussed, and Fourier expansions for a large number of waveforms are tabulated. Notes are given on the production of certain of these waveforms. Conclusion of series; for previous parts see 2244 of August and back references.

621.317.361 + 621.396.611.21 **2967**

Duplex Crystals.—(*Electronic Industr.*, Aug. 1946, Vol. 5, No. 8, pp. 63, 97.) See 1582 of June (Lane).

621.317.42 **2968**

A New Type of Magnetometer (Oersted-Meter).—I. L. Berstein. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 4, pp. 189–193. In Russian.) Complete paper, of which an English summary was abstracted in 2733 of 1945.

621.317.42 **2969**

Fluxmeter Method of Measurement.—H. A. Miller. (*Electrician*, 14th June 1946, Vol. 136, No. 3550, pp. 1577–1579.) The theory of the Grassot fluxmeter and the effect of a shunting resistance.

621.317.7 : 621.396.61 **2970**

Auxiliary Apparatus at the Amateur Station.—W. H. Allen. (*R.S.G.B. Bull.*, Aug. 1946, Vol. 22, No. 2, pp. 20–22.) Practical information on the construction of simple test equipment including absorption and heterodyne frequency meters, monitor, and artificial aerial.

621.317.725 : 621.385 **2971**

Historic Firsts : Vacuum-Tube Voltmeter.—(*Bell Lab. Rec.*, July 1946, Vol. 24, No. 7, pp. 270, 274.)

621.317.727 **2972**

Direct Current Potentiometers.—S. Holmqvist. (*Ericsson Rev.*, 1946, Vol. 23, No. 1, pp. 35–37.) Description of a new potentiometer in which accuracy of measurement is not affected by switch transition resistance. A modification is described for use in the measurement of two potential differences or currents.

621.317.76 **2973**

A Standard of Frequency and Its Applications.—C. F. Booth & F. J. M. Laver. (*J. Instn elect. Engrs*, Part III, July 1946, Vol. 93, No. 24, pp. 223–241.) An historical survey of the development of frequency standards, an analysis of the factors affecting their design, and a description of British Post Office apparatus giving frequencies known to $\pm 1 \times 10^{-8}$. This apparatus consists of one fork-controlled oscillator and four groups of three quartz oscillators (one group of AT-cut 1 000-kc/s plates, three of GT-cut 100-kc/s plates with various types of mounting). The oscillator outputs are selected to control frequency-dividers which reduce the frequency to 1 kc/s for driving phonic-wheel clocks, the errors of which are measured by comparison with Rugby (GBR) time signals, determined by astronomical observation. Three of the twelve quartz oscillators are calibrated directly in terms of time and the remainder are compared with them.

Details are given of the crystal holders, oscillator circuits, temperature-control arrangements, and methods of inter-comparison of the various oscillator frequencies.

621.317.761 **2974**

A Heterodyne Frequency Meter with Built-In Crystal Calibrator.—A. A. Jones. (*R.S.G.B. Bull.*, Aug. 1946, Vol. 22, No. 2, pp. 18–19.) A calibrated variable-frequency oscillator feeds a mixer stage followed by an a.f. amplifier. The v.f.o. has ranges 125–250 kc/s and 1–2 Mc/s enabling frequencies in the range 125 kc/s–20 Mc/s to be measured by heterodyning the signal of unknown frequency against harmonics of the v.f.o. A 1-Mc/s crystal oscillator gives selected check points at which the frequency calibration of the v.f.o. can be corrected by a trimming capacitor. Reading accuracy 1 part in 5 000.

621.317.761 : 621.396.712 **2975**

Measuring and Monitoring Broadcast Frequencies.—L. S. Cole. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 110–111.) A harmonic of a multivibrator controlled by a signal received from the monitored station is beat against the signal from a standard-frequency transmission, and the frequency of the beat note is measured. The circuit of the multivibrator unit is given.

621.317.761.029.4 **2976**

Electronic Frequency Meter for L.F.—W. A. Roberts. (*Electronic Engng*, Aug. 1946, Vol. 18, No. 222, pp. 238–240.) The signal of unknown frequency is applied to two high-gain-pentode limiting stages, giving substantially square-wave output. Pulses obtained by differentiating are applied to a tube held at cut-off. The resulting anode current varies linearly with the frequency of the pulses, and a meter in the anode circuit is directly calibrated in frequency. Ranges 0–2 kc/s, 0–4 kc/s and 0–8 kc/s; the reading is substantially independent of signal waveform and amplitude. Circuit details are given.

621.317.79 : 621.315.21.029.6 **2977**

Measurement of Velocity of Propagation in Cable.—B. Kramer & F. Stolte. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 128–129.) A variable-frequency oscillator (95–105 Mc/s) is loosely coupled to a parallel-tuned circuit in parallel with a valve voltmeter. The tuning of the oscillator is ganged with that of the coupled circuit so that the circuit resonates with the oscillator at all frequencies. A sample of cable of fixed length (150 cm for polythene dielectric) known to be 3/4 wavelength at about 100 Mc/s is connected in series with the coupled circuit, throwing the circuit off tune with the oscillator except at the frequency at which the cable is 3/4 wavelength long. The tuning is adjusted until the voltmeter gives a maximum reading, and the mean velocity in the cable, deduced from

$v = \lambda f$, is read from the directly calibrated tuning control. Estimated accuracy 2%.

621.317.79 : 621.395.82 : 621.395.645 **2978**
Intermodulation Testing [of audio-frequency amplifiers].—J. K. Hilliard. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 123–127.) The principle of the method is the same as that given in 2641 of September (Pickering). The equipment is described with block diagrams. The results of tests on typical amplifiers are shown by graphs which illustrate the reduction of intermodulation with various improvements of amplifier design.

621.317.79 : 621.396.619 **2979**
A Percent [amplitude] **Modulation Meter.**—R. P. Turner. (*Radio News*, May 1946, Vol. 35, No. 5, pp. 43..121.) Constructional details of a direct-reading a.c.-mains-operated instrument.

621.317.79 : 621.397.62 **2980**
A Television Signal Generator : Part 3—R.F. Circuits and Monitors.—R. G. Hibberd. (*Electronic Engng*, Aug. 1946, Vol. 18, No. 222, pp. 251–253.) Detailed circuit of 45-Mc/s vision generator. The signal from a 7.5-Mc/s crystal oscillator is frequency-multiplied to 45 Mc/s and link-coupled to a push-pull suppressor-grid-modulated output stage. Five output sockets are provided, suitably isolated and matched to 100-ohm cable, and a monitor stage is incorporated in the output. A similar unit is used for the sound channel. Picture and waveform monitors are described for checking output quality and for rapid fault location. Conclusion of series; for previous parts see 2255 of August and 2646 of September.

621.318.5.083 **2981**
Induction Relay Testing.—C. G. Rumsam. (*Elect. Rev., Lond.*, 31st May 1946, Vol. 138, No. 3575, pp. 841–843.) Necessity for suitable precautions in test equipment when accurate timing checks of the relay are required.

621.385.3 : 621.396.822 **2982**
Fluctuations in Electrometer Triode Circuits.—van der Ziel. (*See* 2833.)

621.396.91 : 551.51.053.5 **2983**
Ionosphere Measuring Equipment.—P. G. Sulzer. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 137–141.) Description, with circuit diagrams, of an equipment that sweeps the range 1-20 Mc/s in 30 sec. The transmitted frequency is obtained as the beat between a 30-Mc/s pulsed oscillator and a variable 31–50-Mc/s oscillator. The difference-frequency signal is amplified by an untuned wideband amplifier. The returning signal is beat with the 31–50-Mc/s signal to give 30 Mc/s before passing to a sensitive receiver.

621.317 **2984**
Alternating Current Measurements at Audio and Radio Frequencies. [Book Review]—D. Owen. Methuen, London, 2nd edn., 120 pp., 5s. (*Wireless Engr*, Aug. 1946, Vol. 23, No. 275, p. 233.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

537.228.1 : 612.087 **2985**
A Piezo-Electric Unit for General Physiological Recording.—J. L. Malcolm. (*J. sci. Instrum.*, July 1946, Vol. 23, No. 7, pp. 146–148.) Uses X- or A.T.-cut quartz crystal.

537.591 : [621.317.39.083.7 + 621.396.9 **2986**
New Cosmic Ray Radiosonde Techniques.—S. A. Korff & B. Hamermesh. (*J. Franklin Inst.*, May 1946, Vol. 241, No. 5, pp. 355–368.) The measuring instrument, weighing 119 lb, is raised by a cluster of seventy balloons. It consists of a neutron counter (ionization chamber) with three shields which are placed over the counter in sequence. Impulses from the counter are made to cause momentary cessation of a 2 000-c/s note modulating a v.h.f. transmitter of conventional design. Barometric indications of balloon height, and the beginning of each cycle of shield changes, are signalled by coded interruptions of the modulation. The ground equipment comprises a standard receiver and pen recorder. The equipment and the flight technique are described. For previous work see 29 of 1942 (Clarke & Korff).

