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JULY 1953

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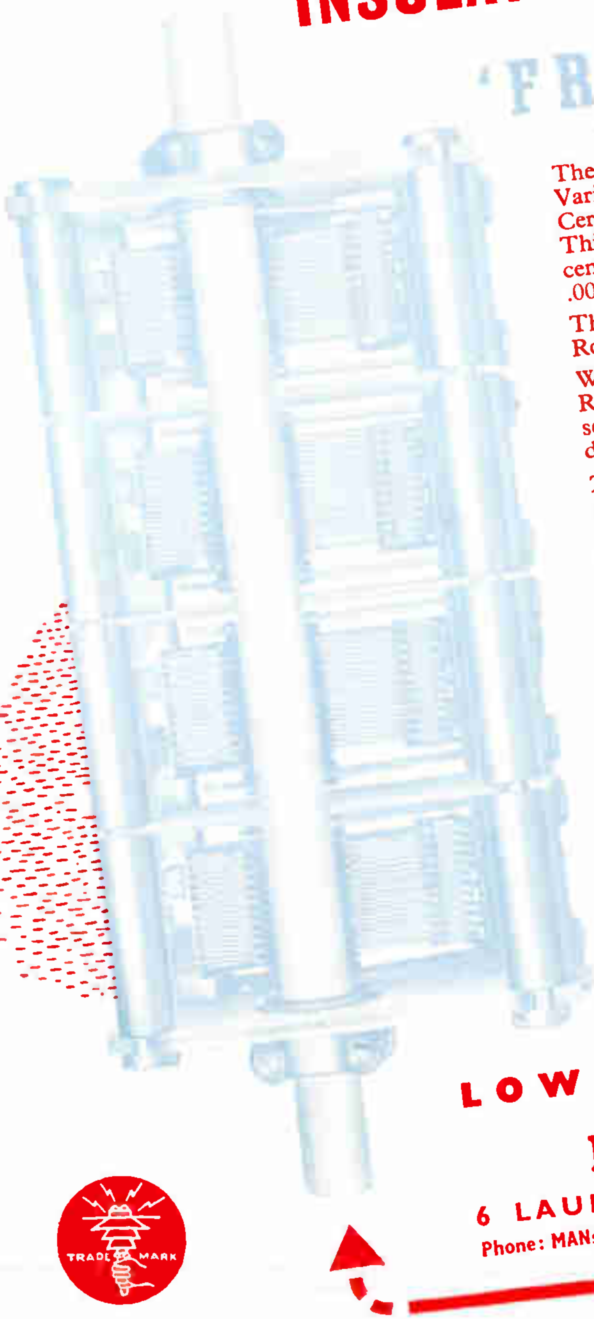

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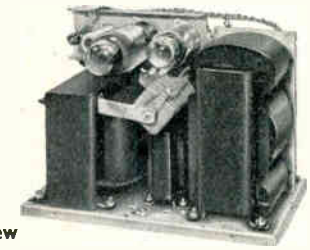

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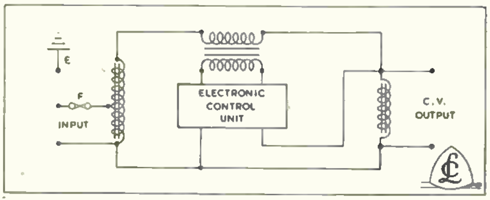

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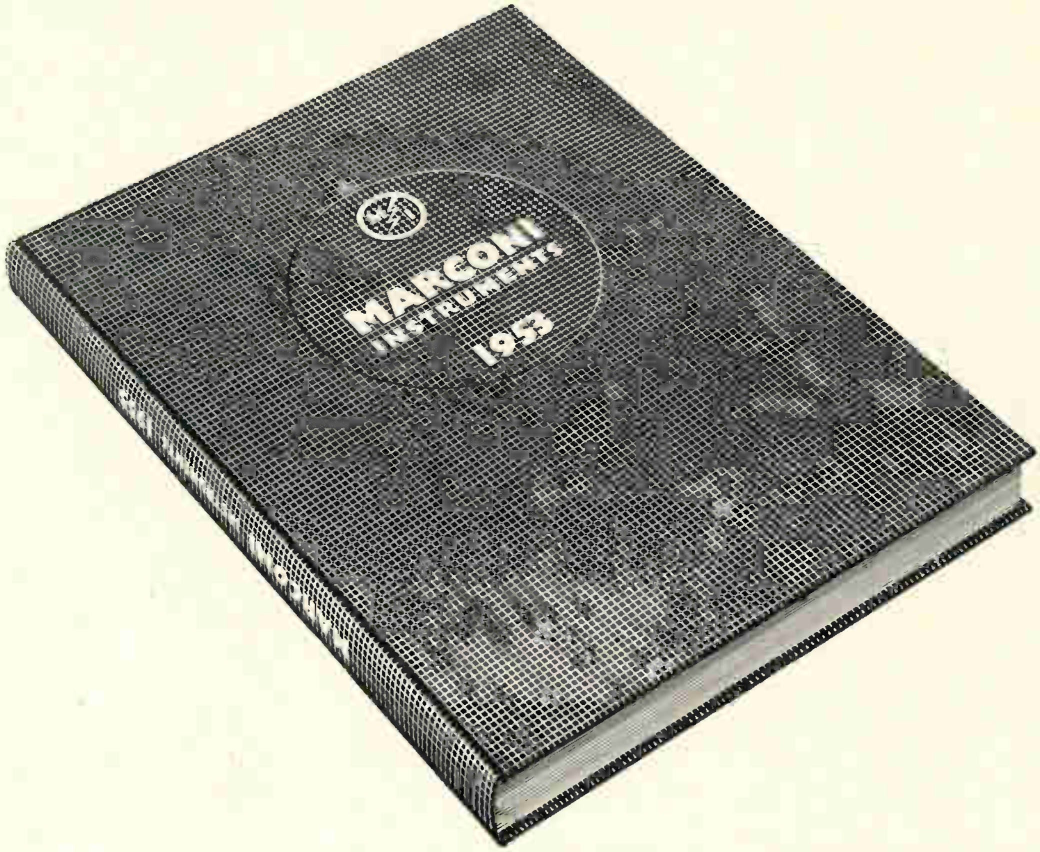

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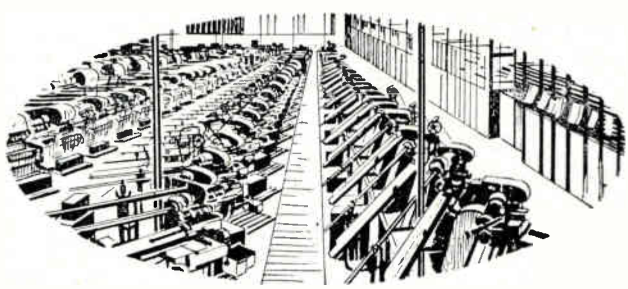

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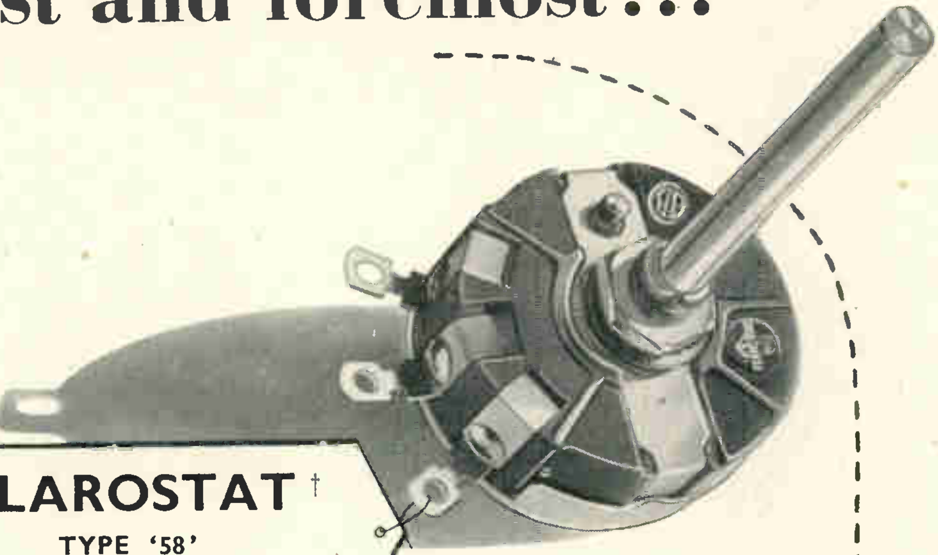

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Volume 30 · Number 7

CONTENTS

JULY 1953

Editorial: The Quartz Tuning Fork 161

Minimum Inductor or Capacitor Filters
by W. Saraga, Dr. Phil. 163

Critical Frequency Variations
by T. W. Bennington 175

Transmission-Line Impedance Measurements
by H. Sutcliffe, M.A. 180

New Books 182

Correspondence 184

Standard-Frequency Transmissions 184

Abstracts and References. Nos. 1874-2192 A.141-A.164

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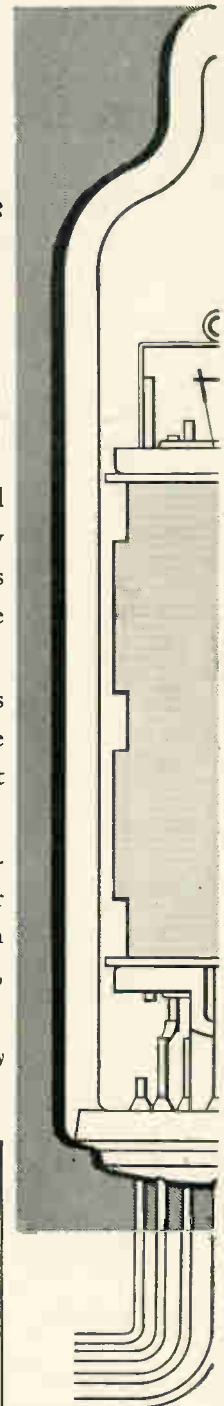
Complete technical details, including characteristic curves, of both battery and indirectly-heated subminiatures will be gladly supplied on request.



Type No.	Description	Filament (V) (mA)	Va=Vg2 (V)	Vg1 (V)	Ia (mA)	Ig2 (mA)	g_m (mA/V)
DAF70	A.F. pentode combined with single diode	1.25 25	67.5	0	1.0	0.25	0.44
DF72	R.F. pentode with sharp cut-off ...	1.25 25	67.5	0	1.7	0.5	1.0
DF73	Variable-mu R.F. pentode	1.25 25	67.5	0	1.7	0.5	0.8
DL70	R.F. output pentode	1.25 110	150 (Vg2=90V)	−7.5	6.5	1.4	1.5
DL75	Output pentode ...	1.25 25	90	−2.5	1.75	0.4	0.85

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# WIRELESS ENGINEER

Vol. 30 JULY 1953 No. 7

The Quartz Tuning Fork

THE use of nickel-iron and other alloys for tuning forks has been known for many years. In 1928 alloys were used that gave a change of frequency of less than one part in a million for a change of temperature of 1°C, but it was found that the elastic properties of such alloys undergo a slow change which causes the frequency to increase steadily at the rate of more than one part in 100,000 per year with little sign of reaching a steady value after several years. Experiments made in 1943 with forks of quartz glass showed just the reverse properties, for, although they did not change with time, the temperature coefficient was so great that to obtain a relative frequency variation of $\pm 10^{-6}$ the temperature had to be kept constant to 0.01°C.

A. Karolus* has recently described some very interesting experiments made with tuning forks of quartz, which show a high degree of constancy. He refers to a similar suggestion made in Japan by Koga in 1928. With the ordinary quartz oscillator the mechanical fastening of the quartz at a node is difficult, and in the usual electrically-maintained tuning fork both the fork and the driving components are rigidly mounted on the same base, thus greatly increasing the damping and affecting the frequency in an uncertain manner. Fig. 1 shows a fork cut out of quartz in a plane normal to the X axis, but it is preferable to cut it in such a direction that its temperature coefficient is as small as possible. For the same frequency the tuning-fork prong can be much shorter and thicker than a quartz rod vibrating transversely, and the fork has a greater mechanical stability and a better Q value. If the fork is symmetrical and properly designed there will be no transverse motion in the stem, but only a very small longitudinal motion, and if it is suspended on light spiral springs as shown in Fig. 2 practically no energy will be transmitted to the vessel. This method of holding the fork is possible because it is maintained in vibration by piezo-electric forces. Each prong has four electrodes, two on each side; these metal coatings are shown shaded in Fig. 1(a), and the diagram (b) shows how they are connected. Connection with the external circuit is made by means of the three or four springs by which the fork is suspended.

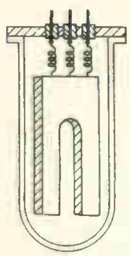


Fig. 2.

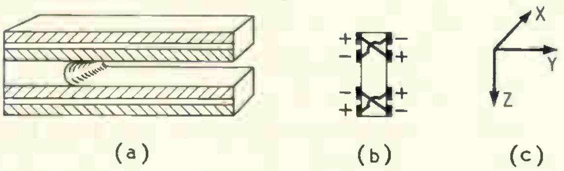


Fig. 1.

Assuming that the three axes are as shown, an electric field applied in the X direction causes a contraction or expansion in the Y direction. Since the electric fields in the upper and lower layer of a prong are in opposite directions, one layer will expand and the other contract, with the result that the prong will bend and, if connected as shown, the two prongs will simultaneously

* *Elektrotechnische Zeitschrift*, 1 March 1953, p. 136.

move inwards or outwards. If connection is made with a valve-voltmeter with a resistance of 1 MΩ and one strikes the spring-suspended fork, the voltmeter will indicate a r.m.s. value of about 1 V, which will, of course, gradually die away. If the frequency is f and the time taken for the voltage to fall to $1/e$ of its initial value is T_0, the Q value is equal to $\pi f T_0$. The voltage supplied to the fork to maintain it in vibration when in air at atmospheric pressure should not exceed about 10 V, but in a vacuum it should not exceed about 1 V, which indicates the great damping effect of the air. The air pressure also affects the frequency, an increase of 1 mm of mercury causing a relative decrease in the frequency of from 3 to 7 $\times 10^{-7}$. It is therefore advisable to keep the fork in an air-tight vessel and preferably at a pressure of only a few mm of mercury.

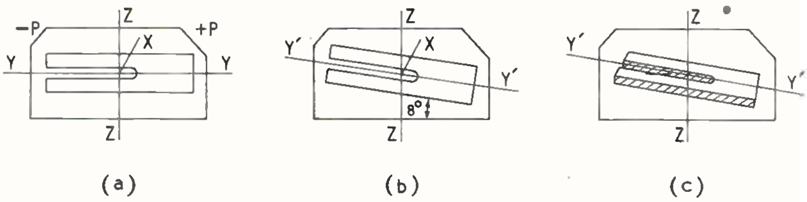


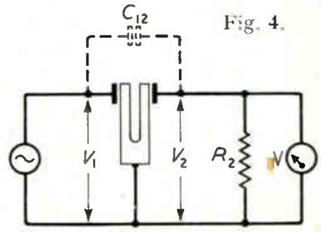
Fig. 3.

A general idea of the size of the forks is obtained from the two following examples. A fork with a frequency of 1 000 c/s had a total length of 90 mm with prongs of 70 mm; the prongs were 6 mm square and separated by 6 mm; another fork with a frequency of 20 kc/s had a total length of 35 mm but the prongs were only 15·5 mm long, 6 mm wide in the direction of oscillation and separated by only 3 mm; the thickness was 5 mm.

The frequency depends on the dimensions, the elasticity and the density of the quartz, which all vary with the temperature. The coefficients of expansion and elasticity vary with the orientation within the crystal. The temperature coefficient of the frequency varies quite considerably with the temperature, in an actual case increasing from $-1{\cdot}5 \times 10^{-6}$ per °C at 0°C to $-4{\cdot}5 \times 10^{-6}$ at 30°C. These low values of temperature coefficient are obtained by cutting the fork from the crystal in the plane shown in Fig. 3; in (a) it is shown in the YZ plane; in (b) it is rotated about the X axis until its axis Y′Y′ makes an angle of −8° with the YY axis of the crystal; in (c) it is rotated about Y′Y′ through an angle of about 55°. This is considered the most favourable cut from which to make the fork; it is called the NT cut; it gives the highest Q values and very low temperature coefficients. The damping due to stresses set up in the manufacture of the fork can be reduced by heat treatment. Fig. 4 shows diagrammatically the connections for determining the resonance curve and the voltage ratio V_2/V_1.

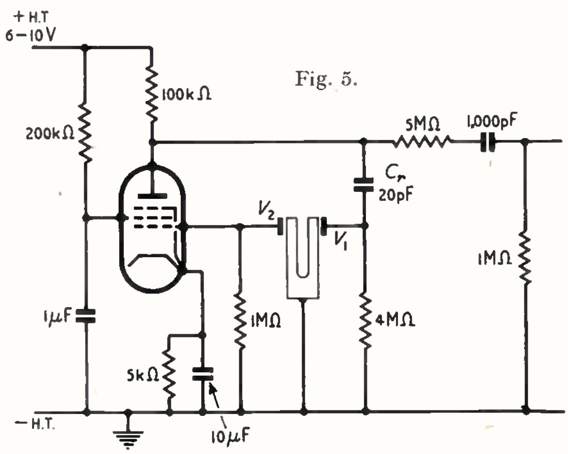
Contrary to what one might expect, the damping is decreased, the resonance curve made sharper, and the Q value increased, by connecting a resistance R_2 across the secondary terminals; in an actual case decreasing R_2 from 10 MΩ to 0·1 MΩ caused an increase of Q from 20×10^3 to 95×10^3; the voltage ratio V_2/V_1 fell from 2·0 to 0·25. It is surprising that with $R_2 = 10$ MΩ and the fork in an evacuated container, the voltage V_2 is between two and three times V_1, but if a cathode-ray oscillograph is connected across the V_1 terminals the reading jumps to two or three times the V_1 value on suddenly disconnecting the a.c. supply; it then decreases exponentially. At frequencies below the resonant frequency V_2 and V_1 are 180° out of phase, but above the resonant frequency they are in phase; exactly at resonance they are 90° out of phase, showing that the piezo-electric voltages are then 90° out of phase with the applied voltage. The resonance is very sharp, a change in the frequency of less than one part in a thousand reducing the voltage V_2 to 1% of its resonant value. Apart from the piezo-electric action, the quartz acts as a dielectric between the two electrode systems; this is shown in Fig. 4 as an effective capacitance C_{12}; the effect is usually negligibly small but can cause dissymmetry in the resonance curve in some cases.