539.16.08 : 614.84 **2987**
Electronic Fire and Flame Detector.—P. B. Weisz. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 106–109.) Detects flames, sparks, and arcs by the use of a Geiger-Müller counter tube sensitive to ultraviolet light of wavelength shorter than 3 000 Å. The device is not sensitive to daylight or to light from glass-enclosed sources. The tube and associated circuits are described. The device is triggered *e.g.* by a match struck 60 feet away.

551.501 + 621.396.91 + 621.317.39.083.7 **2988**
Recent Advances in Meteorological Methods.—N. K. Johnson. (*Nature, Lond.*, 2nd March 1946, Vol. 157, No. 3983, pp. 247–250.) Early developments included the German radio buoy, and the determination of the position of storms by atmospherics. Upper winds are measured by means of balloons, carrying radio transmitters to enable their track to be plotted by d.f. technique, or carrying only reflectors for detection by radar. Radiosonde balloons are used to obtain information on the temperature, pressure, and humidity of the upper air. Reference is also made to observations taken in aircraft, and to the use of high-velocity shells for exploration of the stratosphere.

578.088.7 : 621.317.755 **2989**
Double-Beam C.R. Tube in Biological Research.—Bullock. (*See* 3072.)

621.317.39 : 620.172.222 **2990**
Electric Strain Gauges.—A. B. White. (*Elect. Rev., Lond.*, 2nd Aug. 1946, Vol. 139, No. 3584, pp. 175–176.) Description of the principles of operation of the resistance strain gauge. Use of cathode-ray tube technique for recording varying strains is outlined.

621.317.39 : 621.753.3 **2991**
Electronic Comparator Gage.—W. H. Hayman. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 134–136.) Description, with circuit diagrams, of a device for converting the movement of the contact point of a mechanical gauge into a change of inductance in an r.f. circuit, giving an electrical indication. At its most sensitive setting the device gives readings to about 10^{-5} inch. Relays can be operated when measurements fall outside prescribed limits.

621.365[.5 + .92 **2992**
Radio-Frequency Heating. — L. Hartshorn. (*Nature, Lond.*, 11th May 1946, Vol. 157, No. 3993, pp. 607–610.) Substance of Royal Institution

lecture. A non-technical description of the underlying principles of dielectric and induction heating, and some examples of their applications.

621.365.5 **2993**

Induction Heating of Long Cylindrical Charges.—H. F. Storm. (*Trans. Amer. Inst. elect. Engrs*, June 1946, Vol. 65, No. 6, pp. 369–377.) Further development of formulae deduced in a previous paper (981 of 1945) to include any radius of charge, and any depth of penetration, the generated heat being expressed in terms of a rapidly converging series. The analysis is applied to the case where the charge is subdivided into a number of cylindrical rods, and the optimum radius of rod for maximum inductor efficiency is deduced.

621.365.92 **2994**

Problems in the Design of High-Frequency Heating Equipment.—W. M. Roberds. (*Proc. Inst. Radio Engrs, W. & E.*, July 1946, Vol. 34, No. 7, pp. 489–500.) Discussion of the required coupling circuits. A simple analysis of a transformer-coupled circuit is given, and the advantages of close and loose coupling compared. A generator can be made more versatile if low-impedance tank circuits and loose coupling are employed.

621.38 : 518.5 **2995**

Super Electronic Computing Machine.—A. W. Burks. (*Electronic Industr.*, July 1946, Vol. 5, No. 7, pp. 62–67, 96.) A description of the Electronic Numerical Integrator and Computer (Eniac) with diagrams of some of the circuits. See also 1928 of July.

621.38 : 665.54 **2996**

Electronic Uses in Petroleum Refining.—(*Electronic Industr.*, July 1946, Vol. 5, No. 7, pp. 58 . . 106.) Electronic devices prove useful in catalytic petroleum processes where rapid and accurate means of following changes in complex chemical mixtures are necessary.

621.384 **2997**

Application of Pulse Technique to the Acceleration of Elementary Particles.—E. G. Bowen, O. O. Pulley & J. S. Gooden. (*Nature, Lond.*, 22nd June 1946, Vol. 157, No. 3999, p. 840.) May provide a cheap tool for studies in nuclear physics.

621.385.833 + 537.533.72 **2998**

Optical Characteristics of a Two-Cylinder Electrostatic Lens.—L. S. Goddard. (*Proc. Camb. Phil. Soc.*, June 1946, Vol. 42, Part 2, pp. 106–126.) "Explicit formulae are obtained for the focal lengths and the positions of the principal planes. These formulae involve the two parameters which completely specify the lens, namely, the voltage ratio σ and the gap width ϵ (the separation of the cylinders). . . Use of the method in conjunction with the relaxation method for determining electrostatic field distributions means that electrostatic electron optical systems of axial symmetry may be designed to a large extent in the office instead of in the laboratory."

621.385.833+537.533.72 **2999**

A Note on the Petzval Field Curvature in Electron-Optical Systems.—L. S. Goddard. (*Proc. Camb. Phil. Soc.*, June 1946, Vol. 42, Part 2, pp. 127–131.) The work of Glaser (2205 of 1941) is applied to obtain exact expressions for the Petzval field curvature in the case of both magnetic and electrostatic electron lenses. See also Klemperer & Wright (2483 of 1939) for similar work on a two-cylinder electrostatic lens.

778 : 537.533.8 : 621.386.1 **3000**

Secondary Electron Photography.—J. E. Roberts. (*Nature, Lond.*, 25th May 1946, Vol. 157, No. 3995, pp. 695–696.) Irradiation of printed matter with high-voltage X rays gives a positive image due to secondary emission of electrons from metallic ink particles.

621.38 : 6 **3001**

Electronics in Industry. [Book Review]—G. M. Chute. McGraw-Hill Book Co., New York, 1946, 461 pp., $5.00. (*Electronic Industr.*, Aug. 1946, Vol. 5, No. 8, p. 112.) ". . . prepared for instrumentation men and operating technicians in industry. . . ."

PROPAGATION OF WAVES

07(94) : 621.396.11 **3002**

Radio Propagation Bulletin : Council for Scientific and Industrial Research.—(*J. Instn Engrs Aust.*, March 1946, Vol. 18, No. 3, p. 61.) Notice of new Australian publication.

551.51.053.5 : 523.78"1945.07.09" : 621.396.11 **3003**

On the Results of Radio-Observations during the Solar Eclipse (Corpuscular and Ultra-Violet) of July 9, 1945.—Al'pert & Gorozhankin. (*See* 2893.)

551.51.053.5 : 523.78 **3004**

Solar Eclipses and Radio Investigations of the Ionosphere.—Al'pert & Gorozhankin. (*See* 2892.)

551.51.053.5 : 621.396.11 **3005**

Ionosphere Storm Effects in the *E* Layer.—Bennington. (*See* 2899.)

551.51.053.5 : 621.396.11 **3006**

On the Refractive Index of an Ionized Gas (Ionosphere).—Ginsburg. (*See* 2901.)

551.51.053.5 : 621.396.11 **3007**

Absorption of Radio Waves in the Ionosphere.—Ya. L. Al'pert & V. L. Ginsburg. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 2, pp. 42–67. In Russian.) Complete paper, of which an English summary was abstracted in 2514 of 1945.

621.396.11 + 621.392 **3008**

Propagation of Electromagnetic Waves along a Single Wire.—V. V. Vladimirski. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 3, pp. 139–149. In Russian.) Complete paper, of which an English summary was abstracted in 2533 of 1945.

621.396.11 **3009**

On a Certain Method of Solving Problems of Propagation of Electromagnetic Waves along the Surface of the Earth.—M. Leontovich. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 1, pp. 16–22. In Russian.) Complete paper, of which an English summary was abstracted in 2532 of 1945.

621.396.11 **3010**

The Propagation of Radio Waves along a Real Surface.—E. L. Feinberg. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 3, pp. 109–131. In Russian.) For an English version see 2529 of 1945. (In the second line of 2529 of 1945 "homogeneous" should read "inhomogeneous".)

621.396.11 3011
On the Effective Path of Radio Waves along the Ground.—E. L. Feinberg. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 3, pp. 132–138. In Russian.) For English version see 1962 of July.

621.396.11 3012
On the Theory of the Propagation of Radio Waves along a Real Surface.—E. L. Feinberg. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 4, pp. 200–209. In Russian.) Complete paper, of which an English summary was abstracted in 2531 of 1945.

621.396.11 : 551.5 3013
Radio Meteorology : Influence of the Atmosphere on the Propagation of Ultra-Short Radio Waves.—(*Nature, Lond.*, 29th June 1946, Vol. 157, No. 4000, pp. 860–862.) Summary of the proceedings of a joint conference of the Royal Meteorological Society and the Physical Society.

Appleton quoted instances of radar ranges beyond the geometrical horizon and showed that radio vision around the earth is possible when the lapse-rate of atmospheric refractive index is greater than 0.15×10^{-6} per metre. The most favourable combination for producing such an atmosphere is a temperature inversion associated with a lapse of water vapour pressure.

Sheppard "discussed the physical processes determining the vertical gradients of temperature and humidity in the bottom kilometre of the atmosphere."

Smith-Rose stated that there were indications that a simple theory was adequate to explain the observed fields of 9-cm and 3-cm waves over land and sea except for low-level links, and Booker discussed the duct process at these low levels.

Ryde stated that attenuation and back-scattering of centimetre waves ($\lambda \geqslant$ 2 cm) due to water droplets (diam. d of order 10μ) is proportional to d^3. For drizzle and rain, scattering follows Rayleigh's law [$\propto (d/\lambda)^4$]. Attenuations of 3-cm waves up to 1 db per km in Britain and 6 db per km in the tropics are deduced. See also 1972 (Robertson & King) and 1973 (Mueller) of July.

621.396.11 : 551.51.053.5 3014
Maximum Values of Radio Field Intensity on Vertical Reflection from the Ionosphere, and an Evaluation of the Coefficient of Reflection.—V. N. Kessenikh. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 2, pp. 68–75. In Russian.) Complete paper, of which an English summary was abstracted in 2522 of 1945.

621.396.11 : 551.51.053.5 : 523.746 3015
Sunspots and Radio Communication.—(*J. Franklin Inst.*, May 1946, Vol. 241, No. 5, pp. 369–371.) The occurrence between 29th Jan. and 11th Feb. 1946, of one of the largest sunspot groups ever recorded was the cause of severe disturbances to radio propagation. Bright eruptions associated with the group gave rise to a number of sudden "fade-outs" varying in length from a few minutes to several hours. These are believed to be due to increased ionization in the D region of the ionosphere with resulting increase in absorption. The central meridian passage of the main spot was followed 24 hours later by severe magnetic and ionospheric storms associated with auroral displays. High-frequency radio communication, particularly across the North Atlantic, was considerably interfered with due to depression of F_2-layer critical frequencies and increased absorption.

621.396.11 : 551.51.053.5 "1946.07" 3016
Short-Wave Conditions : Expectations for July.—T. W. Bennington. (*Wireless World*, July 1946, Vol. 52, No. 7, p. 222.)

621.396.11.029.63/.64 3017
Propagation of Short Radio Waves.—E. C. S. Megaw (mis-spelt Megan). (*S. Afr. Engng*, June 1946, Vol. 57, No. 6, p. 131.) Extracts from a paper read at the radiolocation convention of the I.E.E. For other accounts see 2576 of September and back reference.

621.396.67 3018
The Radiation Field of an Unbalanced Dipole.—Kelvin. (*See* 2822.)

RECEPTION

621.394/.397].822 + 621.392.6 3019
Suppression of Spontaneous Fluctuations in Amplifiers and Receivers for Electrical Communication and for Measuring Devices.—Strutt & van der Ziel. (*See* 2843.)

621.394/.397].822 + 621.392.6 3020
Suppression of Spontaneous Fluctuations in 2*n*-Terminal Amplifiers and Networks.—van der Ziel & Strutt. (*See* 2844.)

621.394/.397].822 3021
Fluctuations of Electric Current.—D. A. Bell. (*J. Instn elect. Engrs*, Part I, June 1946, Vol. 93, No. 66, p. 275.) Long abstract of 1038 of April.

621.396.61/.62 3022
"Portarig" Ham Station.—Scott. (*See* 3098.)

621.396.61/.62].029.5 : 629.135 3023
A General-Purpose Radio-Communication Equipment for Military Aircraft.—W. W. Honnor & J. P. Blom. (*A.W.A. tech. Rev.*, March 1946, Vol. 6, No. 8, pp. 505–518.) Provides for transmission over frequency ranges 140–500 kc/s and 2–20 Mc/s with crystal control over parts of the h.f. range, and reception over the whole range 140–20 000 kc/s. Operation on c.w., m.c.w., and telephony is provided for, and d.f. and homing systems are incorporated. For more details of the receiver see 3032 below.

621.396.615 : 621.396.662 3024
Permeability-Tuned Oscillators.—Hunter. (*See* 3103.)

621.396.619 3025
F.M.–A.M. Conversion at U.H.F.—W. van Roberts. (*Electronic Industr.*, July 1946, Vol. 5, No. 7, p. 82.) The f.m. signal is passed through a waveguide slightly above the cut-off diameter. The attenuation in the pipe increases rapidly with increase in frequency, so that the emerging wave is amplitude-modulated. Summary of U.S. Patent 2 393 414.

621.396.621 + 534.43 3026
A New Radiogramophone — Svenskradio 1467.—C. Fredin. (*Ericsson Rev.*, 1946, Vol. 23, No. 1, pp. 44–47.) Specification and circuit diagram.

621.396.621 3027
Radio Data Sheet 336.—(*Radio Craft*, June 1946, Vol. 17, No. 9, p. 615.) Data for Belmont Radio Model 6D111, Series A.

621.396.621 3028
Sobell Type 615 [broadcast receiver].—(*Wireless World*, July 1946, Vol. 52, No. 7, pp. 226–227.) Test report and circuit diagram.

621.396.621 3029
Ex-R.A.F. Communication Receiver.—"Ex-Signals". (*Wireless World*, July 1946, Vol. 52, No. 7, pp. 212–216.) Description of R.A.F. receiver type R.1155, with practical details for converting it to civilian needs, including elimination of direction-finding circuit, construction of a power pack, and provision for loudspeaker operation. Circuit diagrams and component values of the receiver are included.

621.396.621 3030
An Amateur-Band Eight-Tube Receiver.—B. Goodman. (*QST*, Aug. 1946, Vol. 30, No. 8, pp. 13–18.) Constructional details of a communication-type receiver with frequency ranges limited to the amateur bands.

621.396.621 : 621.396.828 3031
[Methods of] **Reducing Hum Levels** [in mains receivers].—J. King. (*Radio Craft*, June 1946, Vol. 17, No. 9, pp. 619..648.)

621.396.621.029.5 : 629.135 3032
A General-Purpose Communication Receiver for Military Aircraft.—J. B. Rudd & T. R. W. Bushby. (*A.W.A. tech. Rev.*, March 1946, Vol. 6, No. 8, pp. 519–527.) A more detailed description of the receiver section of the equipment described in 3023 above, with a schematic diagram.

621.396.621.029.5 : 629.135 3033
A Ten-Channel Aircraft Receiver.—J. B. Rudd. (*A.W.A. tech. Rev.*, March 1946, Vol. 6, No. 8, pp. 489–504.) A superheterodyne for either local or remote control on any one of ten crystal-controlled frequencies from 200 to 13 000 kc/s. Alternatively a manually tuned range covers 200-400 kc/s. A cathode-follower input circuit is used, and the beat oscillator may be remotely controlled.

621.396.621.029[.58 + .62 3034
F.M. and A.M. Receiver for Comparison Tests.—W. F. Frankart. (*Electronics*, July 1946, Vol. 19, No. 7, p. 168.) Brief description and circuit diagram. Tuning range 15–170 Mc/s, sensitivity 1 μV. The performance was improved by the use of germanium crystal diodes.

621.396.622 3035
Applying A.M.D. [audio-modulated detection] **to the Communications Receiver.**—D. A. Griffin & L. C. Waller. (*QST*, Aug. 1946, Vol. 30, No. 8, pp. 56–61..136.) Constructional details of an adaptor for a communication receiver comprising an audio oscillator, squaring amplifier, selective amplifier, and a power supply. For a discussion of the merits of the system see 2694 of September (same authors).

621.396.622.72 3036
Oscillation Hysteresis in Grid Detectors.—Zepler. (See 2854.)

621.396.682 : 621.396.621 3037
A.C./D.C. Voltage Dropping.—W.T.C. (*Wireless World*, July 1946, Vol. 52, No. 7, pp. 236–237.) The use of a series resistor for reducing the mains voltage applied to an a.c./d.c. series-heater receiver is unsatisfactory with a.c. mains. The rectifier conducts only at the peaks of the positive half-cycles and causes additional voltage drop at those periods. Adjustment of the dropping resistor to give correct effective heater current therefore gives too low a voltage for the h.t. supply. Two alternative schemes for overcoming this difficulty are suggested.