Fig. 4.



A suitable circuit for the self-excitation of the fork is shown in Fig. 5. The d.c. supply to the

Fig. 5.



anode of the pentode is from 6 to 10 V and the cathode-heating voltage is reduced from 6 to 4 V; the grid bias is between $-0{\cdot}2$ and $-0{\cdot}3$ V. With these values the grid-cathode resistance is reduced to about 200 kΩ, and this constitutes the secondary circuit resistance, which, as we saw above, must be kept low; with this value V_2 is about $0{\cdot}2V_1$. The voltage V_1 is supplied from the anode through the capacitor C_r; hence an amplification of about 5 is sufficient to maintain the oscillation if C_r has a large capacitance, but since the anode and grid voltages are then 180° out of phase, V_1 and V_2 will also be 180° out of phase and the fork will not oscillate at its resonant frequency. For exact resonance V_1 and V_2 should be about 90° out of phase and this can be attained by reducing C_r to a value between 20 and 50 pF depending on the frequency; this will necessitate an increase in the amplification. When these are correctly adjusted, the anode-supply voltage or the heating voltage can vary by as much as 10% without changing the frequency by one part in 10^8.

If maintained in oscillation, the frequency of the fork gradually increases; even after several months it may increase by 1 part in 10^8 per day. This ageing is not permanent for, if switched off and allowed to rest for several months, it returns to its initial state and, on switching on, it goes again through the same changes. The total change after one or two months amounts to only about one part in 100,000; if it is much greater than this, there must be something wrong either with the fork or with the valve.

The research on the subject is being continued and Karolus promises a further report on the results of the experiments.

G. W. O. H.

MINIMUM INDUCTOR OR CAPACITOR FILTERS

By W. Saraga, Dr. Phil., A.M.I.E.E., Sen.Mem.I.R.E.

(*Telephone Manufacturing Co., Ltd.*)

SUMMARY.—It is often required to transform a given filter—usually in order to meet specific size or cost requirements—into an equivalent network (i.e., a network with the same insertion characteristics) which has either a smaller number of inductors or a smaller number of capacitors than the given network. In this article suitable transformation methods available to the filter designer are surveyed and new methods, where necessary, are developed. It is shown that the transformation method to be selected in any particular case depends on whether the filter to be transformed is an image-parameter filter which can be split into separate *m*-derived sections joined on an image-parameter basis, or whether the filter is of a more general character; e.g., obtained by an empirical adjustment process or designed as an insertion-parameter filter. In the case of band-pass filters the transformation discussed here can only be carried out if the filter to be transformed contains at least one half-section of 'constant-*k*' configuration; there are, however, no requirements regarding the symmetry or dissymmetry of the loss-frequency curves of these band-pass filters. The transformation methods discussed in this article are all of the 'direct' type (i.e., the transformations are carried out in terms of the network elements only, without recourse to impedance-frequency functions of the network as a whole); such transformations usually involve less numerical work than less direct methods. Two practical examples of applying the transformation procedures recommended to band-pass filters are described in detail.

1. Introduction

IT is frequently required to transform a given filter in such a way that an equivalent network (i.e., a network with the same insertion loss and insertion phase shift as functions of frequency) with a smaller number of inductors or a smaller number of capacitors is obtained, and the present article will deal with transformation problems of this kind.* A typical engineering problem in which such requirements may occur is the adaptation of a filter in the carrier-frequency range, consisting of powder-cored inductors and silvered-mica capacitors, to meet minimum-cost or minimum-size requirements. The inductors of such a filter are usually responsible for its main bulk and the capacitors for its main cost. Furthermore, the size of powder-cored inductors is, within wide limits, independent of their inductance value, whereas the cost of silvered-mica capacitors is roughly proportional to their capacitance. Thus, in order to reduce size, it is desirable to decrease the *number of inductors*, and in order to reduce cost it is desirable to decrease the *total capacitance* of the network. To minimize the number of inductors or the number of capacitors of a network is a problem which lends itself to a discussion in general terms. However, a network configuration with the minimum number of

* The term 'equivalent network' is not used here in its most general meaning in which it covers not only insertion but also impedance characteristics. In other words, in the transformation problems here under consideration changes of impedance characteristics are permitted.

MS accepted by the Editor, December 1952

capacitors has not necessarily the smallest total capacitance. Usually a configuration with the smallest—or a sufficiently small—total capacitance has to be found by trial and error,* starting from a configuration with a small (though not necessarily the smallest) number of capacitors. The present article will discuss the minimum-*number* problem only. As networks with a minimum number of capacitors can be obtained from networks with a minimum number of inductors by means of a conventional impedance inversion process, a detailed investigation of one of these two types of networks is sufficient for our purpose, and in this article the minimum-inductor type will be chosen.

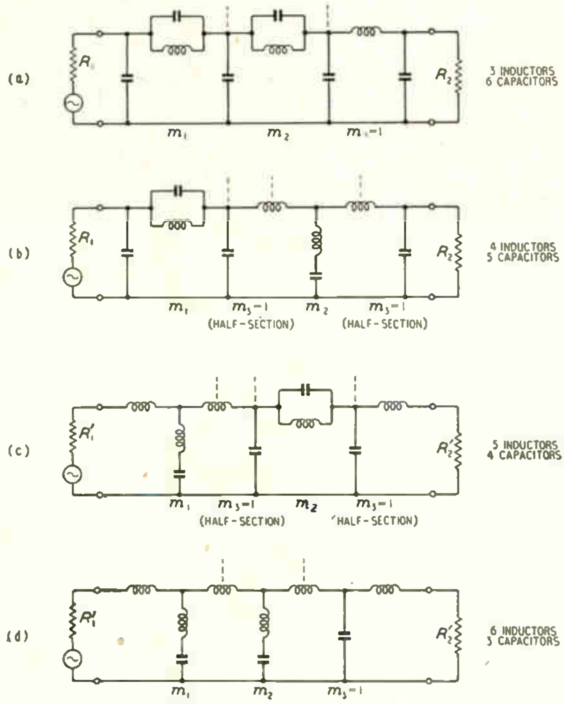


Fig. 1. *Transformation of image-parameter low-pass filter. Dotted lines indicate boundaries between sections or half-sections;* R_0 = *image impedance of filter at zero frequency;* $R_1' = R_0^2/R_1$; $R_2' = R_0^2/R_2$.

2. General Survey

In the case of low-pass and high-pass filters consisting of *m*-derived sections joined on an image-parameter basis it is easy to obtain at will networks with the minimum number of inductors or capacitors, or with any desired intermediate distribution, by a judicious choice of shunt-derived and series-derived sections or half-sections. This is illustrated in Fig. 1 for low-pass filters and in Fig. 2 for high-pass filters. It is sufficient to discuss the low-pass case as the networks shown in Fig. 2 can be obtained from those in Fig. 1 by means of a conventional low-pass—high-pass transformation. Any one of the networks given in Fig. 1 can be obtained from any other one of these networks by splitting the given network into its constituent *m*-derived sections or half-sections (which are indicated in the figure), replacing one or more or all of these sections by the corresponding sections with inverse image impedances and then joining these sections in the same or a different sequence. As long as the rules of the image-parameter theory concerning the joining of various sections are observed, a change in the sequence of the individual sections will not affect the image-transfer constant of the composite filter because no junction losses occur. In order to leave also the insertion loss and the insertion phase shift unchanged it is in some cases necessary to modify the terminating resistances in the way indicated in Figs. 1 and 2.

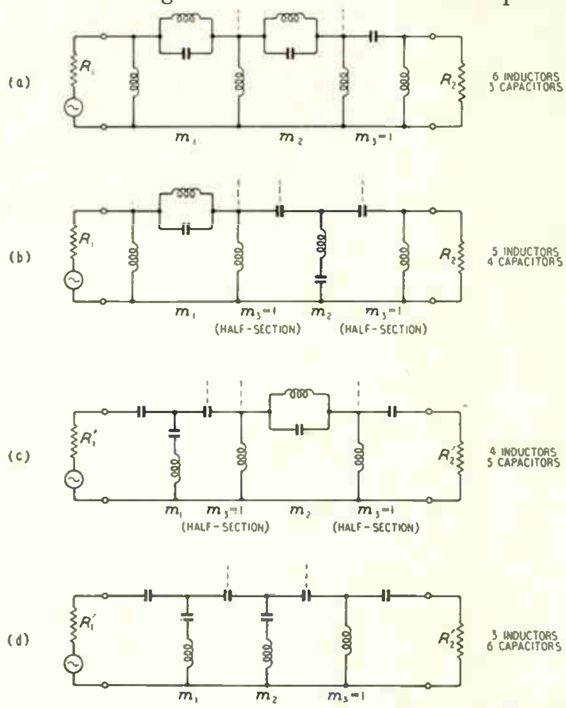


Fig. 2. *Transformation of image-parameter high-pass filter. Dotted lines indicate boundaries between sections or half-sections;* R_0 = *image impedance of filter at infinite frequency;* $R_1' = R_0^2/R_1$; $R_2' = R_0^2/R_2$.

The networks shown in Fig. 1(c) and (d) can be obtained from those in (b) and (a), respectively, directly by impedance inversion; i.e., without decomposing the given filters into their constituent image-parameter sections. It seems, however, —at least at first sight—that such a decomposition is necessary for transforming the configurations given in Fig. 1(a) and (d) into those of Fig. 1(b) and (c), respectively. Now let us assume that the

* The total capacitance of a network can, of course, be decreased by choosing as high an impedance level for the network as is compatible with the associated circuits and with the need to keep the lumped circuit capacitances large compared with stray capacitances.

networks in Fig. 1 are *not* image-parameter filters, but networks of a more general character. Then the configuration (b) can still be transformed into the configuration (c)—and (a) into (d)—by means of inversion. But it is not immediately clear whether the configurations (a) and (d) can be transformed into the configurations (b) and (c), respectively, nor *how* the transformations, if possible, can be carried out. Questions of this kind are the subject of this article. However, the following discussion of band-pass filters will lead to similar problems which are at the same time of a more general character and of greater practical importance. It is thus more convenient to defer a discussion of the two questions mentioned above, relating to low-pass and high-pass filters, and to deal with the band-pass filter case first.

Let us consider the simple case of *frequency-symmetrical* band-pass filters (the symmetry is, as usual, referred to a logarithmic frequency scale). The usual design method develops such filters as band-pass analogues of low-pass filters,[1,2,3,4,5] and this always leads to band-pass filters with equal numbers of inductors and capacitors because the band-pass analogue of each element, inductance or capacitance, of a low-pass filter is a resonant circuit consisting of one inductance and one capacitance (a series-resonant circuit being the analogue of an inductance and a parallel-resonant circuit being the analogue of a capacitance). This is illustrated in Fig. 3; Fig. 3(a) and (b) shows conventional low-pass filter sections and (c) and (d) show the analogous band-pass filter sections. These well-known sections can be transformed in various ways; (e) and (f) show less-known equivalents of the sections in (c) and (d), each of which has again an equal number of inductors and capacitors.* Thus it can be said that the configurations in Fig. 3(c), (d), (e) and (f) are at the same time minimum-inductor and minimum-capacitor configurations. Other known equivalent circuits [see e.g., the network in Fig. 3(g) which is equivalent to the network in Fig. 3(d)], have unequal numbers of inductors and capacitors, but this is achieved not by decreasing the number of one type of component but solely by increasing the number of the other type. Therefore these circuits, which are often of great practical value because they may have more practicable component values than the original circuits, are of no direct interest in our present discussion.

As far as filters with frequency-dissymmetrical performance curves are concerned, Belevitch[6] and Rowlands[7] have shown that such filters, when given in their classical form, can be trans-

* The network in Fig. 3(e) can be obtained from that in Fig. 3(c) and the network in Fig. 3(f) can be obtained from that in Fig. 3(d) by means 'fo series-π' or 'shunt-T' transformations (discussed in Section 3).

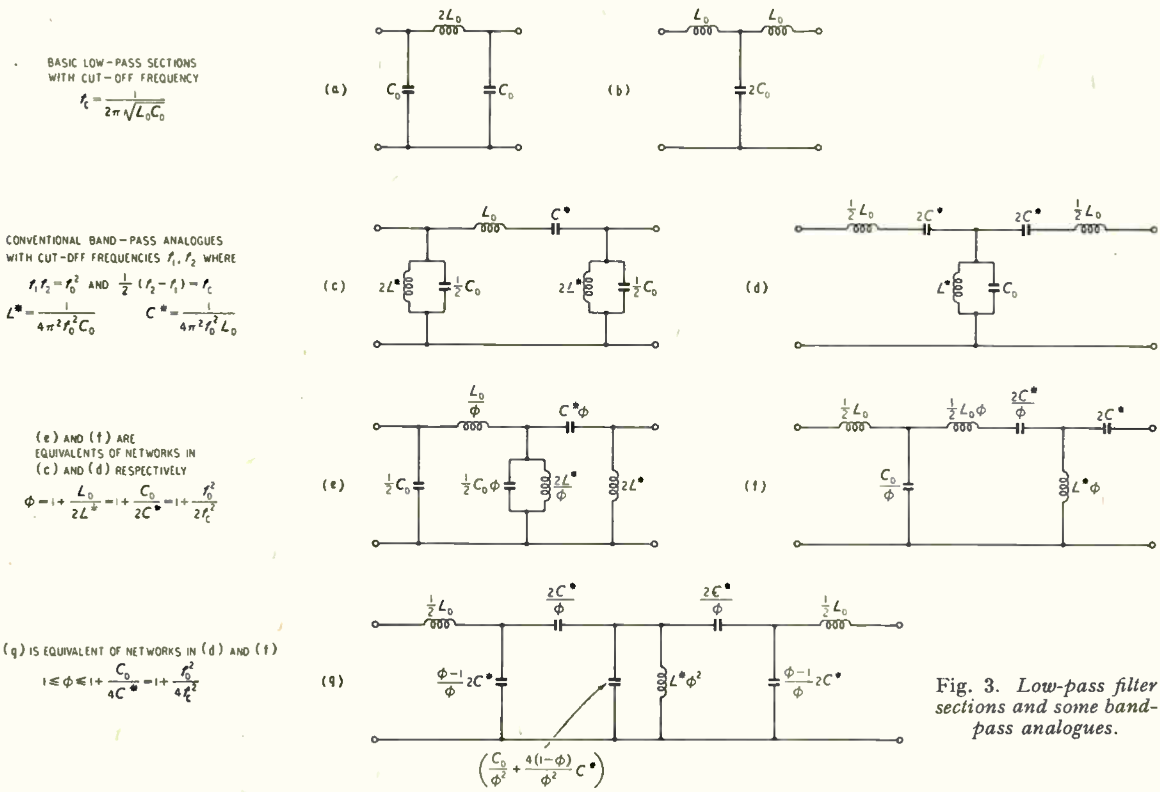


Fig. 3. *Low-pass filter sections and some band-pass analogues.*

formed into equivalent configurations with a smaller number of either inductors or capacitors. A typical, but simplified, example of such a filter in its minimum-inductor form, together with the corresponding loss-frequency curve, is shown in Fig. 4. As neither of the two last-named authors mentions any application of these ideas to *frequency-symmetrical* filters, and in view of the results of the discussion of Fig. 3, one might think that the dissymmetry of the performance curve is a necessary condition for the existence of equivalent but different minimum-inductor and minimum-capacitor configurations. However, this is not the case. According to Orchard,* the symmetry or dissymmetry of the loss-frequency curves of band-pass filters is irrelevant for the transformation problem, and minimum-inductor and minimum-capacitor versions can be found, in the image-parameter as well as in the insertion-parameter case, if the given filter contains (in addition to branches producing attenuation poles at finite frequencies) at least one half-section of "constant-k" *configuration* (it is not necessary that it should have the *element values* of an image-parameter constant-k half-section).

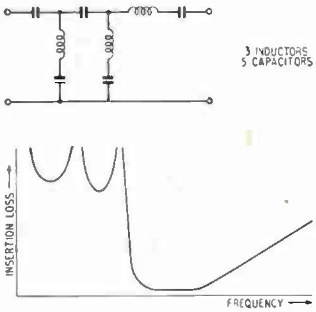


Fig. 4. *Minimum-inductor version of band-pass filter with dissymmetrical loss-frequency curve.*

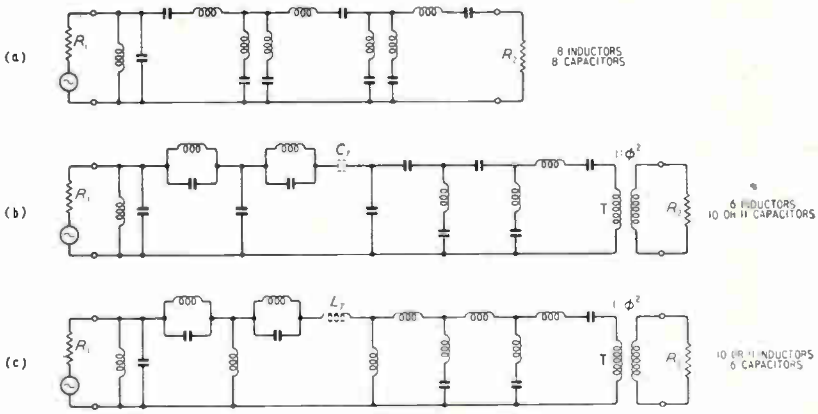


Fig. 5. *Transformation of a band-pass filter; (a) given filter, (b) equivalent filter with minimum number of inductors, (c) equivalent filter with minimum number of capacitors; T can be eliminated by replacing R_2 by R_2/ϕ^2 or by adding C_T or L_T.*

The transformation of such a filter is illustrated in Fig. 5. Fig. 5(a) shows the given band-pass filter, inserted between resistances R_1 and R_2, which consists of 8 inductors and 8 capacitors and contains a half-section of the constant-k type. Fig. 5(b) shows an equivalent network with 6 inductors—which is the smallest number possible—and 10 capacitors, containing also an ideal transformer T. If it is permitted to change the ratio of the resistances R_1 and R_2 between which the new network has to work then T can be absorbed in one of the resistances. Otherwise it is necessary to introduce an additional element to absorb T [e.g., the capacitor C_T in Fig. 5(b)]. An equivalent configuration with a minimum number of capacitors is shown in Fig. 5(c).†

A transformation method suggested by Orchard which is applicable to the case illustrated in Fig. 5 even if the filter shown is not an image-parameter filter (in the case of image-parameter filters a simpler method is available) consists of computing one of the open- or short-circuit impedances of the given network as a function of frequency and developing the network in the required new form from the computed impedance.** Such a method of network transformation which involves the evaluation of an impedance-frequency function of the network may be designated as 'indirect' and distinguished from 'direct' methods of transformation which lead directly from one configuration of the network to another without the introduction of impedance-frequency functions. Direct transformation methods—if available—are usually shorter and involve less numerical computation than indirect methods. The main subject of the article is the discussion and development of direct transformation methods which are suitable for the treatment of problems of the kind illustrated in Fig. 5; i.e., for the treatment of band-pass filter transformation problems. In the last section some related low- and high-pass problems are briefly discussed.