621.396.82 : 551.57 : 629.135 3038
Flight Research on Precipitation Static.—E. L. Cleveland. (*Electronic Industr.*, Aug. 1946, Vol. 5, No. 8, pp. 66–69, 94.) A general account of the causes, effects, and remedies. See also 1991/1993 of July and 2322, 2323 & 2344 of August (U.S. Army-Navy precipitation-static project).

621.397.823 3039
Tele[vision] **Interference : Parts 1 & 2.**—Goldsmith. (*See* 3097.)

621.396/.397].62 3040
Radio Receiver Design. Part 2 : Audio Frequency Amplifiers, Television and Frequency Modulated Receiver Design. [Book Review]—K. R. Sturley. Chapman & Hall, London, 1945, 480 pp., 28s. (*Nature, Lond.*, 8th June 1946, Vol. 157, No. 3997, p. 751.) This volume, with its companion, Part 1, "forms a most useful work of reference for the radio engineer and designer". For other reviews see 414 of February and 728 of March.

STATIONS AND COMMUNICATION SYSTEMS

621.394/.396] "1846/1946" 3041
Development in Teletechnics 1846–1946 : Tele-Signalling.—T. Ericsson. (*Ericsson Rev.*, 1946, Vol. 23, No. 2, pp. 150–160.)

621.394/.395] "1846/1946" 3042
Developments in Teletechnics 1846–1946 : Telegraphy and Telephony.—N. Heden. (*Ericsson Rev.*, 1946, Vol. 23, No. 2, pp. 122–149.)

621.395.44 : [621.315.052.63 + 621.398 3043
New Carrier Frequency Systems for Telephony and Remote Metering and Control on Power Lines.—S. Rohde. (*Ericsson Rev.*, 1946, Vol. 23, No. 1, pp. 2–34.) A discussion of the fundamentals of carrier-frequency transmission over power lines leading up to a description of the Ericsson equipment giving telephone, teleprinter, remote metering, and control-signal facilities.

Single-sideband working is used with carrier frequencies in the band 50–150 kc/s; different frequencies are used for receiving and transmitting telephony, and for the remote metering and control channels. The modulation and demodulation processes involved are explained. The terminal equipment, protective devices, and auxiliary equipment are described.

A telephone channel range of 300–400 km on a 220-kV line is obtained without repeaters.

621.395.44 3044
Three-Channel Carrier Telephone System for Open-Wire Lines.—T. Bohlin. (*Ericsson Rev.*, 1946, Vol. 23, No. 1a, pp. 50–70.) A detailed description

of a modern system for carrier telephone communications. For distances up to 500 km only terminal equipment is required, but for long distances up to several thousand kilometres intermediate repeaters are inserted. Each channel uses a frequency band of 300–2 700 c/s, and transmission and reception occupy the whole range from 6 kc/s to 30 kc/s, different frequencies being used in different directions. Attenuation curves are given, and the effect of wet and dry weather indicated.

621.395.64 **3045**

Rural Line Repeater with Negative Feedback.—J. Ljungberg. (*Ericsson Rev.*, 1946, Vol. 23, No. 1a, pp. 71–74.) The equipment consists of 2-wire repeaters which can be connected to the mains, and is suitable for use where a normal repeater station is not warranted.

621.395.823 **3046**

Practical Aspects of Telephone Interference arising from Power Systems.—P. B. Frost & E. F. H. Gould. (*J. Instn elect. Engrs*, Part I, June 1946, Vol. 93, No. 66, pp. 255–274.) Experimental paper divided into six sections. (1) Electromagnetic induction at fundamental frequency; good agreement between calculated and measured values of induced voltage usually obtains; (2) interference at audio frequencies; mainly from faulty power lines due to induction of harmonic components; (3) multiple earthing of high-voltage systems; (4) multiple earthing of low-voltage systems; (5) apparatus developments; gas-discharge tubes, noise-eliminating filters, improved psophometer; (6) rise of earth potential; damage produced near faults in power systems.

621.396 "1846/1946" **3047**

Developments in Teletechnics 1846-1946: Radio-Technics.—T. Övergaard. (*Ericsson Rev.*, 1946, Vol. 23, No. 2, pp. 161–174.)

621.396.13 **3048**

A Preview of the Western Union System of Radio Beam Telegraphy: Part 1.—J. Z. Millar. (*J. Franklin Inst.*, June 1946, Vol. 241, No. 6, pp. 397–413.) Includes a history of the electric telegraph, with brief descriptions of the teleprinter, multiplex, and facsimile equipment, and of carrier telegraphy using f.m. for wire line operation. A general description is given of the projected system of radio-beam telegraphy which will eventually replace all line telegraph facilities and provide channels for relaying television. The experimental equipment at present in use operates at 4 000 Mc/s, and microwave techniques developed in the last few years are incorporated. Propagation tests in four frequency bands are also being carried out.

621.396.13 : 621.396.97 **3049**

Multiplex Broadcasting.—D. D. Grieg. (*Elect. Comm.*, March 1946, Vol. 23, No. 1, pp. 19–26.) Proposals for broadcasting multiple programmes over the widest area by means of a u.h.f. relay network using a multiplex system. The system offers great economy of relay equipment. Methods of multiplexing are reviewed, and pulse-time methods are shown to be preferable.

621.396.6.029.58 **3050**

Practical Break-In Operation.—W. H. Allen. (*R.S.G.B. Bull.*, July 1946, Vol. 22, No. 1, pp. 7–9.) Intervals in transmission may be used for replies or repetition requests from the receiving end. Practical requirements and circuits are described.

621.396.61.029.64 **3051**

Our Best DX—800 Feet!—A. H. Sharbaugh & R. L. Watters. (*QST*, Aug, 1946, Vol. 30, No. 8, pp. 19–22, 24.) Description of apparatus used to obtain two-way telephone communication over a range of 800 ft at a frequency of 21 900 Mc/s. Transmitter and receiver used the same oscillator, a General Electric Z-668 reflex velocity-modulated tube. The power radiated was less than 10 mW.

621.396.619.018.41 **3052**

Frequency Modulation.—T. J. Weijers. (*Philips tech. Rev.*, Feb. 1946, Vol. 8, No. 2, pp. 42–50.) General description of methods of modulating r.f. waves, with a detailed treatment of frequency modulation. The main characteristics necessary for f.m. transmitters and receivers are discussed, and a section is added on non-quasi-stationary phenomena in networks.

621.396.619.16 **3053**

Pulse-Time Modulation.—J. Zwislocki-Moscicki. (*Electronic Industr.*, July 1946, Vol. 5, No. 7, p. 80.) Illustrated summary of a paper in *Bull. schweiz. elektrotech. Ver.*, 25th July & 22nd Aug. 1945, Nos. 15 & 17. A frequency-modulated beat note of about 50 kc/s is obtained between a steady oscillation and a frequency-modulated oscillation of about 1 Mc/s. The beat signal is formed into pulses and used to key a high-frequency (in this case 30-Mc/s) transmitter. In the receiver, the pulses control the frequency of a dynatron square-wave generator from which a signal is passed to a discriminator. Calculations of the effect of a disturbing signal are given in the original paper.

621.396.619.16 **3054**

Pulse Modulation.—E. Fitch: E. R. Kretzmer. (*Wireless Engr*, Aug. 1946, Vol. 23, No. 275, pp. 231–233.) Two letters discussing 183 of January (Roberts & Simmonds) and 1676 of June (Shepherd). Formulae more exact than those given in 183 are deduced for phase-modulated and duration-modulated pulses. See also 2707 of September (Roberts & Simmonds).

621.396.712.004.5 **3055**

Preventive Maintenance for Broadcast Stations: Part 2.—C. H. Singer. (*Communications*, July 1946, Vol. 26, No. 7, pp. 28..55.) Discussion of the purpose, handling, and packing of maintenance tools, including wrenches, drills, etc. For part 1 see 2709 of September. To be continued.

621.397 + 534.862 **3056**

S.M.P.E. [Society of Motion Picture Engineers] **Spring Technical Conference** [New York, May 1946].—(*See* 3087.)

629.135 : 621.396.82 : 551.57 **3057**

Flight Research on Precipitation Static.—Cleveland. (*See* 3038.)

SUBSIDIARY APPARATUS

537.531 **3058**

A Simple X-Ray Spectrometer.—R. S. Rivlin & H. P. Rooksby. (*J. sci. Instrum.*, July 1946, Vol. 23, No. 7, pp. 148–150.) Built of Meccano parts and sufficiently accurate for the determination of crystal axes.

551.57 : 518.3 **3059**
Measurement of Atmospheric Humidity.—E. C. Woods. (*Distrib. Elect.*, July 1946, Vol. 19, No. 163, pp. 152–153.) A nomogram for the direct indication of relative humidity from wet and dry bulb temperatures.

621–712 **3060**
Low Temperatures at Low Cost.—H. N. Brown. (*J. Franklin Inst.*, Dec. 1945, Vol. 240, No. 6, pp. 487–495.) Design details of a temperature test chamber for small electronic components. Preheated to 100° C, it is cooled steadily at 2/3° C/min to −60° C by gases circulated over solid carbon dioxide. Means of controlling the cooling rate are described, and introduction of moisture is guarded against. Other applications of the equipment should be possible.

621.3.066.6 : 629.1–272 **3061**
Electrical Contact Springs.—(*J. Instn elect. Engrs*, Part III, July 1946, Vol. 93, No. 24, p. 242.) Discussion before the I.E.E., opened by L. B. Hunt and H. G. Taylor. For previous accounts see 2786 and 2787 of 1945.

621.314.2.017 **3062**
Thermal Characteristics of Transformers : Part 2.—V. M. Montsinger. (*Gen. elect. Rev.*, May 1946, Vol. 49, No. 5, pp. 31–40.) Methods of calculating temperature rise in windings and in cooling media are applied to transformer problems. The effects of shape and surface colour and of wind and altitude on heat dissipation are discussed. For part 1 see 2015 of July. To be continued.

621.314.2.029.5 : 621.396.619.018.41 **3063**
The Theory and Design of Intermediate-Frequency Transformers for Frequency-Modulated Signals.—Ross. (*See* 2831.)

621.314.5 **3064**
Exciter-Regulator for Aircraft Alternators.—P. T. Hadley, A. W. Forsberg & O. Krauer. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 120–122.) A description of a system of self-excitation of an alternating-current generator using an electronic exciter controlled by a voltage regulator. Circuit diagrams and performance are given for two equipments, a 3-phase constant-frequency main supply, and a single-phase variable-frequency auxiliary supply.

621.314.632.029.62 : [546.28 + 546.289 **3065**
Crystal Rectifiers.—Stephens. (*See* 3108.)

621.315.21.029.4/.6] : 536.4 **3066**
The Power Rating (Thermal) of Radio-Frequency Cables.—R. C. Mildner. (*J. Instn elect. Engrs*, Part III, July 1946, Vol. 93, No. 24, pp. 296–304.) "The principles used in calculating the temperature rise in cables which are required to transmit radio-frequency power are considered. The theoretical attenuation characteristics and power ratings of a number of standard r.f. cables are set down in graphical form for a wide range of operating frequencies. The ratings are based on a maximum temperature rise of 30° C in an ambient of 55°C, established in a matched line for the steady-state condition. The use of suitable " rating factors " for other operating conditions is proposed. The effect of such operating conditions as the presence of standing waves and the effect of end cooling are briefly considered in relation to the rating of the cables."

621.315.668.2 **3067**
Steel Towers for Transmission Lines.—P. J. Ryle. (*Nature, Lond.*, 29th June 1946, Vol. 157, No. 4000, p. 881.) Formula for above-ground weight in terms of overall height and overturning moment. Summary of an I.E.E. paper.

621.316.578.1 **3068**
Variable Timing up to Thirty Seconds.—D. G. Haines. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 154 . . 158.) Short description, with circuit diagram, of an equipment primarily for controlling photographic exposures. Minimum time 0.5 sec.

621.316.722.078.3 **3069**
Voltage Stabilization.—W. Easton. (*Elect. Rev., Lond.*, 28th June 1946, Vol. 138, No. 3579, pp. 1013–1015.) A stabilizer is described giving a stability of better than 1 in 1 000 when connected to a 440-V 3-phase d.c. supply subject to a 12% variation of voltage.

621.316.74 : 621.396.611.21 **3070**
Oven for Airborne Piezoelectric Crystals.—S. Eaton. (*Elect. Comm.*, March 1946, Vol. 23, No. 1, p. 41.) A small unit on a standard 11-pin base for maintaining crystals at a temperature of 75 ±1°C over the range of ambient temperature −40° to +70°C, with a variation of less than 0.3°C for a constant ambient temperature.

621.317 **3071**
Exhibition of British Scientific Instruments in Sweden.—(*J. sci. Instrum.*, July 1946, Vol. 23, No. 7, pp. 137–138.)

621.317.755 : 578.088.7 **3072**
Double-Beam C.R. Tube in Biological Research.—T. H. Bullock. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 103–105.) Instructions for modifying the DuMont 247 oscilloscope to take the 5SP double-beam tube, with an account of some of the resulting facilities.

621.317.755.087.5 : 620.172.222 **3073**
A Six-Channel Electronic Recorder.—M. Scott. (*Electronic Engng*, Aug. 1946, Vol. 18, No. 222, pp. 233–235, 261.) Description of a 6-c.r.-tube oscillograph giving simultaneous records photographed by a single camera unit on 120-mm paper moving at 0.5 to 1 000 inch/sec. Each tube has an a.c./d.c. amplifier (0–10 kc/s), monitor tube, and a calibration and time-marking unit controlled by a 1-kc/s fork oscillator. Primarily designed for strain-gauge bridge measurements; built-in balancing units allow 48 channels to be switched in batches of 6 without rebalancing the bridge.

621.385.833 **3074**
Electron Microscope of the State Optical Institute.—V. N. Vertzner. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 232–234. In Russian.) Description of the microscope and its lenses, with examples of the magnification produced. See also 2302 of 1945. English summary noted in 1948 of July.

621.386.1 **3075**
X-Ray Tubes with Rotating Anode (" Rotalix " Tubes).—J. A. van der Tuuk. (*Philips tech. Rev.*, Feb. 1946, Vol. 8, No. 2, pp. 33–41.) The latest tubes are described, and various problems connected with the rotating anode are discussed.

621.395.625.6 : 621.383 3076

A Phototube for Dye Image [colour film] **Sound Track.**—A. M. Glover & A. R. Moore. (*J. Soc. Mot. Pict. Engrs*, May 1946, Vol. 46, No. 5, pp. 379–386.)

621.395.625.6 : 621.383 3077

Behavior of a New Blue-Sensitive Phototube [for black-and-white or colour film tracks] **in Theater Sound Equipment.**—Phyfe. (*See* 2806.)

621.396.62 + 621.317.35 3078

Alarm System for Panoramic Receivers.—W. A. Anderson. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 92–95.) A motor-driven commutator divides each sweep period of the panoramic display into 40 equal parts and supplies a direct voltage with an independently controlled amplitude during each part. The output from this device is added to the receiver output and adjusted to cancel the cathode-ray deflexions produced by the received signals. Deflexions produced by reception of a new signal or by drift of the frequency of a signal previously neutralized triggers an alarm circuit. Other applications of the device (*e.g.* for coded transmission and network analysis) are mentioned.

621.396.682.029.4/.6 3079

R.F. Power Supplies.—M. Rhita. (*Radio Craft*, June 1946, Vol. 17, No. 9, pp. 616..647.) A 300-kc/s oscillator with an air-cored transformer and rectifier produces 10 kV for c.r.t. operation.

771.35 3080

A Classification of Photographic Lens Types.—R. Kingslake. (*J. opt. Soc. Amer.*, May 1946, Vol. 36, No. 5, pp. 251–255.) The classification, based on the number of components in the lens, has been used in the Eastman Kodak Company for several years.

539.16.08 + 621.318.572 3081

Electron and Nuclear Counters. [Book Review]—S. A. Korff. D. Van Nostrand, New York, 212 pp., $3.00. (*Electronic Industr.*, July 1946, Vol. 5, No. 7, p. 112.) Deals with the action and construction of counter tubes and auxiliary electronic circuits. ". . . an extensive and scholarly summary. . . ."

621.327.3/.4 3082

Electric Discharge Lamps. [Book Review]—H. Cotton. Chapman & Hall, London, 435 pp., 216 figs., 36s. (*Elect. Rev., Lond.*, 5th July, 1946, Vol. 139, No. 3580, p. 26.) ". . . gives a most valuable account of the whole subject. . . ."

TELEVISION AND PHOTOTELEGRAPHY

621.32 : 621.397.5 3083

An Appraisal of Illuminants for Television Studio Lighting.—R. E. Farnham. (*J. Soc. Mot. Pict. Engrs*, June 1946, Vol. 46, No. 6, pp. 431–440.) Discussion of required spectral sensitivity and illumination levels, and description of suitable sources.

621.325 : 621.397.5 3084

Carbon Arcs for Motion Picture and Television Studio Lighting.—F. T. Bowditch, M. R. Null & R. J. Zavesky. (*J. Soc. Mot. Pict. Engrs*, June 1946, Vol. 46, No. 6, pp. 441–453.) Discussion of photometric and spectral energy distribution of carbon arc sources and their future use in television.

621.383.8 3085

The Image Orthicon — A Sensitive Television Pickup Tube.—A. Rose, P. K. Weimer & H. B. Law. (*Proc. Inst. Radio Engrs, W. & E.*, July 1946, Vol. 34, No. 7, pp. 424–432.) A detailed account of the tube described more briefly in 1376 of May. For application see 2374 of August (Kell & Sziklai).