It will be shown that the transformation methods to be used depend on whether the given network is an image-parameter filter (i.e., can be decomposed into a number of m-derived sections

* Private communication by H. J. Orchard, Post Office Research Station.

† Other examples of band-pass filters (of the image-parameter type) with unequal numbers of inductors and capacitors, with or without frequency-symmetrical response curves, have been described by Laurent.[8] However, Laurent's 'zig-zag' filters have a configuration (see Fig. 6) which is basically different from that of the filters considered here, and they will therefore not be discussed in this article.

** The general method of developing a filter from one of these impedances has been described by Darlington[9] and the application of this method to obtain band-pass filters in their minimum-inductor or minimum-capacitor form has been described by Taylor and Orchard.[10]

with equal adjacent image impedances at each junction) or whether the given filter is of a more general character (in the latter case the filter may have been obtained by empirical modification of an image-parameter filter or it may have been designed as an insertion-parameter filter*). We shall deal with the transformation of an image-parameter filter first.

* Insertion-parameter filters have been introduced into engineering practice by Darlington.[9] For a more concise treatment of insertion-parameter filters, see References 10, 11, 12, and 13. For an elementary introduction and a comparison with image-parameter filters, see Reference 14.

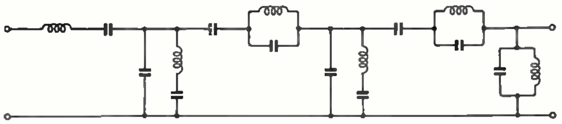
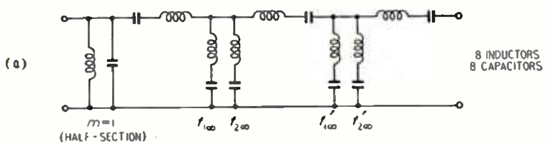
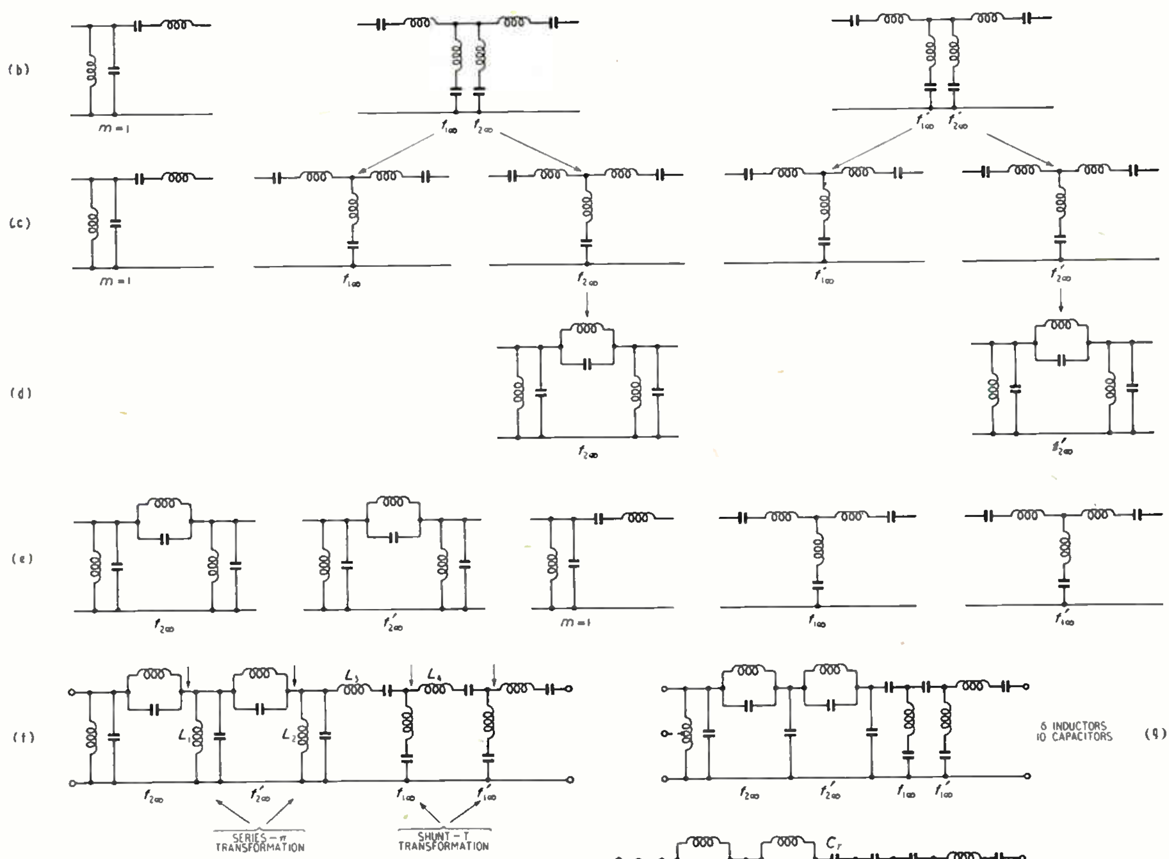


Fig. 6. *Zig-zag filter described by Laurent.*





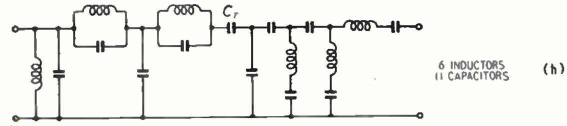


Fig. 7. *Transformation, in stages, of band-pass filter shown in Fig.* 5(a), *assuming that it is an image-parameter filter, to network shown in Fig.* 5(b).

3. Transformation of an Image-Parameter Band-Pass Filter

Let us consider the $2\frac{1}{2}$-section band-pass filter shown in Fig. 7(a). This is the simplest type of filter which permits a general discussion of all problems involved. In structure this filter is identical with the filter shown in Fig. 5(a), but we shall assume that the filter in Fig. 7(a) has been designed in accordance with the conventional image-parameter theory and can therefore be split into separate *m*-derived sections. As it contains a constant-*k* half-section, it is suitable for the intended transformation. We shall assume that it is desired to obtain an equivalent network with the *minimum number of inductors*. The corresponding problem concerning a configuration with the minimum number of capacitors will not be discussed explicitly as its solution will be obvious from the treatment of the first problem.

We shall make use of two well-known network equivalences. The first equivalence is usually called an L-transformation (see, e.g., Shea[15]) and is illustrated in Figs. 8(a) and (b).* Another transformation, due to Norton[16] (it is discussed in most textbooks) and extended by Belevitch,[6] which will be used for the transformation of the filter in Fig. 7(a) is illustrated in Fig. 9(a). We shall refer to it as the 'shunt-T' transformation. Fig. 9(b) shows the corresponding 'series-π' transformation. The L-transformation can be regarded as a particular case of the 'shunt-T' or the 'series-π' transformation, but for our purpose it is convenient to treat it as a separate type of transformation.

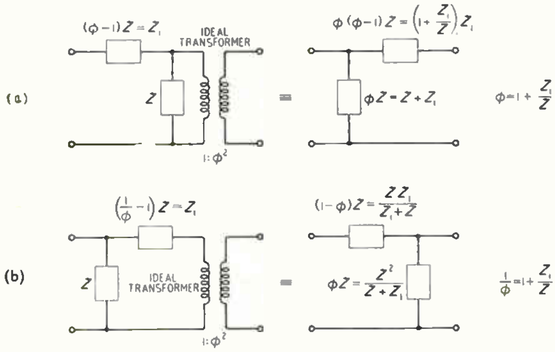


Fig. 8. *L-transformation.*

We are now ready to transform the filter in Fig. 7(a) and it will be shown that the only tools required are the 'elementary' transformations discussed in the preceding paragraph (Figs. 8 and 9) and a knowledge of the theory of *m*-derived band-pass filter sections, in particular of the sections and equivalences shown in Fig. 10.† Fig. 7(b) shows the decomposition of the filter into separate sections, namely a constant-*k* half-section and two *m*-derived full sections, one with attenuation peaks at the frequencies $f_{1\infty}$ and $f_{2\infty}$ and the other with peaks at the frequencies $f_{1\infty}'$ and $f_{2\infty}'$, where $f_{1\infty}$ and $f_{1\infty}'$ are below, and $f_{2\infty}$ and $f_{2\infty}'$ above, the pass band. In Fig.7 (c) a further stage of decomposition is shown: each of the *m*-derived sections shown in Fig. 7(b) (each of which has two attenuation peaks) is split into 'elementary' sections with one attenuation peak per section. In Fig. 7(d) the T-sections with attenuation peaks above the pass band are shown to be replaced by the corresponding π-sections. This is done because in the case of sections with peaks *above* the pass band (i.e., sections with 'low-pass behaviour') only a π-configuration can be used for the elimination of inductances (whereas in the case of peaks *below* the pass band, (i.e., in the case of 'high-pass behaviour'), only the given T-sections are suitable for inductance elimination). It must be emphasized that the π-sections are not fully equivalent to the T-sections which they are replacing; they have the same image transfer constant but inverse image impedances (see Fig. 10). Therefore they cannot be connected to the remaining part of the filter in place of the sections they are replacing, unless the remaining part is also modified; viz., the sequence of its sections rearranged. This is illustrated in Fig. 7(e) in which the sections are shown in a sequence in which they can be joined in accordance with conventional image-parameter practice. It will be seen that the constant-*k* half-section is used to provide a transition between π-sections and T-sections. Fig. 7(f) shows the complete filter obtained by joining the sections shown in Fig. 7(e). This version of the filter has a great number of redundant elements, but at the same time a structure which permits their elimination. This can be done by means of two shunt-T and two series-π transformations; the points where the ideal transformers have to be inserted in preparation for these transformations are indicated by arrows in Fig. 7(f). The transformation ratios of these transformers have to be so chosen that the inductances L_1, L_2, L_3, and L_4 are eliminated. The result is shown in Fig. 7(g).‡ Any other two pairs of inductances in the shunt and series arms could have been chosen for elimination. In the case illustrated in Figs. 7(f) and 7(g) it is necessary to eliminate L_2 before L_1, and L_3 before L_4.|| The

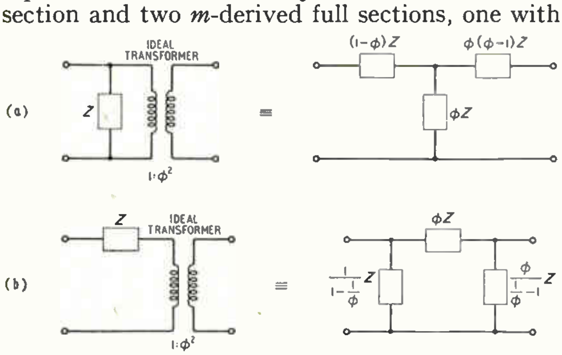


Fig. 9. (*a*) *Shunt-T transformation,* (*b*) *series-π transformation.*

* The transformation in Fig. 8(b) can be derived from that in Fig. 8(a) (or vice versa), but for the sake of convenience both transformations are shown.

† The theory of these sections can be found in text-books by Shea,[15] Starr,[17] Scowen[18] and, of course, in the original publication by Zobel;[19] see also Belevitch[20] for a different form of the design formulae. Rowlands[7] has investigated in detail filters composed of sections of the type shown in Fig. 11(b) or composed of sections of the type shown in Fig. 11(d). They are obtained by *m*-derivation from the basic 3-element band-pass sections shown in 11(a) and (c) respectively. If both types [11(b) and 11(d)] are used in the same filter (this case is *not* discussed by Rowlands) a different transformation procedure can be adopted and a different final structure can be obtained. This alternative method will not be considered

‡ It can easily be proved (see, e.g., Belevitch[6]) that the resulting network has positive element values provided that $f_{1\infty}$ and f_{∞}' are smaller than the resonant frequencies of the series arms with L_3 and L_4, respectively, and that $f_{2\infty}$ and $f_{2\infty}'$ are larger than the resonant frequencies of the shunt arms with L_1 and L_2 respectively.

|| If L_1 were eliminated first, the elimination of L_2 would reproduce an inductance in the position of L_1. Here it is of interest to point out that Belevitch and Rowlands, in their publications quoted above (Refs. 6, 7), describe methods for the *simultaneous* elimination of a number of elements, by means of which in some cases explicit formulae for the final element values can be found. In the comparatively simple elimination problem illustrated in Figs. 7(f) and 7(g) such formulae could easily be obtained in an elementary way, but it appears doubtful whether the use of these formulae would offer any practical advantage over the 'operational' method of elimination, suggested in this article, which is very simple.

circuit in Fig. 7(g) has the minimum number of inductors for any network equivalent to the originally given network [Fig. 7(a)] and the minimum number of capacitors attainable for the minimum inductor version of the filter.*

Owing to the insertion of ideal transformers with transformation ratios determined by the element values of the given filter, the ratio of the required terminating resistances for the final transformed network will in general be different from the ratio

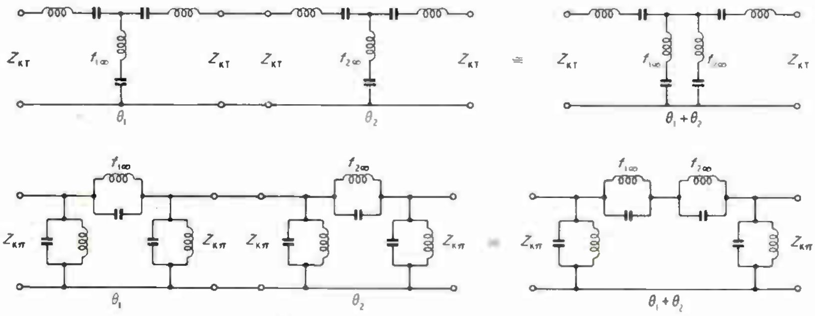


Fig. 10. *M-derived band-pass filter sections, and relations between these sections, used for the transformation illustrated in Fig. 7. θ_1, θ_2, $\theta_1 + \theta_2$ are image-transfer constants, Z_{KT} is mid-series image impedance of constant-k frequency-symmetrical band-pass filter section, $Z_{K\pi}$ is corresponding mid-shunt image impedance, $f_{1\infty}$ and $f_{2\infty}$ are attenuation-peak frequencies below and above the pass-band respectively.*

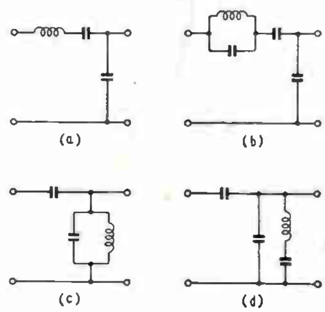


Fig. 11. *(a) and (c) are 3-element band-pass filter sections, (b) and (d) are m-derived sections discussed by Rowlands.*

4. Transformation of a Band-Pass Filter which is not an Image-Parameter Filter

We shall now consider a filter which has the same structure as that discussed in the preceding section [see Fig. 5(a) and Fig. 7(a)] but with element values which do not allow us to interpret it as being composed of separate sections with matching image impedances. Our aim is the same as in Section 3, namely to transform the given filter into an equivalent network with a minimum

of the terminating resistances for the original network. The original resistance ratio can be restored either by using the shunt arm inductor at one end of the filter as an auto-transformer [see Fig. 7(g)] or by the insertion of an ideal transformer in tandem with a capacitive or an inductive L-section. Under certain conditions this transformer can be absorbed by means of a shunt-T or a series-π transformation. This is illustrated in Figs. 12(a) and (b) for the two cases $\phi > 1$ and $\phi < 1$, respectively, for capacitive L-sections. It will be seen that this transformation leads to physical elements if $1 \leqslant \phi \leqslant 1 + C_2/C_1$ [Fig. 12(a)] or $1 \leqslant 1/\phi \leqslant 1 + C_2/C_1$ [Fig. 12(b)]. The number of capacitors is increased by one. Fig. 7(h) shows the result of such a transformation applied in the network in Fig. 7(g). The additional capacitor is designated as C_T. In practice it may be found that some of the element values occurring in a network in accordance with Fig. 7(h) are inconvenient or completely impracticable. Then it is necessary to try to find an acceptable compromise by judicious repeated application of L-transformations and series-π and shunt-T transformations and by changing the position of the remaining inductances in the circuit.

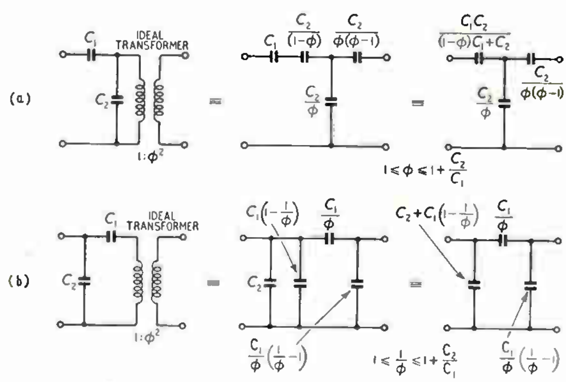


Fig. 12. *L-T and L-π transformations.*

number of inductors. (We shall again omit an explicit discussion of the inverse problem, viz., how to obtain a network with a minimum number of capacitors, as its solution will become obvious from the discussion of the analogous minimum-inductor problem.)

An analysis of the transformation of the image-parameter filter in Fig. 7 shows that there are two essential steps:—

1. Changing the sequence of attenuation peaks from $f_{1\infty}, f_{2\infty}, f_{1\infty}', f_{2\infty}'$ to $f_{2\infty}, f_{2\infty}', f_{1\infty}, f_{1\infty}'$;
2. Replacing the T-sections with 'low-pass behaviour' by corresponding π-sections.

* Dr. J. M. Linke (Post Office Research Station) who read this article in manuscript has informed me that he has filed, in July 1950, a British Patent Application[21] describing a method of transformation of image-parameter band-pass filters which is substantially identical with the method illustrated in Fig. 7 of this article.