621.396.615.17 : 621.397.645 3086

Electromagnetic Deflection : Television Line Scanning Amplifier.—W. T. Cocking. (*Wireless World*, July 1946, Vol. 52, No. 7, pp. 217–222.) Discussion of circuit technique using a pentode or tetrode valve transformer-coupled to the deflector coil in a television line-scanning amplifier. Detailed analysis is given of the equivalent circuit of a typical amplifier. A linear scan may be obtained, using standard silicon-steel transformer cores, from a saw-toothed input which is rounded at the beginning and end of the fly-back, thus eliminating very high component frequencies. It is generally assumed that the circuit should be critically damped to avoid oscillations causing nonlinearity at the start of the scan, but by slightly underdamping, the effective capacitance across the primary circuit can be charged, by the overswing, to the correct value to suit the start of the scan. Details of a practical circuit and its adjustment for correct operation are given.

621.397 + 534.862 3087

S.M.P.E. [Society of Motion Picture Engineers] **Spring Technical Conference** [New York, May 1946].—(*Electronics*, July 1946, Vol. 19, No. 7, pp. 188..198.) An account of the proceedings, including abstracts of the following papers : Modernization Desired in Studio Equipment, by L. L. Ryder; Theater Television, by L. B. Isaac; Unified Approach to Film [television] Pickup Tubes, and the Eye, by A. Rose; Color Television, by P. C. Goldmark; Factors Governing Frequency Response [in film sound recording], by M. Rettinger & K. Singer; Theater Servicing Test Equipment, by E. Stanko & P. V. Smith.

621.397 : 621.396.931 3088

Facsimile to Moving Train *via* V.H.F.—(*Electronics*, July 1946, Vol. 19, No. 7, pp. 168..178.) General description, with block diagrams.

621.397.26 3089

The B.B.C. Television Waveform.—(*J. Televis. Soc.*, Dec. 1945, Vol. 4, No. 8, p. 196.) See also 2368 of August.

621.397.26 3090

Strato-Television.—C. E. Nobles. (*J. Televis. Soc.*, Dec. 1945, Vol. 4, No. 8, pp. 200–203.) An account of the Westinghouse proposals. See also 3970 of 1945 and 2370 of August.

621.397.26 3091

A Method of Transmitting Sound on the Vision Carrier of a Television System.—D. I. Lawson, A. V. Lord & S. R. Kharbanda. (*J. Instn elect. Engrs*, Part III, July 1946, Vol. 93, No. 24, pp. 251–274.) "The paper describes a television system in which sound pulses having a constant height and variable width are inserted in the line synchronizing periods. It is claimed that this method of transmission leads to a simplified receiver, and that the programme quality is better in the presence of severe interference. Other advantages are that the frequency bandwidth for transmission is reduced; the method of receiving sound ensures automatic volume control; the sound pulses provide a fixed reference level for automatic volume control on the vision channel; mutual interference between vision and sound often present on two-channel reception is avoided; reduced transmission bandwidth simplifies the design of the receiving antenna; mutual coupling between the vision and sound antennae at the transmitter is avoided; and the installation and maintenance costs of the sound transmitter are saved.

"The frequency range of the system operated in conjunction with the pre-war British transmission would be limited to 5 kc/s."

For earlier less detailed accounts of the system see 459 of February and back references. See also 382 of May (Fredendall, Schlesinger & Schroeder).

621.397.5 **3092**

Studio Technique in Television.—D. C. Birkinshaw & D. R. Campbell. (*J. Instn elect. Engrs*, Part III, July 1946, Vol. 93, No. 24, pp. 293–294.) Discussion of I.E.E. paper. See 3961 of 1945 and 781 of March.

621.397.5 **3093**

Informal Meeting [of the Television Society] **and Exhibition.**—(*J. Televis. Soc.*, Dec. 1945, Vol. 4, No. 8, pp. 197–199.) Descriptions of some of the items exhibited.

621.397.6 : 621.396.67 **3094**

C.B.S. Tele Antenna.—Sather. (*See* 2826.)

621.397.62 : 621.317.79 **3095**

A Television Signal Generator: Part 3—R.F. Circuits and Monitors.—Hibberd. (*See* 2980.)

621.397.64 **3096**

[Frequency compensation in] **Video Amplification.**—J. McQuay. (*Radio Craft*, June 1946, Vol. 17, No. 9, pp. 613..655.)

621.397.823 **3097**

Tele[vision] **Interference: Parts 1 & 2.**—T. T. Goldsmith. (*Electronic Industr.*, July & Aug. 1946, Vol. 5, Nos. 7 & 8, pp. 60–61, 108 & 73–75..96.) A general analysis of signal sources which may affect both picture and sound reception quality, with (part 2) specific recommendations for engineering changes that can be made to effect improvement.

TRANSMISSION

621.396.61/.62 **3098**

"Portarig" Ham Station.—R. F. Scott. (*Radio Craft*, June 1946, Vol. 17, No. 9, pp. 611..650.) A transmitter-receiver with crystal control for mains or 6-V battery operation.

621.396.61 **3099**

Frequency Meters as Master Oscillators.—E. H. Franklin. (*QST*, Aug. 1946, Vol. 30, No. 8, pp. ..132.) Description of an amplifier for boosting the output of a frequency meter (U.S. Service type) so that it may be used to control the frequency of a transmitter. The accuracy of frequency control is found to be about 100 cycles per megacycle under severe changes of temperature and humidity.

621.396.61/.62].029.5 : 629.135 **3100**

A General-Purpose Radio-Communication Equipment for Military Aircraft.—Honnor & Blom. (*See* 3023.)

621.396.61.029.5 : 629.135 **3101**

A Communication Transmitter for Civil Aircraft.—J. G. Downes. (*A.W.A. tech. Rev.*, March 1946, Vol. 6, No. 8, pp. 473–488.) The oscillator uses crystals for 2.5 to 13 Mc/s and tuned circuits for 300 to 510 kc/s. It drives a power amplifier (output 40 W) which is anode-modulated by an audio amplifier to provide telephony, c.w. telegraphy, and modulated c.w. telegraphy. Frequency selection is accomplished by means of a turret switch driven by an electric motor through gearing and a geneva movement.

621.396.615 **3102**

Raising the Efficiency of the V.H.F. Linear Oscillator.—G. D. Perkins & H. G. Burnett. (*QST*, Aug. 1946, Vol. 30, No. 8, pp. 48–52.) A description of practical details for the frequency range 140–250 Mc/s.

621.396.615 : 621.396.662 **3103**

Permeability-Tuned Oscillators.—T. A. Hunter. (*QST*, Aug. 1946, Vol. 30, No. 8, pp. 42–46.) A comparison between variable permeability- and capacitance-tuned oscillators shows (*a*) the range of permeability tuning is restricted to about 3 : 1 compared with 4 : 1 for capacitance tuning; (*b*) less frequency drift occurs with permeability-tuned oscillators during warming-up time, as the total tuning capacitance may be made larger than for capacitance-tuned oscillators with the same frequency range; (*c*) temperature compensation may be applied to both types of oscillator; (*d*) the permeability-tuned oscillator is superior to the other in frequency stability when subjected to mechanical vibration.

621.396.619.018.41 **3104**

F.M. Carrier Stabilization: Part 2—Western Electric, Westinghouse, R.C.A. Circuits.—I. Queen. (*Radio Craft*, June 1946, Vol. 17, No. 9, pp. 605..637.) For part 1 see 2765 of September.

621.396.619.018.41 : 621.396.66 **3105**

Direct F.M. Frequency-Control Methods.—N. Marchand. (*Communications*, July 1946, Vol. 26, No. 7, pp. 30–35.) Discussion of three methods for stabilizing the centre frequency of an f.m. transmitter which uses a direct system of modulation. Basic circuits for each of the methods are presented and analysed. Part 7 of a series. For previous parts, see 2767 of September and back references.

621.396.712 **3106**

Canada's New Short Wave Transmitters.—H. B. Seabrook & F. R. Quance. (*Electronic Industr.*, July 1946, Vol. 5, No. 7, pp. 72–74..105.) Engineering details. See also 193 of January (Smith) and 744 of March (Cahoon).

VALVES AND THERMIONICS

621.3.032.216 : 537.533.8 **3107**

Secondary Electron Emission from Oxide-Coated Cathodes: Part 1.—M. A. Pomerantz. (*J. Franklin Inst.*, June 1946, Vol. 241, No. 6, pp. 415–433.)

An investigation of factors affecting the yield of secondary electrons under both continuous and pulsed bombardment. The variations of yield and energy distribution with primary voltage and with temperature have been determined, and these and other phenomena are discussed in the light of the present state of the theory.