Both (1) and (2) are based on image-parameter concepts and, therefore, if the given filter is not an image-parameter filter, neither of these steps can be carried out in the same way as before. Thus we shall have to consider methods which are not restricted to image-parameter filters but are generally applicable.

It will now be shown that the sequence of two shunt arms producing attenuation peaks $f_{1\infty}$ and $f_{2\infty}$ (one below and one above the pass band) can

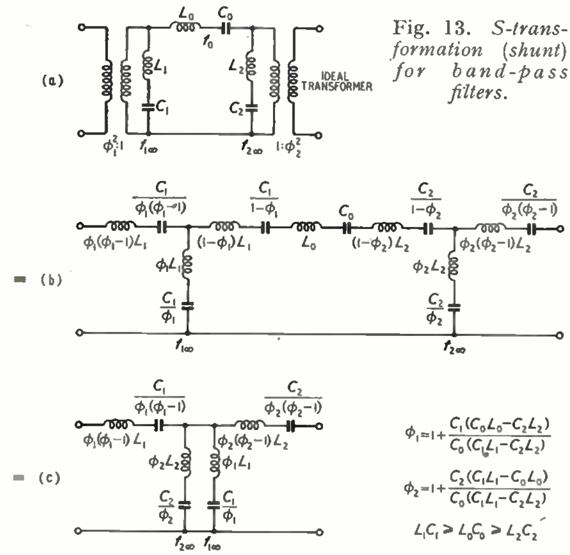


Fig. 13. *S-transformation (shunt) for band-pass filters.*

be reversed by applying the shunt-T transformation twice with suitably chosen transformation ratios ϕ_1 and ϕ_2. This is illustrated in Fig. 13 in which $f_{1\infty} \leqslant f_0 \leqslant f_{2\infty}$ and f_0 is the resonant frequency of the series arm. Fig. 13(a) shows the given network including two added ideal transformers and Fig. 13(b) the resulting equivalent network. We choose the ratios ϕ_1 and ϕ_2 so that simultaneously in the central series arm the total inductance becomes zero and the total capacitance infinite. This requirement yields two equations for $1 - \phi_1$ and $1 - \phi_2$:—

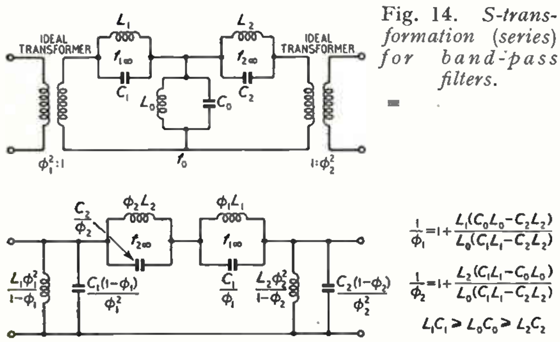


Fig. 14. *S-transformation (series) for band-pass filters.*

$$(1 - \phi_1)L_1 + (1 - \phi_2)L_2 = - L_0$$
$$(1 - \phi_1)1/C_1 + (1 - \phi_2)1/C_2 = - 1/C_0$$

from which we find

$$\phi_1 = 1 + \frac{C_1(C_0L_0 - C_2L_2)}{C_0(C_1L_1 - C_2L_2)} \quad .. \quad .. \quad (1a)$$

and $$\phi_2 = 1 + \frac{C_2(C_1L_1 - C_0L_0)}{C_0(C_1L_1 - C_2L_2)} \quad .. \quad (1b)$$

From the original assumption $f_{1\infty} \leqslant f_0 \leqslant f_{2\infty}$ or $L_1C_1 \geqslant L_0C_0 \geqslant L_2C_2$ it follows that $\phi_1 \geqslant 1$ and $\phi_2 \geqslant 1$. This ensures that all network elements are positive and therefore physical. Fig. 13(c) shows the final network with reversed sequence $f_{2\infty}, f_{1\infty}$.*

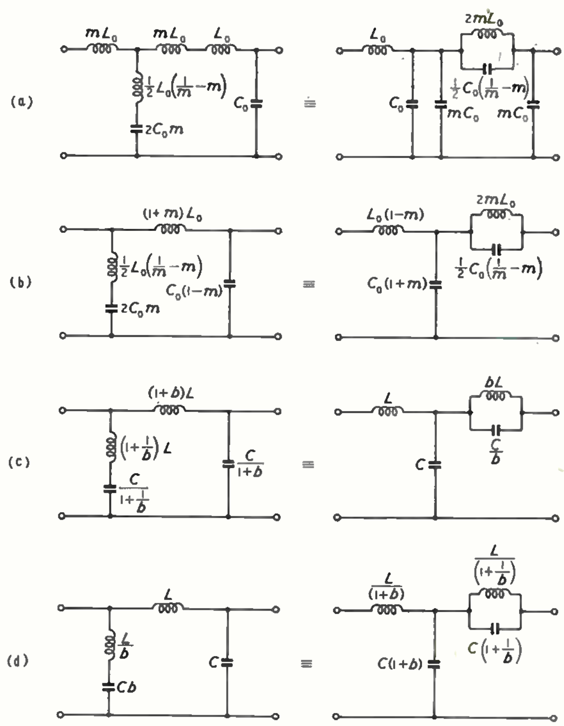


Fig. 15. *Derivation of shunt-series and series-shunt transformations (low-pass).*

Obviously, a similar transformation must exist which allows the designer to reverse the sequence of two parallel resonant circuits occurring in the series arms of a band-pass filter. This transformation is given (without derivation) in Fig. 14. We shall refer to either of the transformations shown in Figs. 13 and 14 as S-transformations (S for sequence) and we shall distinguish between S-transformations (shunt) and S-transformations (series) for Figs. 13 and 14, respectively.

We shall now consider the replacement of 'low-

* The result and the proof would, of course, be unchanged if $f_{1\infty} \geqslant f_0 \geqslant f_{2\infty}$.

pass' T-sections by corresponding π-sections. This is based on the complete equivalence of the two (image-parameter) filters shown in Fig. 15 (a) each consisting of a constant-k half-section and an m-derived full section. This equivalence follows from the elementary theory of image-parameter filters. By disregarding series inductances and parallel capacitances common to both networks we obtain the equivalence given in Fig. 15(b) which is repeated, with more convenient symbols in Fig. 15(c).* This subtraction of common elements leads to the 'basic' equivalence (i.e., an equivalence without any superfluous elements); in practice, however, it is often more convenient to connect identical elements or networks at the input or output side of each of the networks shown in Fig. 15(c) and to use the equivalence in such a generalized form. Fig. 15(d) shows, for the sake of convenience, the same equivalence as Fig. 15(c) but with different symbols, for use in the

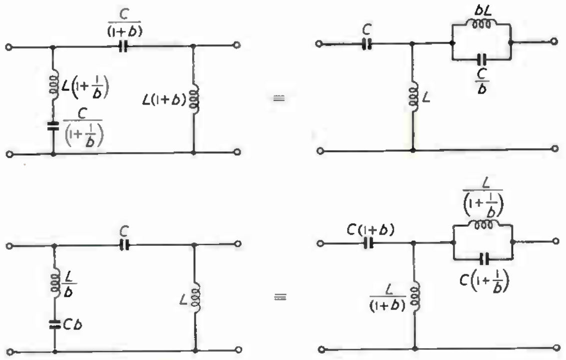


Fig. 16. *Shunt-series and series-shunt transformations (high-pass).*

* This equivalence was originally published, and applied to network transformations, by Zobel[22] in 1931 who derived it as a star-delta equivalence. The same network relation was demonstrated by Bode[23] in 1934 as an equivalence of two h-derived sections. Another application of this equivalence to network transformations was described by Selach and Zimbalisty.[24] In 1946 Rowlands[25] (see also Rowlands[26]) obtained the equivalence by comparing the matrices of the two networks.

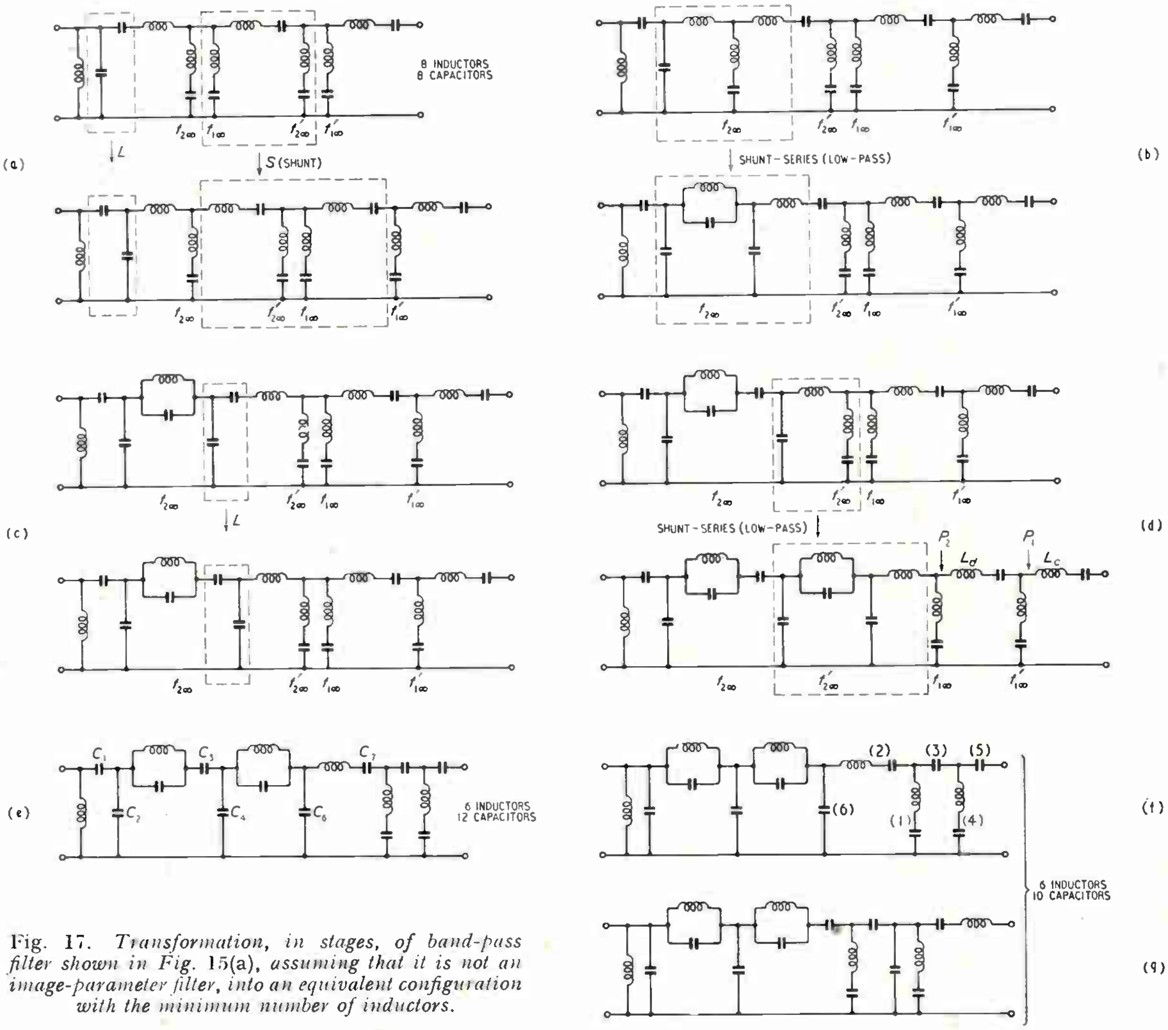


Fig. 17. *Transformation, in stages, of band-pass filter shown in Fig. 15(a), assuming that it is not an image-parameter filter, into an equivalent configuration with the minimum number of inductors.*

inverse direction. The corresponding equivalences for 'high-pass' sections are given in Fig. 16. The transformation shown in Fig. 15(c) and (d) will be referred to as 'shunt-series (low-pass)' or 'series-shunt (low-pass)' transformations and those shown in Fig. 16(a) and (b) will be designated as 'shunt-series (high-pass)' or 'series-shunt (high-pass)' transformations.

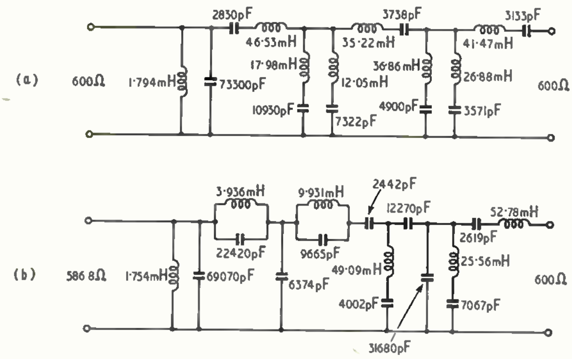
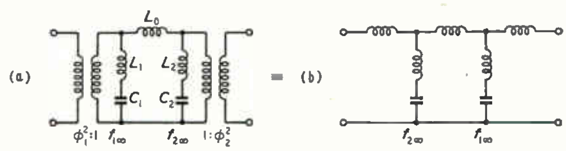


Fig. 18. *Reproduction of Figs.* 17(a) *and* 17(g) *with element values.*

We are now ready to transform the filter shown in the top part of Fig. 17(a). It has the same configuration as the filter in Fig. 5(a) and the image-parameter filter shown in Fig. 7(a). Fig. 17(a), (b), (c) and (d) shows, in this sequence, four steps of transformation. The transformations are indicated by arrows pointing from an encircled part of the filter to be transformed to the corresponding part after transformation; at the side of each arrow the type of transformation is indicated. Impedance changes, which occur when an L-transformation or either of the two S-transformations is carried out, are *not* indicated in Fig. 17; but in practice, when the transformation is carried out quantitatively, it is, of course, necessary to take these changes of impedance into account. It will be seen that by application of the transformations indicated in Fig. 17(a) to (d) we obtain from the original filter shown in the top part of Fig. 17(a) the filter shown in the bottom part of Fig. 17(d). Then two shunt-T transformations are carried out, at the points P_1 and P_2 indicated in the bottom part of Fig. 17(d), so as to eliminate L_c and L_d (L_c before L_d). The result is shown in Fig. 17(e). This circuit has only six inductors, which is the minimum number attainable, but 12 capacitors, which is two more than the minimum number of capacitors when the number of inductors has been fixed as six. If all of these redundant capacitors are eliminated, the new network will generally be equivalent to the original network [in Fig. 17(a)] in tandem with a 'residual' ideal transformer the turns ratio of which is different from unity.

This means that the ratio of source resistance to load resistance for the transformed network without redundant elements will generally have to be different from that for the given network. However, a network without redundant elements can be obtained in various configurations—two such configurations are shown in Fig. 17(f) and (g) and their derivation is described below—and in some cases a configuration can be found for which ϕ_{res} is nearly unity. If, for instance, the original network has the element values indicated in Fig. 18(a) we obtain by transformation the network in Fig. 18(b) which has the configuration of the network shown in Fig. 17(g) with a residual transformation ratio of $\phi_{res} = 1{\cdot}011$. If it is required to make ϕ_{res} exactly equal to unity, it is necessary to introduce at least *one* additional element, but it is often found that, in order to obtain element values which can be used in practice, it is necessary to introduce *more than one* redundant element.

A comparison of the circuits (e) and (f) in Fig. 17 shows that the capacitors C_1 and C_3 of Fig. 17(e) do not occur in Fig. 17(f). They can be eliminated as follows:—an L-transformation applied to C_1 and C_2 allows us to merge the new series-arm capacitance with C_3 to form a single series-arm capacitance C_3' and thus eliminate one of the two redundant capacitances. A second L-transformation applied to C_3' and C_4 produces a new series-arm capacitance C_5 (not shown) and an L-transformation applied to C_5 and C_6 allows us to merge the new series capacitance with C_7. Thus both redundant capacitances have been eliminated.



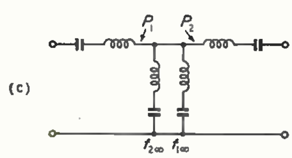


Fig. 19. (*a*) *and* (*b*) *show a required low-pass filter S-transformation*, (*c*) *shows the result of applying the S-transformation* (*shunt*) *to* (*a*).

The circuit shown in Fig. 17(g) can be obtained from that in Fig. 17(f) by first applying a shunt-T transformation to shunt arm (1) in 17(f) so as to transfer the inductance in series arm (2) to series arm (3). A second shunt-T transformation applied to shunt arm (4) can be used to transfer the inductance from series arm (3) to series arm (5). Finally, the capacitance in shunt arm (6) can by repeated L-transformations be transferred to a position in parallel with shunt arm (4).

It will be seen that the network obtained *before* the final L-transformations are carried out has the same configuration as the network in Fig. 7(g), which is obtained by the transformation procedure applicable to *image-parameter* filters (before a redundant capacitor is introduced to restore the original ratio of load to source resistance).*

which determine different peak attenuation frequencies. Let us assume that it is desired to transform in this way the low-pass filter section shown in Fig. 19(a) into the configuration shown in Fig. 19(b). The S-transformation (shunt) illustrated in Fig. 13 can *formally* be applied to

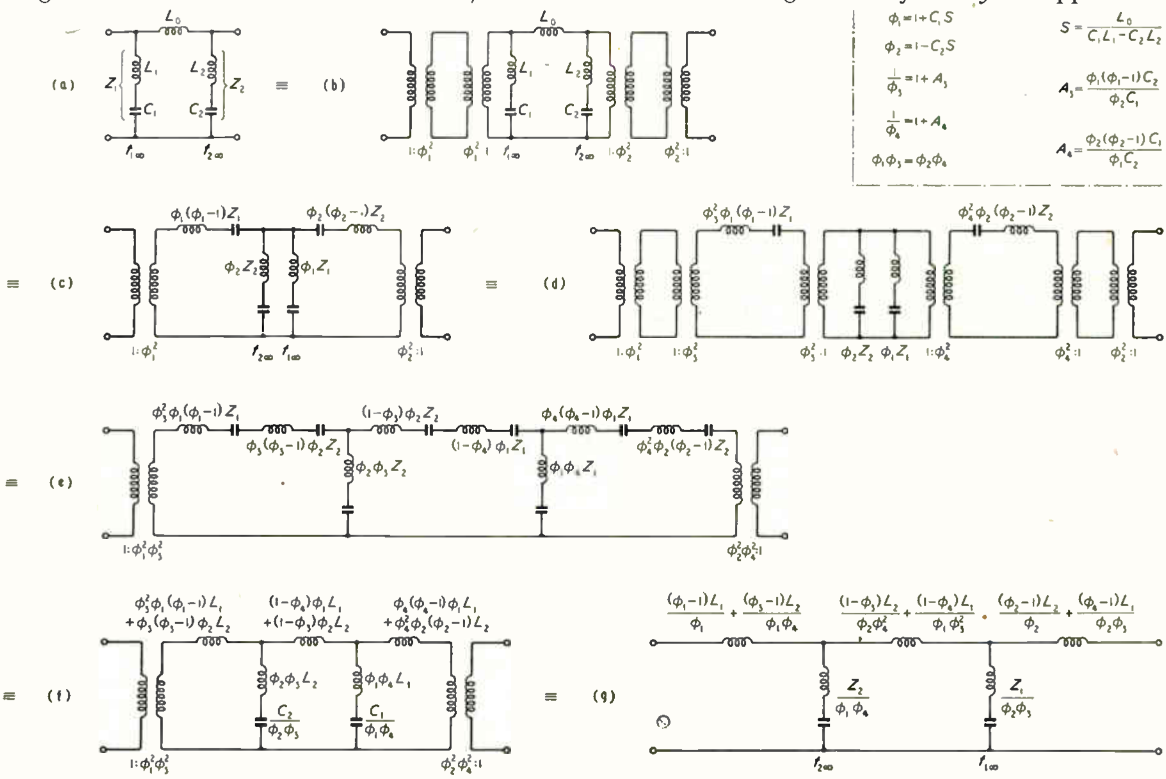


Fig. 20. *Transformation* 19(a) *to* 19(b) *in stages.*

5. Transformation of Low-Pass Filters and High-Pass Filters

In Section 2 it was pointed out that a suitable method for transforming a low-pass filter of the type shown in Fig. 1(a) into the network shown in Fig. 1(b) or from Fig. 1(d) to Fig. 1(c) might not be obvious if the given filter is not an image-parameter filter so that the method of decomposition of the filter into its constituent sections is not available. Inspection of Fig. 1 shows that now, having discussed the corresponding problem for band-pass filters, we can carry out the required transformation by means of the series-shunt (low-pass) or shunt-series (low-pass) transformations.

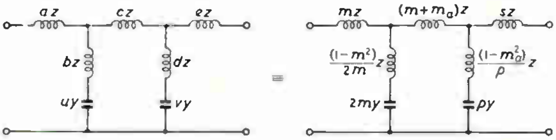
A further transformation problem which may occur in low-pass and high-pass filters is a requirement to change the sequence of resonant arms

Fig. 19(a) with $C_0 \to \infty$ (only formally because ϕ_2 may be < 1 as the condition $L_1C_1 \geqslant L_0C_0$ is no longer satisfied). This would not lead to the required configuration in Fig. 19(b) but to a configuration as shown in Fig. 19(c), with unwanted capacitances in the series arms. However, it can be shown (see Appendix) that by two shunt-T transformations at the points P_1 and P_2 indicated in Fig. 19(c), with suitably chosen transformation ratios ϕ_3 and ϕ_4 it is possible to obtain an inductance in the central series arm and no capacitances in any of the *three* series arms; i.e., the required configuration shown in Fig. 19(b). That this is possible is not trivial, as we have only *two* parameters, ϕ_3 and ϕ_4, to choose and we have to meet *three* conditions. The final result is shown in Fig. 20, as the equivalence of the networks in Figs. 20(a) and 20(g).

This equivalence has been first published by Rowlands[27] (see also Rowlands[26]) who proved its validity by means of matrix considerations. It can be shown that his result, which is reproduced

* The transformations illustrated in Fig. 7 always lead to positive elements; no such guarantee can be given in the case of Fig. 17. However, the occurrence of negative elements during a transformation can be disregarded as long as it is possible to absorb these elements in subsequent transformations.

in Fig. 21, agrees with our result (Fig. 20). There is, however, one difference: in Fig. 20 the equivalence is expressed in terms of the network elements of the two networks whereas Rowlands' representation of the equivalence is in terms of multiples of "the reactance of the series arm of a general half-section constant-k filter" and the susceptance of the corresponding shunt-arm. It seems that in the case of filters which are not image-parameter filters Rowlands' representation would need some preliminary work of 'translation' whereas the representation derived in this article (Fig. 20) could be applied immediately.



$$a = m_a \qquad b = \frac{(1-m_a^2)\left[2mp+(m_a-m)^2\right]}{p(m+m_a)^2} \qquad c = \frac{2mp+(m_a-m)^2}{p+m-m_a}$$

$$d = \frac{(1-m^2)\left[2mp+(m_a-m)^2\right]}{2m(p+m-m_a)^2} \qquad e = s + \frac{m^2-m_a^2}{p+m-m_a}$$

$$u = \frac{p(m_a+m)^2}{2mp+(m_a-m)^2} \qquad v = \frac{2m(p+m-m_a)^2}{2mp+(m_a-m)^2}$$

Fig. 21. *Transformation identical with that shown in Fig. 20 but with Rowlands' designations.* z = *reactance of the series arm and* y = *susceptance of the shunt arm of a general half-section constant-k filter.*

Acknowledgments

I wish to thank Mr. J. G. Flint, Technical Director of the Telephone Manufacturing Co., Ltd., for permission to publish this paper and Miss J. Nicholson for working out the transformation example illustrated in Figs. 17 and 18 and for many talks on the transformation procedure described. I am grateful to Mr. H. J. Orchard and Dr. J. M. Linke, both of the Post Office Research Station, for discussions on the general transformation problem which stimulated the investigation, the results of which are described in this article.

APPENDIX

The equivalence of the networks shown in Fig. 20(a) and (g) will now be proved. Fig. 20(b) shows the same network prepared for the S-transformation (shunt), two ideal transformers with turns ratios $1 : \phi_1$ and $\phi_1 : 1$ being added in front of the network and two ideal transformers with turns ratios $1 : \phi_2$ and $\phi_2 : 1$ being added after the network. ϕ_1 and ϕ_2 are chosen in accordance with equations (1a) and (1b), which refer to Fig. 13. In the special case of Fig. 20(a) we have $C_0 = \infty$ and therefore

$$\phi_1 = 1 + C_1 S \quad \text{(2a)}$$

$$\phi_2 = 1 - C_2 S \quad \text{(2b)}$$

where $S = L_0/(C_1 L_1 - C_2 L_2)$ (2c)

Carrying out the S-transformation (shunt) we obtain the network shown in Fig. 20(c). In order to get rid of the unwanted capacitors in the series arms we introduce ideal transformers [see Fig. 20(d)] with turns ratios $1 : \phi_3$, $\phi_3 : 1$ and $1 : \phi_4$, $\phi_4 : 1$ in preparation for two shunt-T transformations. Fig. 20(e) shows the network obtained after these transformations have been carried out. ϕ_3 and ϕ_4 will now be so chosen that the total capacitances in the two terminating series arms disappear (i.e., become infinite). Thus we obtain

$$\phi_3\,\phi_1\,(\phi_1 - 1)/C_1 + (\phi_3 - 1)\,\phi_2/C_2 = 0 \quad \text{(3a)}$$

$$\phi_4\,\phi_2\,(\phi_2 - 1)/C_2 + (\phi_4 - 1)\,\phi_1/C_1 = 0 \quad \text{(3b)}$$

Solving (3a) for ϕ_3 and (3b) for ϕ_4 we obtain

$$1/\phi_3 = 1 + A_3 \text{ where } A_3 = \phi_1\,(\phi_1 - 1)\,C_2/\phi_2 C_1 \quad \text{(4a)}$$

$$1/\phi_4 = 1 + A_4 \text{ where } A_4 = \phi_2\,(\phi_2 - 1)\,C_1/\phi_1\,C_2 \quad \text{(4b)}$$

If ϕ_3 and ϕ_4 are chosen in accordance with (4a) and (4b), the capacitances in the two series arms disappear. The capacitance in the middle series arm would also disappear if

$$(1 - \phi_3)\,\phi_2/C_2 + (1 - \phi_4)\,\phi_1/C_1 = 0 \quad \text{(5)}$$

By substituting ϕ_3 and ϕ_4 from (4a) and (4b) it can be shown that (5) is satisfied by these values. This means that all three unwanted series-arm capacitances can be eliminated at the same time, and the network in Fig. 20(e) can be simplified as shown in Fig. 20(f).

A further simplification is possible because, as proved below,

$$\phi_1\,\phi_3 = \phi_2\,\phi_4 \quad \text{(6)}$$

This means that the network in Fig. 20(f) has an ideal transformer with turns ratio $1 : \phi_1\,\phi_3$ at its input and an ideal transformer with the reciprocal turns ratio $\phi_1\,\phi_3 : 1$ at its output. Both transformers can therefore be absorbed by the remainder of the network by dividing all impedances by $\phi_1^2\,\phi_3^2$. We then obtain the network shown in Fig. 20(g) using (6) where convenient.

Equation (6) will now be proved. From (4) we find $\phi_1\phi_3 = \phi_1\phi_2 C_1\ [C_1\phi_2 + C_2\phi_1\ (\phi_1 - 1)]$ and $\phi_2\phi_4 = \phi_1\phi_2 C_2\ [C_2\phi_1 + C_1\phi_2\ (\phi_2 - 1)]$ so that $\phi_1\phi_3 = \phi_2\phi_4$ if $C_1 C_2 \phi_2 + C_2^2\phi_1\ (\phi_1 - 1) = C_1 C_2 \phi_1 + C_1^2 \phi_2\ (\phi_2 - 1)$ or, making use of equations (2a) and (2b),

$$C_1C_2\,(1 - C_2S) + C_2^2\,(1 + C_1S)\,C_1S = C_1C_2\,(1 + C_1S) - C_1^2\,(1 - C_2S)\,C_2S$$

or, dividing both sides by C_1C_2,

$$1 - C_2S + C_2S + C_1C_2S^2 = 1 + C_1S - C_1S + C_1C_2S^2 \quad \text{(7)}$$

As (7) is satisfied, equation (6) is proved.

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CRITICAL FREQUENCY VARIATIONS

Sunspot Minimum to Maximum in Northern and Southern Hemispheres

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(*British Broadcasting Corporation*)

SUMMARY.—Twelve-month running averages of critical frequencies for the F_2 layer are plotted against twelve-month running averages of sunspot numbers for two stations in the northern hemisphere and two in the southern hemisphere, as well as for one station near the equator. It is found that, whereas in the northern hemisphere there is a pronounced tendency for the rate of increase of critical frequency to become smaller for the higher values of sunspot number, this tendency is not evident in the southern hemisphere. Near the equator the critical frequency behaviour lies between that for the northern and southern hemispheres respectively.

A suggestion is made that a 'saturation' effect may occur for high values of sunspot number in the northern hemisphere at the time of the annual minimum, which occurs in local summer, but not in the southern hemisphere where there are two annual minima, one of which occurs in local winter.

Introduction

IN short-wave planning it is of considerable importance to be able to estimate, for a given degree of solar activity as represented by a given sunspot Number, the corresponding critical frequencies of the ionospheric layers in all parts of the world. This is so because it is possible to forecast fairly accurately what the sunspot Number will be several months ahead, and even to estimate its value very roughly several years ahead. If, therefore, the world-wide critical frequencies corresponding to a given sunspot Number are known, then from them can be determined the frequencies of use for short-wave communication in any part of the world at a future time when the sunspot Number has that value. A major part of the problem, therefore, is to ascertain exactly how the critical frequencies vary with the continual variation in the sunspot Number.

In long-distance communication it is the F_2 layer of the ionosphere which is of most importance and it is, therefore, the critical frequency variations of that layer which it is most important to examine. It is the purpose of this article to do this for one or two of the very few ionospheric measuring stations from which the necessarily continuous records are available.

There are, of course, large short-period variations in the value of the sunspot Number, and there are large day-to-day and seasonal fluctuations in the value of the F_2 critical frequency at any geographical location. In order to establish the general relationship between the two quantities it is necessary to smooth out these fluctuations, and this is best done by taking the twelve-month running averages of the monthly means of both.

MS accepted by the Editor, September 1952

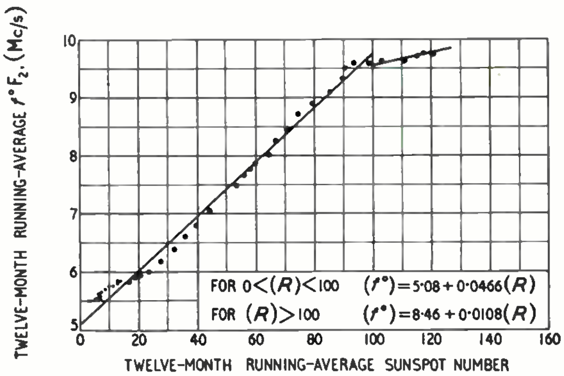

Fig. 1. *Variation of noon $f°F_2$ at Slough with sunspot number (September/October 1933 to April/May 1937).*

Measurements in the Northern Hemisphere

In Fig. 1 are plotted the twelve-month running averages of the noon critical frequency at Slough against the twelve-month running averages of the sunspot Numbers for the 'increasing' phase of the last sunspot cycle; namely, from the epochs Sept./Oct. 1933 to April/May 1937. During that cycle the running average sunspot Number reached a maximum value of 120·7, at the epoch April/May 1937.

A casual inspection of the plotted points shows that the relationship between the sunspot Number and the critical frequency is, at first, substantially linear, but that, when the sunspot Number reaches a value 90–100 there is a distinct change in the slope. The mean slope for the sunspot Number values 0–100 is shown as a straight line, as is also that for the values >100, the equations for the two separate curves being given. In these (R) is the twelve-month running average of the sunspot Number and ($f°$) the twelve-month running average of the ordinary-ray critical frequency of the F_2 layer.

The graph gives a clear indication that, while ($f°$) increases linearly with (R) up to a sunspot Number of approximately 100, it does not continue to vary at the same rate for higher values, but follows a second straight line of reduced slope. From this it might be supposed that when the solar ionizing radiation exceeded a certain value, as would possibly be the case when the sunspot Number increased beyond 100, then a saturation effect might occur in the F_2 layer, and its ionization, and hence the critical frequency, fail to continue to increase at the former rate. If this were so the effect might be expected to become still more apparent at still higher values of (R).

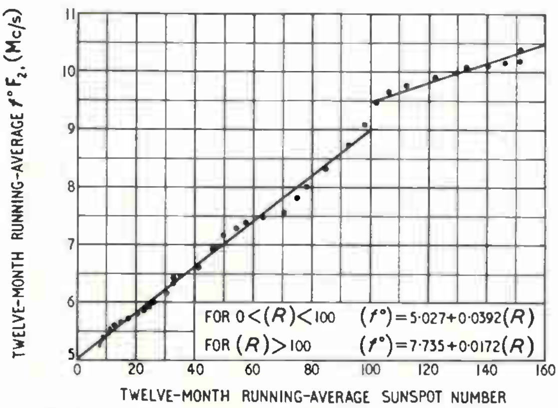

Fig. 2. *Variation of noon $f°F_2$ at Slough with sunspot number (February/March 1944 to May/June 1947).*

During the present sunspot cycle the sunspot Number did reach a far higher value at sunspot maximum than was the case during the last cycle, and in Fig. 2 there are plotted the twelve-month running averages of the noon critical frequency at Slough against the twelve-month running averages of the sunspot Number for the 'increasing' phase of this cycle, namely, from the epochs Feb./March 1944 to May/June 1947. The value of (R) at the latter epoch was 151·9.

The mean slopes for the two conditions (R) = <100 and (R) = >100 are again shown by the two separate straight lines, and it is seen that, for the lower values of sunspot Number, the slope was considerably less steep than during the previous cycle. This itself is difficult to explain, though perhaps it is hardly to be expected that the slopes for the two cycles would be *exactly* similar, and it is likely that, in order to establish the true mean slope of a curve showing the variation ($f°$) with (R), their behaviour during many more than two sunspot cycles would have to be examined, and this is not yet possible. It is probable that the actual slope of such curves may be related to the time period which elapses during the variation of the sunspot Number between its lowest value and 100. During the last cycle this period was approximately 39 months, but during the present cycle it was only 30 months approximately.

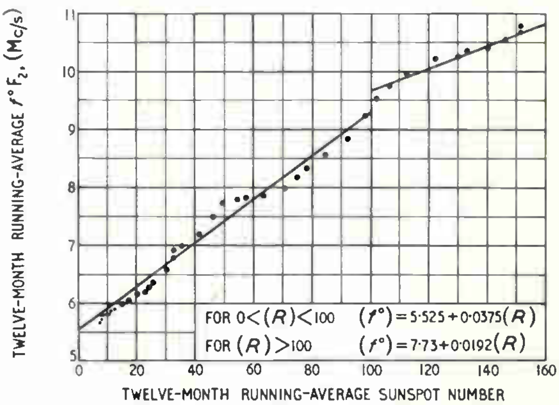

Fig. 3. *Variation of noon $f°F_2$ at Washington with sunspot number (February/March 1944 to May/June 1947).*

The significant point about the two curves, however, and that in which we are here most interested, is that they both show the marked change of slope at around (R) = 100. As Fig. 2 shows, during the present cycle, as during the last one, the variation of ($f°$) with (R) was much less rapid after the latter exceeded a value of about 100, and this decreased slope held good for all values of (R) greater than about 100.

It is now of interest to examine the data for another location on the earth's surface in order to see whether similar results are obtained. Accordingly, that for Washington is plotted in Fig. 3, along similar lines to those used in the previous figures; Washington being some 13° lower in latitude than Slough, and differing in longitude by some 76°.

Comparing Fig. 2 and Fig. 3, that is, comparing conditions during the same cycle at two stations in the northern hemisphere widely different in longitude, it is seen that for Washington the point of zero intercept is somewhat higher than for Slough, which may be accounted for by the fact that Washington lies in a lower latitude than Slough, and in lower latitudes the ionization of the layer is generally higher. But the slope of the two curves is very similar indeed for values of $(R) < 100$, and again there is the marked change of slope which occurs at about $(R) = 100$. For higher values of (R) the Washington curve again has a very similar slope to that for Slough.

It will be noted that in these figures, as well as in those which follow, there is a relatively small amount of scatter in the distribution of the measured values, for both low and high values of (R).