621.314.632.029.62 : [546.28 + 546.289 **3108**

Crystal Rectifiers.—W. E. Stephens. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 112–119.) A description of the mechanical construction and performance of germanium and silicon rectifiers developed for frequency conversion and signal detection at microwavelengths. The preparation and electrical properties of the materials are described. Noise, stability, and the dependence of the properties on temperature are considered, and properties of 22 types of rectifier with assigned type-numbers are tabulated. See also 1728 of June (Cornelius).

621.385 **3109**

Total Emission Damping with Space-Charge-Limited Cathodes.—C. N. Smyth. (*Nature, Lond.*, 22nd June 1946, Vol. 157, No. 3999, p. 841.) Electrical damping at very high radio frequencies may be due to emission from the cathode surface which returned to the cathode after a time comparable with the h.f. period. The effect could be reduced by cooling the cathode, and was not detectable at low frequencies. Such damping behaves as a source of noise with the general characteristics of 'shot' noise.

621.385 **3110**

Valve Standardization.—J. W. Ridgeway. (*Wireless World*, July 1946, Vol. 52, No. 7, pp. 239–240.) Report by the Chairman of the British Valve Manufacturers' Association, on progress towards the manufacture of valves having standard working characteristics.

621.385 : 003.6 **3111**

Suggested Rules for Symbols in Valve Nomenclature.—(*Electronic Engng*, Aug. 1946, Vol. 18, No. 222, p. 254.) Extracts from rules proposed by the British Valve Manufacturers' Association for use in technical literature issued by its members.

621.385.1 **3112**

The Effect of Grid-Support Wires on Focusing Cathode Emission.—Chai Yeh. (*Proc. Inst. Radio Engrs, W. & E.*, July 1946, Vol. 34, No. 7, pp. 444–447.) A conformal transformation is applied to a half section of a valve system consisting only of anode and cathode, with grid-support wires. Those parts of the cathode that have a positive field adjacent due to electrostatic charges on the electrodes are thereby determined, enabling the angle of electron emission to be found. Curves show the variation of this angle with anode and grid potentials and with electrode dimensions and spacings.

621.385.16 **3113**

The Magnetron.—W. E. Willshaw & E. C. S. Megaw. (*Engineering, Lond.*, 19th April 1946, Vol. 161, No. 4188, pp. 361–363.) Illustrated general description.

621.385.16.029.64 **3114**

Rising Sun Pulsed and C.W. Magnetrons.—H. G. Shea. (*Electronic Industr.*, Aug. 1946, Vol. 5, No. 8, pp. 46–50.) The construction and performance of cavity magnetrons with alternate small and large cavities are described. Oscillations in unwanted modes are suppressed with more efficient operation than is obtained with the strapped-anode technique. Other advantages are (*a*) larger and simpler structure for a given small wavelength (*e.g.* 6 mm), (*b*) mode separation independent of anode-block thickness, (*c*) mode separation persists for a relatively large number of cavities (*e.g.* 38), (*d*) copper losses are less than with strapped anodes. An important disadvantage is zero-mode contamination of the wanted π mode for magnetic fields near $12\,000/\lambda$ oersted. A c.w. magnetron with a tungsten-coil cathode gave 900 W with 26% efficiency at 2.6 cm wavelength.

621.385.3/.4].029.62 **3115**

High Power Tubes for V.H.F. Operation.—W. W. Salisbury. (*Communications*, June 1946, Vol. 26, No. 6, pp. 33, 49.) Survey of triodes and tetrodes giving powers above 1 kW usable at frequencies between 100 and 220 Mc/s.

621.385.3.029.63 : 621.397.61 **3116**

High-Power U.H.F. Tube.—(*Radio Craft*, June 1946, Vol. 17, No. 9, pp. 608..640.) The 6C22 valve, anode dissipation 2 kW, and its use in the Columbia 490-Mc/s colour television transmitter.

621.385.38 : 621.396.619.16 **3117**

Hydrogen Thyratrons.—H. Heins. (*Electronics*, July 1946, Vol. 19, No. 7, pp. 96–102.) A description of the 4C35 and 5C22 tubes developed for use with high-voltage line pulse-forming circuits used for modulating magnetrons. Hydrogen filling gives the required low de-ionization time. The special construction and properties are discussed in relation to the mechanism of the modulator circuits. Switching rates up to 5 000 per sec have been obtained with the 5C22 with 8 kV and 75 A peak current, and rates over 100 000 per sec have been obtained with the 4C35 at lower voltages and currents. Possible industrial applications are mentioned.

621.385.4 **3118**

Space Charge and Electron Deflections in Beam Tetrode Theory.—S. Rodda. (*J. Televis. Soc.*, Dec. 1945, Vol. 4, No. 8, pp. 182–193. Discussion, pp. 193–195.) Secondary emission from the anode is annulled in beam tetrodes by a sufficient depression of potential in the screen/anode space, produced either by the space charge alone or with the aid of auxiliary electrodes. The potential distribution in the space is calculated by extending Gill's analysis for a plane parallel system (*Phil. Mag.*, 1925, Vol. 49, pp. 993–1005.) The critical current condition in which a virtual cathode is formed is found to give "knee" voltages (anode voltages at which the characteristic abruptly flattens) much higher than the observed values. The assumptions of transverse deflexions of the electrons at the grid and screen wires and of reflection at a finite non-zero potential lead to results in fair agreement with experiment.

621.385.4 **3119**

Beam Tetrodes.—S. Rodda. (*Wireless Engr*, July 1946, Vol. 23, No. 274, pp. 202–203.) Assuming copious emission of secondary electrons with zero velocity, it is shown that the space charge due to the secondary electrons plays an important part in producing a potential minimum in the screen/anode space, when the primary electron flow itself is insufficient for the formation of the minimum. Brief note only.

621.385.4 **3120**
The 6AR6 Tube.—E. A. Veazie. (*Bell Lab. Rec.*, July 1946, Vol. 24, No. 7, pp. 264–265.) Short description of the design and performance of a small beam-tetrode that can operate with 20 W anode dissipation and 1 300 V anode voltage.

621.385.5 : 621.395.645 **3121**
Dynamic Characteristics of Pentodes.—Haefner. (*See* 2846.)

621.385.5 : 621.395.645 **3122**
Reentrant Pentode A.F. Amplifier.—R. Adler. (*Electronics*, June 1946, Vol. 19, No. 6, pp. 123–125.) A special pentode operating as two triodes in cascade giving gains up to 500 with a 45-V plate supply. Control of regeneration, and design precautions to be observed are discussed. The second grid forms the anode of the first triode, and the third grid and plate form the second triode.

621.385.832 **3123**
The 5RP Multiband Tube: An Intensifier-Type Cathode-Ray Tube for High-Voltage Operation.—I. E. Lempert & R. Feldt. (*Proc. Inst. Radio Engrs, W. & E.*, July 1946, Vol. 34, No. 7, pp. 432–440.) The performance at frequencies up to 100 Mc/s is improved by increasing the trace intensity by means of several cylindrical intensifying electrodes introduced into the region between the deflecting plates and screen. The distortions caused by an excessive ratio of intensifier potential to second-anode potential are illustrated, and the design to enable a ratio of 10 : 1 to be used is described. Applications to high-speed transient recording and projection are suggested, and the extension of the frequency range to 1 000 Mc/s using coaxial connexions to the deflecting plates is proposed.

621.385.832.032.2 **3124**
The Electron Gun of the Cathode Ray Tube: Part 2.—H. Moss. (*J. Brit. Instn Radio Engrs*, June 1946, Vol. 6, No. 3, pp. 99–129.) Conclusion of 3534 of 1945. An extended practical treatment is given of the factors entering into the design of the triode portion of the tube, in which its characteristics are related to the electrode voltages and geometry. The results of this section are summarized in tabular form. Relevant data are given for a number of c.r. tubes in general use, for which the smallness of the useful cathode area "demonstrates how vital is the fine structure of the emitting cathode surface". Discussion included.

621.386.1 **3125**
X-Ray Tubes with Rotating Anode ("Rotalix" Tubes).—van der Tuuk. (*See* 3075.)

621.396.822 : 621.385.2 **3126**
'Shot-Effect' in Diodes Under Retarding Field Conditions.—R. Fürth & D. K. C. MacDonald. (*Nature, Lond.*, 22nd June 1946, Vol. 157, No. 3999, p. 841.) Experiments were carried out with a number of close-spaced diodes over a wide range of current up to a limiting current I_c, and shot effect was measured as under saturated conditions. A discrepancy of up to 10 : 1 was found between the theoretical and practical values of I_c. This can be explained by the existence of a potential barrier at the anode surface which would prevent slower electrons from penetrating into the anode.