Measurements in the Southern Hemisphere

So far it has been shown that at Slough and Washington in the northern hemisphere, there is distinct evidence of a discontinuity in the relation between solar radiation and F_2 ionization at a sunspot Number of about 100. It is now of importance to see whether this holds true for other places on the earth's surface. Unfortunately, ionospheric measuring stations are not so systematically and symmetrically disposed upon the earth's surface that one can select measurements which give a good picture of the geographical variations in ionization. But it was thought that, for comparison with the measurements of Slough and Washington, two stations with comparable latitudes in the southern hemisphere would suffice, and that measurements from an additional station as near as possible to the equator would be informative. Accordingly the records from Christchurch, Canberra and from Huancayo were examined, the co-ordinates of all the stations being given in Table 1.

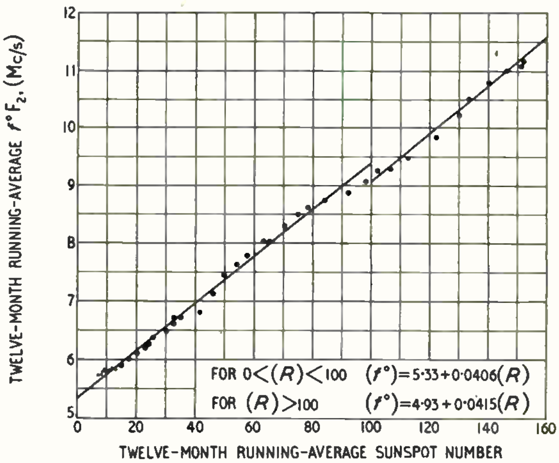

Fig. 5. *Variation of noon $f°F_2$ at Christchurch with sunspot number.* (*February/March* 1944 *to May/June* 1947).

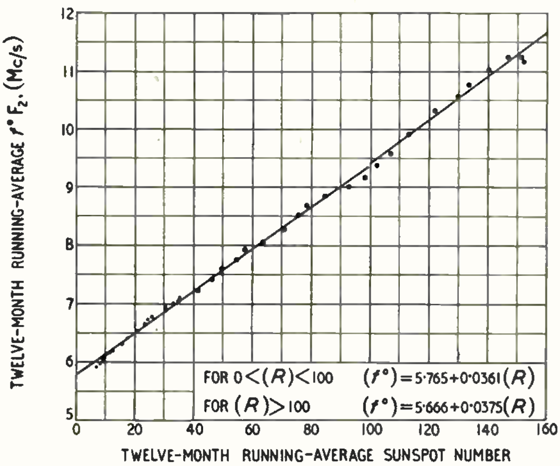

Fig. 4. *Variation of noon $f°F_2$ at Canberra with sunspot number* (*February/March* 1944 *to May/June* 1947).

TABLE 1

	Station	Lat.	Long.	Magnetic Lat.
Northern Hemisphere	Slough Washington	51·5°N 38·7°N	0·6°W 77·1°W	54°N 52°N
Equatorial	Huancayo	12·0°S	75·3°W	2°N
Southern Hemisphere	Canberra Christchurch	35·3°S 43·6°S	149·0°E 172·7°E	45°S 51°S

In Fig. 4 the data for Canberra is plotted along similar lines to those used for the previous figures, Canberra being the station with latitude comparable with that of Washington. As before, the mean slopes for the two sections for $(R) < 100$ and $(R) > 100$ are shown by the separate straight lines. Comparing Figs. 3 and 4 it is seen that the point of zero intercept is somewhat higher in the case of Canberra, which is again probably due to its latitude being somewhat lower than that of Washington. For the section of the curve for $(R) < 100$ the slope is quite similar to that for Washington, but the upper sections of the two curves are seen to be entirely different. In the case of Canberra there is no abrupt decrease in the slope around $(R) = 100$: in fact there is even a slight increase in the slope of the curve for the higher values of sunspot Number. This suggests that, at Canberra, the F_2 layer is not subject to the 'saturation' effect found at the two northern-hemisphere stations.

Fig. 5 gives the data for Christchurch, which it is intended to compare with that for Slough as given in Fig. 2. The point of zero intercept is higher in the case of Christchurch than in that for Slough, because Christchurch is in a lower latitude. (It is, however, lower than that for Canberra, which is consistent with Christchurch lying in the higher latitude.) The slopes for

Slough and Christchurch are very similar for values of $(R) < 100$, but for the higher values the two curves are markedly different. In the case of Christchurch, there is no decrease in the slope for the higher values of (R) but even, as in the case of Canberra, a slight increase. Both southern-hemisphere stations differ, therefore, from the two northern-hemisphere stations, in that, far from there being any evidence of a decreased variation in critical frequency with sunspot Number for values of $(R) > 100$, there is a distinct tendency for the critical frequency variation to increase for these higher values of (R).

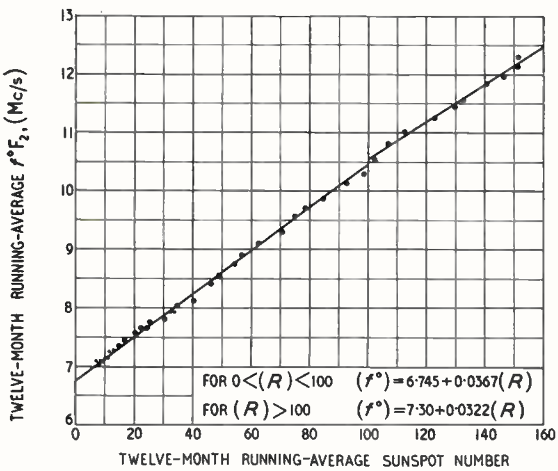

Fig. 6. *Variation of noon $f^\circ F_2$ at Huancayo with sunspot number (February/March 1944 to May/June 1947).*

In Fig. 6 the data for Huancayo are plotted: Huancayo being a station only a few degrees south of the geographic, and lying close to the magnetic equator. It might be expected that the long period ionospheric variations at such a station would exhibit tendencies midway between those exhibited by stations lying in higher latitudes in the northern and southern hemispheres respectively. Fig. 6, therefore, should be compared with Figs. 3 and 4; i.e., with the two stations lying nearest in latitude to Huancayo, north and south of the equator. The point of zero intercept is seen to be much higher for Huancayo than for the other two stations, as would be expected for the reasons already explained. The slope of the curve for $(R) < 100$ is, however, seen to be very similar for Huancayo to that for the other two stations. For values of $(R) > 100$, however, the curve for Huancayo has a slope whose value lies between those for the northerly and southerly stations, being slightly smaller than for $(R) < 100$.

If now we list the stations from north to south according to their latitude, and beside each give the mean slopes for $(R) < 100$ and $(R) > 100$ we shall be able to see how conditions vary on a geographical basis. This is done in Table 2.

TABLE 2

Station	For Sunspot Numbers <100	For Sunspot Numbers >100
Slough	0·0392(R)	0·0172(R)
Washington	0·0375(R)	0·0192(R)
Huancayo	0·0367(R)	0·0323(R)
Canberra	0·0361(R)	0·0375(R)
Christchurch	0·0406(R)	0·0415(R)

It is seen that, while the slope for values of $(R) < 100$ remains, within limits, similar for all the stations, that for $(R) > 100$ varies in a striking manner, as between the northern and southern hemispheres, increasing considerably from the northernmost to the southernmost station. For Slough and Washington it is much less, for Huancayo slightly less, and for Canberra and Christchurch appreciably greater, than that for values of $(R) < 100$.

In many other respects the curves for the several stations seem to be quite consistent with their increasing or decreasing latitude: in this respect only do they show a marked discrepancy as between similar latitudes in the two hemispheres. It seems to be clear, therefore, that, while in the northern hemisphere the F_2 layer is subject to a 'saturation' effect in its ionization when the solar ionizing radiation exceeds a certain value, this effect does not occur in the southern hemisphere, where the *average* ionization—as indicated by the *twelve-month running average* of critical frequency—thus increases by a greater amount than it does for similar latitudes in the northern hemisphere.

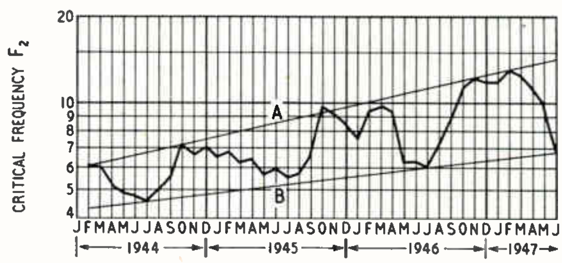

Fig. 7. *Monthly mean of noon f° for Washington.*

Differences in Critical-Frequency Variations in the Two Hemispheres

The results given above may have some physical significance. Because, however, of the complexity of the world-wide variations in the F_2 ionization, and of the difficulty of making direct comparisons between sufficient measurements made in one hemisphere and those made in the other, it is very hard to obtain data which might suggest an explanation. And it is beyond the scope of this article to go into the physics of the ionosphere. However, the month-by-month variations in the two hemispheres have been examined, and the results are given as they have a bearing on the behaviour of the running average critical frequency. For if we can find a connection between the total variation of $(f^\circ)_{F2}$ from sunspot minimum to sunspot maximum and the type of seasonal variation at any station, then the reason for the different behaviour of the F_2 layer in the two hemispheres under conditions of very high solar activity may become clear.

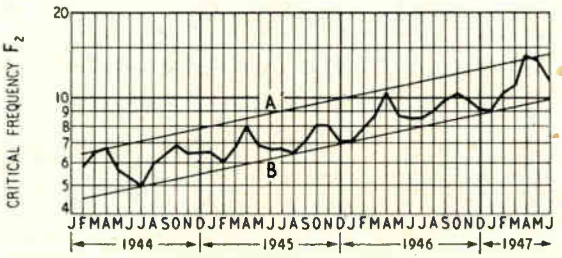

Fig. 8. *Monthly mean of noon f° for Canberra.*

In Fig. 7 the monthly means of the noon critical frequencies for Washington are plotted for the period of the 'rising' phase of the present sunspot cycle, while in Fig. 8 those for Canberra are similarly plotted, these two stations being taken as providing examples of conditions in the two hemispheres. It is seen that the annual variations are quite different in the two hemispheres, there being, generally speaking, one pronounced minimum and one maximum (which has within it a small subsidiary trough) per year in the northern hemisphere, these occurring, respectively, around the local summer and around the local winter seasons. In the southern hemisphere, on the other hand, there are, generally speaking, two minima and two maxima per year, the minima occurring round the local summer *and around the local winter* seasons, and the maxima near the equinoxes. Thus, during June/July there is a minimum in *both* hemispheres.

It is not proposed to discuss here the reasons for these fundamental differences, except to say that the maxima and minima are obviously not due to a seasonal effect alone, but probably to a combination of effects which operate differently in the two hemispheres, such as have been suggested by Berkner and Wells[1] and by T. L. Eckersley.[2] But if the values of critical frequency for the maxima (A) and those for the minima (B) are compared for the two places, it is seen that, whereas at Washington the percentage increase in critical frequency from sunspot minimum to sunspot maximum is greater for the maxima than for the minima, at Canberra the percentage increases for the minima and maxima are approximately equal. Since the percentage increase for the maxima is not very different for the two stations this means that the percentage increase in the *average* critical frequency is greater for Canberra than for Washington. If the values of the intercepts of A and B (representing envelopes of maxima and minima respectively) are read off for the epochs of sunspot minimum and sunspot maximum, the figures of Table 3 are obtained.

TABLE 3

Station	Percentage increase of f° from sunspot minimum to maximum		
	For Maxima	For Minima	Mean increase
Washington	130·0%	52·0%	98·0%
Canberra	119·0%	118·0%	118·5%

The table indicates that the greater mean increase in the case of Canberra was due to the fact that the increase for the minima was of the same order as that for the maxima, whereas for Washington it was less than half as great.

We are thus led to the idea that the 'saturation' effect in the northern hemisphere must occur mainly at the time of the annual minima (i.e., during local summer) when the atmosphere is most expanded and the solar radiation may be partly ineffective in raising the ionization, at least so far as it may be observed as a separate F_2 layer. Its absence in the southern hemisphere seems clearly to be connected with the significant differences in the nature of the minima as compared to those of the northern hemisphere, namely, the facts that there are two minima per year, that one of these occurs in local winter and that neither are so deep as those for the northern hemisphere. The causes of the general variations in F_2-layer ionization are, however, not yet perfectly understood, and the aim of this article is to draw attention to the difference in the behaviour of the layer in the two hemispheres under conditions of high solar activity, rather than to speculate upon the reasons for this difference.

REFERENCES

[1] L. V. Berkner and H. W. Wells, "Non-Seasonal Change of F_2 Region Ion Density," *Terrestrial Magnetism*, 1938, Vol. 43, No. 1.
[2] T. L. Eckersley, "On the Existence of a Biannual Component in the F_2 Layer Ionisation," *Terrestrial Magnetism*, 1940, Vol. 45, No. 1.

TRANSMISSION-LINE IMPEDANCE MEASUREMENTS

Method of Three Readings

By H. Sutcliffe, M.A., A.M.I.E.E.

(Department of Electrical Engineering, University of St. Andrews, Dundee).

1. Introduction

THE most common method of measuring impedances at high frequencies uses a standing-wave meter in a transmission system of known characteristics. The computation of impedance from the standing-wave position and amplitude can be performed rapidly by means of a Smith-type reactance chart.[1]

The travel of the moving pick-up in such a standing-wave detector must be at least half a wavelength in the transmission system. This means that the equipment is cumbersome for wavelengths of more than, say, a metre. A more convenient experimental technique at these longer wavelengths is to measure the current or potential difference at fixed points in the transmission line. It has been pointed out by Duffin[2] that there are advantages in fixed-point measurements even at microwavelengths.

The impedance at any point in the line can be derived from any three such measurements, provided that the meter separations are known in wavelengths and are not multiples of a quarter wavelength. The calculation can be performed by the method of Section 2 for the particular case where the meter separations are one-eighth of a wavelength, but is otherwise rather lengthy. Section 3 gives a graphical method which is reasonably quick and has the advantage of arriving at the solution as a point on a Smith chart.

Both methods are restricted to the case of a loss-free transmission line whose characteristic impedance is real. Admittance rather than impedance will be considered, since it is usual to connect transmission-line circuits in parallel rather than in series.

2. Calculation of Admittance

The circuit is assumed to be as in Fig. 1. Line sections one-eighth of a wavelength long are required if the calculation is to be simple.

Vector equations for the line current I and potential V are:

$$I = I'e^{-j\theta} + I''e^{j\theta} \quad \ldots \quad (1)$$

$$G_0 V = I'e^{-j\theta} - I''e^{j\theta} \quad \ldots \quad (2)$$

where $\theta = 2\pi x/\lambda$, G_0 is the characteristic admittance of the line and I' and I'' represent the incident and reflected current waves.

The relation $I'' = I'k\,e^{j\phi}$ defines the current reflection coefficients k and ϕ which are used in Section 3.

It may be shown from (1) and (2) that:

$$I = I_a\left[\cos\theta - j\frac{G_0}{Y_l}\sin\theta\right] \quad \ldots \quad (3)$$

where Y_l is the load admittance and I_a is the vector load current. Substituting in (3) for $\theta = -\pi/4$ and $\theta = -\pi/2$ gives:

$$I_b = I_a\,(1 + jG_0/Y_l)/\sqrt{2} \quad \ldots \quad (4)$$

$$I_c = I_a\,jG_0/Y_l \quad \ldots \quad (5)$$

Let $Y_l/G_0 = g + jb = y$.

Then from (4) and (5),

$$|y| = I_a/I_c \text{ and } b = \frac{2I_b^2 - I_c^2 - I_a^2}{2I_c^2}$$

I_a, I_b and I_c are the readings on the three ammeters, the magnitudes of the current vectors I_a, I_b and I_c.

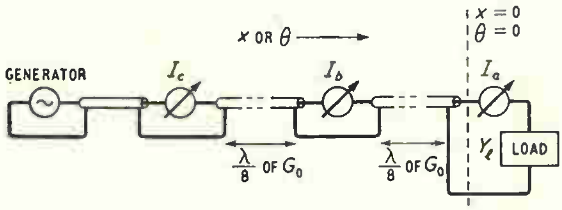

Fig. 1. *Arrangement of apparatus for three-point measurements.*

3. Graphical Method

The method relies on a graphical interpretation of equation (1). The same idea is the basis of the Smith chart.

If both sides of (1) are multiplied by $e^{j\theta}$ it becomes:

$$Ie^{j\theta} = I'\left[1 + ke^{j(\phi + 2\theta)}\right] \quad \ldots \quad (6)$$

MS accepted by the Editor, October 1952 and in final form, December 1952.

Equation (6) could be represented as in Fig. 2 if k, ϕ, and I' were known. The solid lines represent conditions at the load and dotted lines represent conditions at the other two meter positions. These, for the purpose of illustration, are taken as in Section 2 at $\lambda/8$ and $\lambda/4$ from the load. The lengths of lines OA, OB, OC are proportional to the three meter readings I_a, I_b and I_c respectively.

The information available to construct the figure is, however, not k, ϕ and I', but may be summarized as follows.

(a) The lengths OA, OB, OC, are known.

(b) The shape of the figure ABCP is known. It is a right-angled isosceles triangle with P at the mid-point of the hypotenuse.

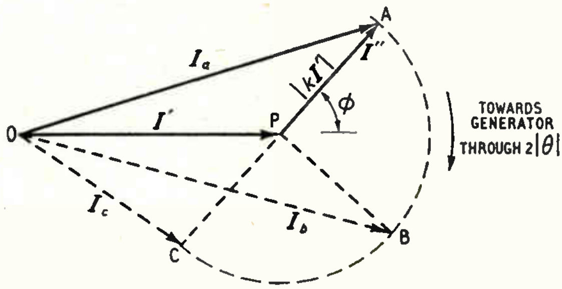

Fig. 2. *Graphical representation of equation* (6)

The graphical solution, then, proceeds as follows. Draw three concentric circles with centres at O and radii proportional to I_a, I_b and I_c. The line on which P must lie is drawn through O in any direction. The position of P on it must now be selected by trial so that requirement (b) is satisfied. This process is aided considerably by the use of a transparent sheet engraved as in Fig. 3. The sheet position is adjusted over the three circles until the three points of intersection, A-line on the sheet with the I_a circle, B-line with the I_b circle and C-line with the I_c circle, all lie on the same I'' line on the sheet. The point A can now be marked and the line OA, which represents the vector $\boldsymbol{I_a}$, can be drawn. The corresponding potential-difference vector, from equation (2), will be V_aG_0 given by OP — PA. The load admittance can then be obtained graphically from the drawing if it is required.