621.396.822 : 621.385.3 **3127**
Fluctuations in Electrometer Triode Circuits.—van der Ziel. (*See* 2833.)

MISCELLANEOUS

001.89 **3128**
Organization of Scientific and Industrial Research.—(*Nature, Lond.*, 4th May 1946, Vol. 157, No. 3992, pp. 565–568.) An editorial discussion of recent proposals for organization on a national scale, with particular reference to the Bush report (see 492 of February) and the discussion of it by other authorities.

001.89 (410) **3129**
Scientific and Industrial Research in Great Britain.—(*Nature, Lond.*, 1st June 1946, Vol. 157, No. 3996, pp. 709–712.) An editorial account of the scope, responsibilities, and activities of the Department of Scientific and Industrial Research, and future trends in its research programme.

001.89 (410) **3130**
[Scale of grants to workers and students for] **Scientific and Industrial Research in Great Britain.**—O. F. Brown. (*Nature, Lond.*, 29th June 1946, Vol. 157, No. 4000, p. 879.)

001.89 : 6 **3131**
Industry and Research.—(*Engineer, Lond.*, 5th April 1946, Vol. 181, No. 4708, pp. 312–314, and *Nature, Lond.*, 25th May 1946, Vol. 157, No. 3995, pp. 684–686.) An account of a conference under the auspices of the Federation of British Industries. The main speeches and discussion covered education and research in large and small firms and in government laboratories.

001.891 : 629.13 **3132**
Aviation and Scientific Research.—M. Griaule. (*Nature, Lond.*, 22nd June 1946, Vol. 157, No. 3999, pp. 848–849.) Section formed under the auspices of the Congrès de l'Aviation Française. Research investigations using aircraft may be classed under the three headings: stratosphere, atmosphere, and earth's surface.

001.891 : 8–96 **3133**
Rationalization of the Literature of Scientific Research.—(*Nature, Lond.*, 8th June 1946, Vol. 157, No. 3997, pp. 745–748.) The necessity for an organization to deal with scientific literature.

061.5 : 621.317.2.027.8 **3134**
The New Brown Boveri High-Tension Testing Laboratory.—W. Wanger. (*Brown Boveri Rev.*, Sept./Oct. 1943, Vol. 30, Nos. 9/10, pp. 212–217.) **The Installations of the New Brown Boveri High-Tension Testing Laboratory.**—F. Beldi & C. Degoumois. (*Same journal*, pp. 218–221.) Abstracts in *Rev. gén. Élect.*, Jan. 1946, Vol. 55, No. 1, p. 1D.

061.5 : 621.381.39 **3135**
War Years' Review: Part 1.—(*Elect. Comm.*, March 1946, Vol. 23, No. 1, pp. 3–18.) A survey of the wartime activities of Standard Telephones & Cables, Ltd., London and Sydney. The first of a series describing the wartime work of the I.T. & T. associates.

061.5 : 621.39 **3136**
Telecommunications Research.—(*Electrician*, 7th June 1946, Vol. 136, No. 3549, p. 1513.) Brief report of the achievements of the Marconi's Wireless

Telegraph Co. in high-speed communications and ionospheric work.

061.6 3137

The National Physical Laboratory.—(*Engineer, Lond.*, 28th June 1946, Vol. 181, No. 4720, pp. 590–591.) An account of the first post-war annual exhibition of work in progress.

061.6 : 621.3.027.3 3138

The Parsons Memorial Lecture : "High-Voltage Research at the National Physical Laboratory".—R. Davis. (*J. Instn elect. Engrs*, Part I, April 1946, Vol. 93, No. 64, pp. 177–186.) An account of the methods of producing and measuring high d.c., power-frequency, and surge voltages, and the application to the protection of high-voltage transmission lines and barrage balloons. See also 2415 of August.

347.771 3139

Patent Law Proposals.—(*Engineer, Lond.*, 7th June 1946, Vol. 181, No. 4717, pp. 513–515.) Recommendations of changes to improve the British Patents and Designs Acts.

5 + 6] : 621.396.97 3140

Science and Radio.—(*Nature, Lond.*, 8th June 1946, Vol. 157, No. 3997, pp. 757–758.) A conference to consider the contribution of the B.B.C. to the promotion of scientific knowledge.

5 + 6] [(437) + (436.9) 3141

Science in Czechoslovakia and Yugoslavia.—(*Nature, Lond.*, 13th April 1946, Vol. 157, No. 3989, p. 487.)

534.1 3142

Some Notes on Vibration Analysis.—R. J. Manley. (*J. roy. aeron. Soc.*, July 1945, Vol. 49, No. 415, pp. 419–426.) An outline of the fundamental process of solving vibration problems by applying Lagrange's equation to a system of idealized inertia, spring, and dissipative elements made to represent the actual system. The analysis includes an account of the concepts of natural modes, equilibrium amplitudes, and dynamic magnifiers.

551.5 : 629.135 : 621.396.6 3143

The Effects of Atmospheric Conditions on Aircraft Radio Equipment.—W. W. Honnor. (*A.W.A. tech. Rev.*, March 1946, Vol. 6, No. 8, pp. 529–551.) Describes laboratory test chambers for simulating the ranges of temperature, pressure, and humidity likely to occur. D.c. flash-over voltages of cable connectors are given for saturated air at 35 000 feet and corona voltages at 300 kc/s are given for a large number of materials. A circuit is described for the measurement of flash-over voltages of sphere-gaps at 2.5 Mc/s and 19 Mc/s, and curves show the variation of spark-over voltage with altitude for spacings of 0.05 inch to 0.50 inch. Results are also given for spark-over voltages of variable capacitors, including a wire close to a conducting plane, in air at a pressure of 7 inches of mercury for frequencies up to 20 Mc/s.

6(07) 3144

Science and Education.—E. G. Carter. (*Nature, Lond.*, 16th March 1946, Vol. 157, No. 3985, pp. 344–345.) An account of a conference of the Association of Scientific Workers.

62.004.11 3145

Preparation and Use of Specifications.—G. Reinsmith. (*ASTM Bull.*, March 1946, No. 139, pp. 41–44.)

62.004.11 : 519.283 3146

Use of Statistics in Writing Specifications.—C. Goffman & J. Manuele. (*ASTM Bull.*, March 1946, No. 139, pp. 13–17.)

62.004.11 : 519.283 3147

Dollars for Your Thoughts.—L. E. Simon. (*ASTM Bull.*, March 1946, No. 139, pp. 17–21.) An account of the advantage of framing specifications on the basis of statistical methods and quality control carefully designed to produce the required result.

621.3.025 3148

Demonstration Devices.—W. K. Allan. (*Radio Craft*, May 1946, Vol. 17, No. 8, pp. 532..571.) Description of mechanical and electrical devices for demonstrating alternating current and voltage relationships in circuits.

621.315.1.056.1 3149

Tensions in Hanging Wires.—Hookham. (*See* 2808.)

621.38/.39](43) 3150

German Electronic Equipment.—(*Wireless World*, May 1946, Vol. 52, No. 5, pp. 163–164.) Account of equipment at the Earls Court Exhibition. See also 2438 of August.

621.396(43) 3151

Communications in Germany.—P. Mertz. (*Bell Lab. Rec.*, July 1946, Vol. 24, No. 7, pp. 271–274.) The Germans had a broad-band cable network for multi-carrier telephone and television between the principal cities; wired wireless was extensively used. In the television field, large-screen projectors with definition up to 1 000 lines were envisaged. Much work was being done on photosensitive materials.

621.396.611 3152

A Mechanical Model Analogous to an Oscillatory Electrical Circuit.—G. G. Blake. (*Engineer, Lond.*, 14th June 1946, Vol. 181, No. 4718, pp. 535–536.) The model can be used to show variations in the Q of an oscillatory circuit or to illustrate resonance between an oscillator and a second tuned circuit.

621.396.621.003.1(4) 3153

Report on European Radio Industry.—L. Laden. (*Radio News*, May 1946, Vol. 35, No. 5, pp. 25..114.) Report on the European demand for domestic radio and television receivers, and the capability of the American radio industry to supply them.

001.89 3154

[British] **Industrial Research and Development.** [Book Review]—F. Heath & A. L. Hetherington. Faber & Faber, London, 1946, 25s. (*Engineer, Lond.*, 24th May 1946, Vol. 181, No. 4715, pp. 477–478.) A very favourable review.

016 : [621.38/.39 3155

The Electronic Engineering Master Index. [Book Review]—F. A. Petraglia (Ed.). Electronics Research Pub. Co., New York, 1945, 317 pp., \$17.50. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 324, 326.) See also 2108 of July.

621.396.029.64 3156

Understanding Microwaves. [Book Review]—V. J. Young. J. F. Rider, New York, 400 pp., \$6.00. (*Radio, N.Y.*, May 1946, Vol. 30, No. 5, pp. 45–46.)