In general, a more useful procedure will be to transfer the point A to its corresponding position on the Smith chart which is fitted with a rotatable transparent disc. Fig. 4 shows a skeleton form of the chart marked with points O′, P′ and A′. The triangles OPA and O′P′A′ are similar.

It will be realized that the graphical method is not restricted to a $\lambda/8$ spacing between meter positions, or indeed to an equal spacing. The requirement is that the angle between the A and B lines on the transparent sheet is twice the 'angular length' of the line between meter reading I_a and I_b, and similarly with the B and C lines.

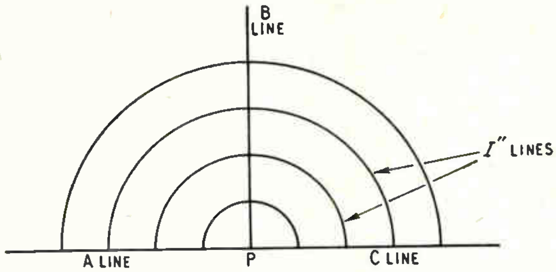

Fig. 3. *Form of transparent sheet for use in constructing Fig.* 2.

For the greatest versatility the A and C lines are engraved on strips pivoted at P so that their angles with the B line can be set to the particular meter separation in use. This would be applicable particularly to such experiments as the measurement of the impedance of an aerial over a range of frequency. The meters and cable lengths would remain in position throughout the measurement but the angles on the sheet would be adjusted at each change of frequency.

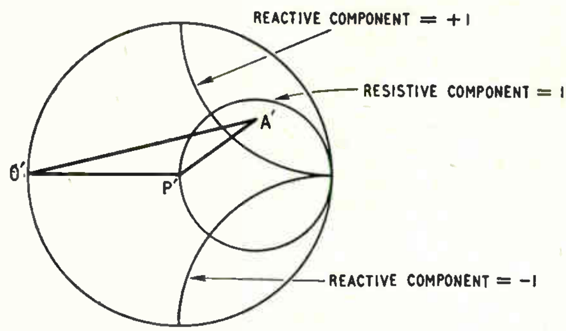

Fig. 4. *Smith chart showing correspondence with Fig.* 2.

4. Conclusion

The three-reading method appears to be somewhat neglected, in spite of the fact that it uses very simple equipment. The reason for the neglect may lie in the difficulty of extracting results from the experimental data. It is hoped that this article may be of assistance in this respect.

REFERENCES

[1] P. H. Smith, *Electronics*, Jan. 1944, Vol. 17, p. 130.
[2] W. J. Duffin, *Wireless Engineer*, Dec. 1952, Vol. 29, No. 351. p. 317.

NEW BOOKS

Radio and Radar Technique

By Dr. A. T. Starr. Pp. 812 + xviii, with 916 illustrations. Sir Isaac Pitman & Sons, Ltd., Pitman House, Parker Street, London, W.C.2. Price 75s.

This large tome is a notable addition to the literature of the subject. It contains in concise form the essentials of our present-day knowledge of radio technique. Applications are not described; the emphasis is on methods and physical interpretations. The reader is expected to have a knowledge of the subject approaching that of a university degree. The subjects on which special emphasis is laid are: (1) the role of noise in electronic systems; (2) microwave techniques; (3) waveforms and pulse techniques; (4) the fundamental behaviour of electronic tubes. In the author's opinion new tubes are the most important item in progress, and the one on which radio engineers are most in need of enlightenment. The book is unusual in that the seven chapters occupy 510 pages and 30 appendices the remaining 280 pages; this is because the main text is kept as physical as possible for the sake of clarity and ease of reading, while the mathematical analysis is done in the appendices. The author expresses his fear that the necessary condensation may make it hard for the reader to understand some parts of the text, and he asks any reader to advise him of any such difficulty. One subject that is not dealt with is the valve oscillator, and one looks in vain in the index for such names as Colpitts or Hartley. This is explained on p. 414 where the author says that "the subject is so well described in the literature that we shall not discuss it." Only by such discrimination could the size of the book be kept within reasonable limits.

The first chapter discusses the various systems of electrical communication, having regard to fundamental characteristics and the various limiting physical "phenoma" (*sic*) such as noise, bandwidth, etc. The various methods of modulation of carrier waves and pulses, signal-noise ratio, radar scanning and displays, are all discussed and the first twelve appendices are devoted to the allied mathematical problems.

The second chapter is entitled "The Electromagnetic Medium" and deals with the nature and propagation of electromagnetic waves of all types. Vector analysis, Maxwell's equations, radiation, diffraction, etc., are considered mathematically in a number of appendices. On p. 67 a table is given showing the relation between the units of the m.k.s., the e.s., the e.m., and the practical systems, but we must confess that we find it very bewildering to be told that the unit of power is the same, viz., the watt, in both the m.k.s. and the practical systems but that the unit of work is the joule in the m.k.s. but the erg in the practical system. Also, if, as stated, the units of mass, length and time in the practical system are the gramme, cm and second, how can the unit of power be the watt? On p. 96 there is a reference to equation 2·40 (a); presumably this is an equation on p. 94.

Chapter 3 is entitled "Microwave and Short-wave Techniques" and deals with discontinuities in lines and waveguides, diaphragms, corners, bends, probes, slots, etc., resonators, standing waves, filters, and the various measurements associated with microwaves. Chapter 4 deals with every type of antenna, including horns, lenses and reflectors, and concludes with methods of determining the gain. Chapter 5 is entitled "Valves" and goes very thoroughly into the properties of electrons and their emission. Considerable space is devoted to the klystron and cavity magnetron in accordance with what the author said in the preface about the need for enlightenment on this subject. Space-charge effects are discussed in Appendix 23 and velocity modulation very thoroughly in Appendix 25. Chapter 6 is entitled "C.W. Circuit Technique" to distinguish it from Chapter 7 which deals with "Waveform Circuit Technique." The former deals with ordinary network theory, Thévenin's and other theorems, transfer impedance, matrix method, wideband amplifiers and frequency modulation; the latter explains Heaviside's operational method, Laplace transforms, delay networks, pulse and saw-tooth circuits, and counters; most of these subjects are dealt with more mathematically in appendices.

Each chapter and appendix concludes with a numbered bibliography, to which references are made throughout the text, and at the end of the book there is an index of the various authors. A little more care might have been taken with the spelling of names and with the initials; Macfarlane is sometimes G. G. and sometimes G. C., Oatley sometimes C. W. and sometimes G. W., Pfleger becomes Ffleger, Tyrrell becomes Tyrrel, Espenschied Espenchied and Wynn-Williams Wyn-Williams, to mention a few that catch the eye on looking down the lists. There is, also, on p. 652 a reference to the 'principle wave', but these are minor defects which it is very difficult to avoid in the first edition of such a comprehensive work.

Notwithstanding the removal of the more mathematical material to appendices, the text, largely because of the condensation, is still unavoidably mathematical, as it must be when dealing with such a subject.

The author is very fond of the words 'clear' and 'clearly'; for example on p. 349 we read "This is *clearly* a particular case of the time function $A(p) \exp (pt)$, where p is a complex number $a + j\omega$ say. It is *clear* that the impedances of a resistance R, inductance L, and capacitance C to a voltage of the form $\exp (pt)$ *are clearly* R, pL and $1/pC$ respectively." Surely it is *clear* that some of these are *clearly* superfluous—and perhaps annoying; but for a change we are told on p. 150 that "*it is easy to see* that any impedance of VSWR between 1 and $1/n^4$ can be matched" and then after five lines "*it is easy to prove* that VSWR between 1 and $1/n^4$ can be matched out by suitable positions of the slugs."

There is no doubt, however, that Dr. Starr has explained everything as clearly as possible with the aid of nearly a thousand illustrations and produced a book that can be unreservedly recommended to anyone with the necessary preliminary knowledge.

G. W. O. H.

Information Theory and its Engineering Applications

By D. A. Bell, M.A., B.Sc.(Oxon.), M.I.E.E. Pp. 138 + viii. Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 20s.

In his preface, the author, who is Reader in Electromagnetism in the University of Birmingham, states that his "chief motive in writing this book was the desire to make available to the 'professional engineer' in telecommunications and allied work the substance of developments published since 1948 in the theory of the performance of communication systems." The author has done this in seven chapters and five appendices while keeping "within the range of mathematics associated with an honours degree in electrical engineering or physics."

The introduction deals with the binary digit as a method of expressing information and points out, what is not always realized, that the common unit of information, the bit, comes from the beginning and end of *bi*nary digi*t*. The relation between entropy and information is discussed and the author is strongly in favour of equating information to negative entropy.

The relation between bandwidth and signalling speed has a chapter to itself and is followed by one on signal-noise ratio. Coding is then treated, and its practical application, while the last chapter is devoted to Wiener's theory of filtering.

The appendices cover, thermodynamic entropy and information, internal information of the English language from word frequencies, the double-sided Fourier transform, the morse code, and logarithms to base 2.

The book is well written and the ideas are clearly presented. The main difficulty which many engineers will find lies in the nature of the mathematics used, a large part of which is of the kind associated with probability. It is not, however, unduly complex and the mathematical part of the book is actually quite small, there being many pages of plain text.

The ideas discussed cannot always be assimilated without effort, but this is the fault of the ideas rather than of their presentation. The subject is a complex one, but highly important to the future development of communications. The author has done a service by bringing together these ideas into a compact volume where they are conveniently accessible for study and reference; he has done a further service by presenting them in a uniform manner.

W. T. C.

Vacuum Tube-Oscillators

By William A. Edson. Pp. 476 + xv. Chapman & Hall, Ltd., 37 Essex Street, London, W.C.2. Price 60s.

The author is visiting professor at Stanford University, U.S.A., and intends his book for a senior or graduate course in electrical engineering as well as for the guidance of practising engineers. "The level of the book is directed towards the graduate of the usual four-year course in electrical engineering." Furthermore, "The viewpoint of design is favored over that of analysis because it represents the basic purpose of engineering and because the ability to design is a priori proof of competence in analysis."

These quotations from the preface well indicate the author's aims in the book. There are 18 chapters and the starting point is the transient behaviour of linear systems. After a short chapter on negative-resistance, non-linear oscillations are discussed in some detail. The conditions existing in the circuit are computed by means of isoclines and presented graphically by cyclograms. Methods of solving van der Pol's equation are discussed. Considerable attention is paid to the conditions which govern the type of oscillation produced, e.g., 'sinusoidal' or relaxation.

Feedback and stability criteria are discussed and, under "Resonators", the properties of capacitors, inductors, quartz crystals, cavity resonators and magnetotriction resonators; there is also a brief reference to molecular resonance. Under the heading "Linear Oscillators", the practical methods of limiting the amplitude of oscillation by lamps, thermistors and a.g.c. circuits are well treated. Ordinary 'sinusoidal' oscillators are then dealt with in a chapter which covers both tuned-circuit types and R.C. (phase-shift) oscillators. Crystal-control has a chapter to itself.

"Intermittent Operation" is the title of Chapter 10 and treats squegging and similar effects occurring in oscillators having an a.g.c. system. The treatment is mainly with the aid of the Nyquist stability criteria. A further chapter deals with power oscillators; that is, with oscillators which must supply power to an external load.

Relaxation oscillators are discussed, both saw-tooth and pulse generators being dealt with. Locking and synchronizing have a chapter to themselves. Frequency multiplication and division, noise, modulation and automatic frequency control have each a chapter and the book concludes with one dealing with long-line and multiple-resonance effects. There is a 14-page bibliography.

The treatment is, on the whole, good and is usually easy to follow. The mathematics are kept to a remarkably simple level and it is only very occasionally that a reader is likely to find anything really difficult. Sometimes, especially towards the end of the book, one feels that the treatment is rather brief and that one would have liked to see a fuller discussion. However, this feeling is inevitable in view of the wide range of the subject if the size of the book is to keep within the bounds of practical convenience.

The book is a good one and is one which the designer will undoubtedly find useful for reference.

W. T. C.

Measurement of Linear and Non-Linear Distortion in Electro-Dynamic Loudspeakers

By Fritz Ingerslev. Pp. 266. In Danish, with 14-page English Summary. Den polytekniske Laereanstalt, Sølvgade 83, København, Denmark.

Bidrag til Teorien for Antennesystemer med hel eller delvis Rotationssymmetri

By H. Lottrup Knudsen. Pp. 228 with 72 diagrams. In Danish, with 7-page English summary. Danmarks tekniske Højskole, Østervoldgade, København, Denmark.

Dry Electrolytic Capacitors

Case study data on productivity and factory performance. Prepared for the Mutual Security Agency, Productivity and Technical Assistance Division, by the United States Department of Labor. Pp. 70 + viii. British Institute of Management, 8 Hill St., London, W.1. Price 5s.

Wireless & Electrical Trader Year Book (24th Edition)

Pp. 264. Trader Publishing Co., Ltd., Dorset House, Stamford Street, London, S.E.1. Price 10s. 6d.

The Cathode Ray Oscillograph in Industry (4th Edition)

By W. Wilson, D.Sc., B.E., Hon.A.C.T.(Birm.), M.I.E.E., M.Amer.I.E.E., M.Brit.I.R.E., M.I.I.A., F.Inst.P. Pp. 273 + xvi. Chapman & Hall, Ltd., 37 Essex Street, London, W.C.2. Price 36s.

A.R.R.L. Handbook 1953 (30th Edition)

By the Headquarters Staff of the American Radio Relay League. Pp. 608. American Radio Relay League Inc., West Hartford 7, Connecticut, U.S.A. Price $4.

Radio Upkeep and Repairs (7th Edition)

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By Edmund A. Laport. Pp. 563 + xii. McGraw-Hill Publishing Co., 95 Farringdon Street, London, E.C.4. Price 76s. 6d.

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The Institute of Physics, 47 Belgrave Square, London, W.1.

CORRESPONDENCE

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

The Value of Forecasts

SIR,—In Section 6 of his paper on "Ionospheric Storm-Warning Services" (*Wireless Engineer*, May 1953, p. 103) Mr. Minnis points out the inadequacy of "number of successes" as a measure of the value of a forecast. It is, of course, a well-known statistical factor that a completely random forecast would, on the average, score a substantial number of successes; and any assessment of the *accuracy* of the forecast (as distinct from its *Value*) must take account also of false warnings issued. The commonest statistical test of *accuracy* uses the "coefficient of association" which can be formed from the diagonal products in Table 8:

$$\frac{x(N - S - y) - y(S - x)}{x(N - S - y) + y(S - x)}$$

Has this coefficient been used in developing any of the existing indices?

Another form of test is the χ^2 test, which is based on the differences between the actual entries in a table such as Table 8 and the entries which would be obtained if one merely preserved the correct ratio of storm days to quiet days in the forecast but distributed them in random sequence. Would it be useful to construct a "weighted χ^2" figure; e.g., by multiplying each entry in the table by its appropriate coefficient as shown in Table 3 and then evaluating χ^2 in the usual way?

D. A. BELL.

Department of Electrical Engineering,
The University, Birmingham.
14th May 1953.

SIR,—A clear distinction must be drawn between (a) the purely statistical problem of deducing from a series of forecasts, such as those in Table 8 (p. 106), the ability shown by the forecaster in *producing* them, and (b) the assessment, in terms of practical economic units, of the value of these forecasts to an operating organization *making use* of them. Mr. Bell's suggestion that Yule's coefficient of association might be used has a bearing on (a), but other coefficients of association and Fisher's χ^2-test would be no less appropriate since there can be no unique definition of accuracy in the present context.

In contrast to (a), (b) is a problem concerning the economics of a communication network rather than a statistical problem and it seems unlikely that the value of a set of forecasts can be expressed simply in terms of any statistical parameter. There is no obvious justification, therefore, for the "weighted χ^2-test" proposed by Mr. Bell. Further, χ^2 is essentially an auxiliary parameter which is normally used to determine a probability and has no particular significance by itself. Since the weighted χ^2-figure could not legitimately be used in this way, it is difficult to see how it could be interpreted.

C. M. MINNIS.

Radio Research Station,
Slough, Bucks.
26th May 1953.

BRITISH INSTRUMENT INDUSTRIES EXHIBITION

The second bi-annual exhibition of instruments is being held from 30th June to 11th July at the National Hall, Olympia. It is open daily from 10 a.m. to 6.30 p.m. and admission costs 2/6d. There are about 170 exhibitors of whom over one-third have exhibits of an electrical or electronic nature.

The Scientific Instrument Manufacturers' Association, is one of the five supporting organizations.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for May 1953

Date May 1953	Frequency deviation from nominal: parts in 10^8 MSF 60 kc/s 1029-1130 G.M.T.	Frequency deviation from nominal: parts in 10^8 Droitwich 200 kc/s 1030 G.M.T.	Lead of MSF impulses on GBR 1000 G.M.T. time signal in milliseconds
1	+ 0·3	0	+ 32·1
2	+ 0·3	+ 1	+ 31·3
3	+ 0·3	N.M.	+ 31·7
4	+ 0·4	+ 1	+ 31·3
5	+ 0·4	0	+ 30·5
6	− 1·5	+ 1	+ 28·9
7	− 1·5	+ 1	+ 26·4
8	− 1·1	+ 1	+ 24·4
9	− 1·4	+ 1	+ 21·9
10	− 1·4	+ 2	+ 18·7
11	− 1·4	+ 1	+ 16·1
12	− 1·3	+ 2	+ 13·4
13	− 1·3	+ 2	+ 10·2
14	N.M.	+ 2	N.M.
15	− 1·6	0	+ 3·8
16	− 1·6	+ 1	− 0·2
17	− 1·6	+ 3	N.M.
18	− 1·5	+ 1	N.M.
19	− 1·4	+ 3	− 12·0
20	− 1·4	+ 1	− 16·2
21	− 1·4	+ 3	− 20·0
22	− 1·6	+ 1	N.M.
23	− 1·6	+ 1	N.M.
24	N.M.	+ 2	− 31·2
25	N.M.	N.M.	− 34·7
26*	− 1·3	+ 1	− 37·3
27*	− 1·4	+ 1	N.M.
28*	− 1·4	+ 1	− 44·1
29*	− 1·3	N.M.	− 47·5
30*	N.M.	+ 4	N.M.
31*	N.M.	N.M.	N.M.

The values are based on astronomical data available on 1st June 1953.

The transmitter employed for the 60-kc/s signal is sometimes required for another service.

N.M. = Not Measured.

* = No MSF Transmission at 1029 G.M.T. Results for 1429—1530 G.M.T.

Correction

An error occurred in Table 1 of the new schedule of standard-frequency transmissions in the June issue. In this Table the transmissions were listed as modulated by a 1,000-c/s tone from 15 to 20 minutes past each hour, whereas the transmissions are actually interrupted over this period, as correctly stated in the text.

ABSTRACTS and REFERENCES

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research and published by arrangement with that Department.

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of journal titles conform generally with the style of the World List of Scientific Periodicals. An Author and Subject Index to the abstracts is published annually; it includes a list of journals abstracted, the abbreviations of their titles and their publishers' addresses.

	PAGE A
Acoustics and Audio Frequencies	**141**
Aerials and Transmission Lines	**143**
Circuits and Circuit Elements	**144**
General Physics	**147**
Geophysical and Extraterrestrial Phenomena	**149**
Location and Aids to Navigation	**151**
Materials and Subsidiary Techniques	**151**
Mathematics	**154**
Measurements and Test Gear	**155**
Other Applications of Radio and Electronics	**157**
Propagation of Waves	**158**
Reception	**159**
Stations and Communication Systems	**160**
Subsidiary Apparatus	**161**
Television and Phototelegraphy	**162**
Transmission	**163**
Valves and Thermionics	**164**
Miscellaneous	**164**

ACOUSTICS AND AUDIO FREQUENCIES

534.2 : 534.011 **1874**

An Acoustic Gyrator.—W. E. Kock. (*Arch. elekt. Übertragung*, Feb. 1953, Vol. 7, No. 2, p. 106. In English.) A device is described which is the acoustic analogue of the microwave gyrator described by Hogan (1233 of 1952). The required nonreciprocal rotation of the plane of polarization of transverse acoustic waves propagated in a tube is accomplished by rotating a section of the tube at high speed.

534.21-13 **1875**

On Sound Waves of Finite Amplitude.—E. T. Copson. (*Proc. roy. Soc. A*, 24th Feb. 1953, Vol. 216, No. 1127, pp. 539–547.) An analytical solution of Riemann's equations for the one-dimensional propagation of sound waves of finite amplitude in a gas obeying the adiabatic law $p = k\rho_\gamma$ is obtained for any value of the parameter γ.

534.231 **1876**

The Sound Field of a Piston Source.—E. W. Guptill. (*Canad. J. Phys.*, March 1953, Vol. 31, No. 3, pp. 393–401.) "An exact solution is presented for the sound field between two infinite walls when the source is a piston in one of the walls. A method is also outlined for the case of a source having any amplitude distribution which is a function only of radial distance from the center of the source."

534.231 **1877**

The Acoustic Radiation of the Rectangular Piston Membrane.—H. Stenzel. (*Acustica*, 1952, Vol. 2, No. 6, pp. 263–281. In German.) General formulae are obtained for calculating the sound field immediately in front of the membrane. The adjacent field is calculated by graphical integration. Field contours for square membranes with different dimension/wavelength ratios are shown. General formulae for the radiation impedance are derived; its two components are calculated and represented graphically for membranes with sides in ratio 1, 2, 5 and 10 to 1.

534.231 **1878**

The Physics of Sound Radiation Pressure.—F. Borgnis. (*Z. Phys.*, 6th Feb. 1953, Vol. 134, No. 3, pp. 363–376.) The radiation pressure of a free beam of a plane compression wave incident normally on a plane obstacle is investigated by means of the hydrodynamic impulse law; this method gives a clear physical idea of the forces on the obstacle. The formulae are derived in terms of both Euler and Lagrange variables. Making use of Brillouin's tensor potential, a boundary condition for the beam is derived which takes account of the energy exchange between the beam and the ambient medium; this boundary condition leads to a simple relation between the radiation pressure and the difference of the energy densities on the two sides of the obstacle. As a particular case, the radiation pressure on the boundary surface between two immiscible fluids is considered.

534.232 : 534.321.9 **1879**

Ultrasonic Whistles.—A. E. Crawford. (*Research, Lond.*, March 1953, Vol. 6, No. 3, pp. 106–110.) Descriptions are given of generators of resonant-cavity and resonant-wedge type using gas or liquid exciting jets; these are useful for low-power applications such as experiments on ultrasonic propagation in gases, and the emulsification of low-viscosity liquids. Power is provided by a compressor or pump.

534.241 : 551.510.52 **1880**

Study of the Echoes of Acoustic Waves in the Stratified Region of the Troposphere.—G. Eckart. (*Acustica*, 1952, Vol. 2, No. 6, pp. 256–262. In French.) Methods of Bremmer and of Schelkunoff are applied to derive wave equations for sound propagation in a stratified atmosphere. The importance of the terms which render the analogy to e.m. wave propagation incomplete [4 of January (Eckart & Liénard)] is clearly shown.

534.26 **1881**

On Acoustic Diffraction through an Aperture in a Plane Screen.—J. W. Miles. (*Acustica*, 1952, Vol. 2, No. 6, pp. 287–291. In English.) Generalized Fourier transforms are applied to derive equations for the scattered wave. The aperture impedance is expressed in variational form and compared with the Kirchhoff approximation. Reflection from a disk and diffraction at a circular aperture for the case of oblique incidence are considered. See also 2686 of 1952.

534.3 **1882**

Experimental Study of the Acoustic, Physiological and Psychophysiological Conditions relating to the Aesthetics of Music.—R. Husson. (*Ann. Télécommun.*, Feb. 1953, Vol. 8, No. 2, pp. 51–72.)

534.32 : 621.396.619.11 **1883**

Perception of Amplitude Modulations.—H. Ebel. (*Akust. Beihefte*, 1952, No. 4, pp. 246–250.) Modulation at high frequencies is perceptible at modulation levels lower than that required for perception of low-frequency modulation. Amplitude modulations are less discernible in speech and music than in pure tones. Experimental results agree with those of Zwicker (303 of February) and give an indication of the limiting distortion factor of a loudspeaker for agreeable reproduction.

534.321.9 **1884**

Ultrasonics in Solids.—G. Bradfield. (*Research, Lond.*, Feb. 1953, Vol. 6, No. 2, pp. 68–79.) Thermal vibrations in solids are discussed in relation to physical constants, and the application of ultrasonic and v.h.f. techniques in elasticity measurements is described. Different forms of $BaTiO_3$ transducer are shown and applications of ultrasonics in different technical fields are reviewed.

534.321.9 : 621.391.6 **1885**

Use of Ultrasonics in Telephony.—L. Pimonow. (*Ann. Télécommun.*, Jan. 1953, Vol. 8, No. 1, pp. 28–30.) Measurements have been made of the attenuation of ultrasonic waves propagated in various media, e.g. metal wires, water-filled pipes and air. As a result, equipment has been developed for short-range telephony by means of modulated ultrasonic waves. For two-way operation a suppressed-carrier system may be used; for one-way operation the carrier should be retained. A system is described suitable for conference-room use, with air as the medium of propagation. The carrier-frequency range is 16–100 kc/s and the radiated power 2–3 W. The receiver is carried on a headband.

534.44 **1886**

Frequency Analysis of Acoustic Phenomena.—R. Bierl. (*Akust. Beihefte*, 1952, No. 4, pp. 225–235.) The application of a spectral-function diagram derived from the Fourier integral in filter-circuit and integration methods of waveform analysis is illustrated. Waveforms considered are rectangular and exponential pulses, and sine waves with rectangular and exponential envelopes. The time variation of amplitude and the relative phase of individual frequency components are determined for a limited number of components from the width and position of maxima and the angular velocity of the radius vector of the spectral-function diagram.

534.6 : 534.321.2 **1887**

Measurement of Harmonic Intervals of the Musical Scale based on the Subjective Sensation of Consonance.—M. Barkechli. (*Acustica*, 1952, Vol. 2, No. 6, pp. 242–250. In French.)

534.6 : 621.395.623 **1888**

The Problem of the Artificial Ear for Calibrating Telephone Receivers.—I. Barducci. (*Arch. elekt. Übertragung*, March 1953, Vol. 7, No. 3, pp. 155–157.) See 1814 of 1952 (Schiaffino).

534.62 **1889**

New Anechoic Chamber of the Technische Hochschule, Karlsruhe.—H. Ebel & P. Maurer. (*Akust. Beihefte*, 1952, No. 4, pp. 253–256.) The design and construction of an anechoic chamber are described. By combining wedge-shaped absorbers and damped Helmholtz resonators an absorption factor of 99% for frequencies down to 160 c/s is attained. Total thickness of the wall lagging is 61 cm. Absorption characteristics of the material and of the complete chamber are compared.

534.75 **1890**

Contribution to a Scientific Theory of Single-Channel Transmission of Sound: Part 2.—P. Burkowitz. (*Funk u. Ton*, Jan. 1953, Vol. 7, No. 1, pp. 10–26.) The significance of the amplitude and path-time ratios of reflected and direct sound, and their relation to tonal quality, are discussed. Part 1 : 1229 of May.

534.771 **1891**

The Békésy Audiometer of the Technische Hochschule, Stuttgart.—W. Kaiser. (*Akust. Beihefte*, 1952, No. 4, pp. 235–238.) Modifications to the audiometer [3325 of 1949 (Békésy)] have been made so that threshold intensities throughout the region of audibility may be accurately determined.

534.771 : 534.61 **1892**

The Trend of the Modulation Threshold in the Audible Range.—E. Zwicker & W. Kaiser. (*Akust. Beihefte*, 1952, No. 4, pp. 239–246.) Audiometer methods were used to determine the threshold of perceptibility of loudness and pitch variations of pure tones modulated by a 4-c/s tone at different modulation levels. Results for cases of defective and also of normal hearing are discussed.

534.84 **1893**

Diffusion in Architectural Acoustics.—W. Furrer & A. Lauber. (*Acustica*, 1952, Vol. 2, No. 6, pp. 251–256. In German.) Analysis of results of measurements shows that the irregularities in the frequency characteristic of a room are not a direct measure of the homogeneity of the sound field, but the mean height of the peaks is a parameter related directly to the 'diffusion', or field homogeneity. This parameter has been determined at frequencies around 375 c/s and 1 650 c/s for 11 studios and halls varying in size from 37 m³ to 20 000 m³. Two examples are discussed.

534.843 **1894**

Boundary Conditions for the Acoustic Wave Equation.—T. Vogel. (*Acustica*, 1952, Vol. 2, No. 6, pp. 281–286. In French.) The concept of specific normal impedance is discussed in relation to the boundary conditions obtaining for sound propagation in a closed space. Experimental results for a simple case are at variance with this concept. A modified hypothesis is suggested involving two specific impedances, one normal and one tangential to the surface considered.

534.843 : 534.24.001.57 **1895**

Reflection of Sound at Surfaces with Periodic Structure.—E. Meyer & L. Bohn. (*Akust. Beihefte*, 1952, No. 4, pp. 195–207.) The efficacy of uniformly spaced diffusing elements fixed to plane walls has been investigated on small-scale models, using frequencies in the range 15–60 kc/s. A diffusion index is calculated, which is the ratio of the reflected sound energy outside the 20°-region of the geometrical reflection to the total reflected energy. The dependence of this index on wavelength, width and depth of the projections and angle of incidence of the sound beam, is discussed for projecting elements of semi-circular, triangular and rectangular cross-section in front of (*a*) perfectly absorbing, (*b*) perfectly reflecting surfaces.

534.846.6 **1896**

Measurement of the Reflecting Power of Ceilings, using Ultrasonics.—F. Canac. (*C. R. Acad. Sci., Paris*, 2nd Feb. 1953, Vol. 236, No. 5, pp. 467–469.) The effectiveness of ceiling treatments such as coffering for controlling the reverberation time of halls is investigated by using small-scale models together with proportionately increased frequencies.

621.395.61 **1897**

Sensitivity of Microphones to Stray Magnetic Fields.—L. J. Anderson. (*Trans. Inst. Radio Engrs*, Jan./Feb. 1953, Vol. AU-1, No. 1, pp. 1–6.) Equipment is described and simple theory is given for (*a*) comparison of various types of microphone with respect to their sensitivity to hum fields, (*b*) measurement of hum fields existing in the neighbourhood of microphones. Charts show the hum spectra observed in some particular cases.

621.395.61 : 534.612 **1898**

An Experimental Probe Microphone for the Measurement of Sound Pressures.—R. B. Archbold. (*P. O. elect. Engrs' J.*, Jan. 1953, Vol. 45, Part 4, pp. 145–148.) Account of the development of a microphone designed primarily for acceptance tests on telephone apparatus. A long narrow tube is coupled to the diaphragm, and the sensitivity/frequency characteristic is smoothed by introducing a small amount of lamb's wool into each end of the tube.

621.395.623.8 : 621.396.645.371 **1899**

Portable P.A. [public-address equipment].—E. Griffiths. (*Wireless World*, May 1953, Vol. 59, No. 5, pp. 201–204.) Description of equipment giving an output of 8 W with < 1% distortion, for use in small halls. It includes record player, amplifier, loudspeaker and power pack, the whole contained in two cases of about equal size and weight. The negative-feedback amplifier has arrangements for either single-ended or push-pull input, the latter being more suitable for use with the crystal pickup.

621.395.625(083.74) : 621.396.822 **1900**

Standards on Sound Recording and Reproducing: Methods of Measurement of Noise, 1953.—(*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 508–512.) Standard 53 IRE 19S1.

621.395.625.3 **1901**

Print-Through Effect in Magnetic Tape for Sound Recording.—H. J. Tafel. (*Fernmeldetech. Z.*, Jan. 1953, Vol. 6, No. 1, pp. 17–24.) An experimental investigation of printing through in adjacent windings of rolled tape, in respect of the intensity and permanence of this magnetization. Its dependence on the temperature, and on the duration, frequency and intensity of the original magnetization is assessed.

621.395.625.3 : 534.76 **1902**

A Practical Binaural Recording System.—O. C. Bixler. (*Trans. Inst. Radio Engrs*, Jan./Feb. 1953, Vol. AU-1, No. 1, pp. 14–22.) Modifications to commercial tape recording and reproducing equipment are described resulting in a simple stereophonic system comprising two microphones and two loudspeakers, each channel using half the tape. Various applications are indicated, including court-room reporting. Broadcasting tests were made by connecting one microphone to an a.m. transmitter and the other to a f.m. transmitter, the listener using a.m. and f.m. receivers simultaneously.

621.395.92 : 621.314.7 **1903**

Transistorized Hearing Aids.—J. D. Fahnestock. (*Electronics*, April 1953, Vol. 26, No. 4, pp. 154–155.) Circuit and performance details are given of various commercially available hearing aids using (*a*) subminiature valves and transistors or (*b*) transistors exclusively. Only junction-type transistors are used, with grounded-emitter circuits. Noise level is discussed. Some models have facilities for switching from microphone to a telephone pickup coil.

681.84 **1904**

Piezo-electric Crystal Pick-ups.—S. Kelly. (*J. Brit. Instn Radio Engrs*, March 1953, Vol. 13, No. 3, pp. 161–170.) Bimorph crystal elements are used, usually torsional in the case of Rochelle salt, and always benders in the case of $BaTiO_3$. Design methods make use of equivalent electrical circuits. Needle-tip impedance can be reduced to obtain satisfactory tracking at a needle pressure of < 5 gm. Frequency response can be levelled from 20 c/s to 20 kc/s, using simple equalizers. Wear and distortion are discussed. Details are given of a two-stylus pickup for 78- and 33⅓-r.p.m. records.

AERIALS AND TRANSMISSION LINES

621.315.2.015.7 **1905**

Theory of Pulse Technique for Coaxial Cables.—P. Behrend. (*Z. angew. Phys.*, Feb. 1953, Vol. 5, No. 2, pp. 61–64.) Analysis is given for the deformation experienced by rectangular or half-sine-curve pulses traversing a coaxial cable, the transfer function of the cable being assumed to be a subfunction of a Laplace transform. Results are shown in graphs.

621.392.21.09 **1906**

Physical Explanation of the Surface Wave on a Dielectric-Coated Line.—P. J. M. Clavier. (*Câbles & Transm.*, Jan. 1953, Vol. 7, No. 1, pp. 34–38.) The propagation of a surface wave is treated as a series of reflections alternately at the metal surface and the dielectric/air interface. By analogy with waveguide propagation an E_0 mode is defined. Below the limiting frequency for propagation along the line, energy is radiated and the mode analogy is destroyed. The relation between angle of incidence on the reflecting surfaces and the phase and group velocities is illustrated and the variation of the latter as a function of frequency is shown graphically.

621.392.26 : 621.315.61 **1907**

Propagation in Waveguides filled Longitudinally with Two or More Dielectrics.—L. G. Chambers. (*Brit. J. appl. Phys.*, Feb. 1953, Vol. 4, No. 2, pp. 39–45.) Discussion of the propagation of pure TE and TM modes in inhomogeneously filled rectangular and circular waveguides, summarizing the results of research work published since 1943. 16 references.

621.396.67 **1908**

An Alternative Method of solving Hallén's Integral Equation and its Application to Antennas near Resonance.—R. King. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 140–147.) Hallén's equation is separated into two equations for the in-phase and quadrature-phase current components respectively; these are solved by an iteration method. For values of aerial electrical half-length near odd multiples of $\lambda/4$, at least a third-order solution is required for the accurate determination of in-phase current and conductance. Conductance values for a range of radii are evaluated using the third-order formula; comparison with experimental results indicates that for aerials near resonance, just as for very short and very long aerials, account must be taken in the iteration procedure of both the current components.

621.396.67 **1909**

Power Gain of Curtain Arrays of Aerials.—P. Hammond. (*Wireless Engr*, May 1953, Vol. 30, No. 5, pp. 108–111.) The directional concentration of power by systems

D

comprising uniformly spaced aerials carrying equiphase currents is investigated, using the concept of radiation resistance. The field due to an infinitely long filament is first considered and a solution is obtained in terms of Bessel functions of zero order and of the first and second kinds. From this the power output can be determined for a single aerial and for combinations of various numbers of aerials in arrays. For a spacing of about $3\lambda/4$ between elements, the power gain passes through a maximum, its value being then about 50% greater than the value for $\lambda/2$ spacing. This maximum is also obtained for finite-height aerials and for arrays having depth as well as width.

621.396.67 : 621.315.612.4 : 621.396.611.4 **1910**

Quasi-degenerated Modes in High-ϵ Dielectric Cavities.—Schlicke. (See 1942.)

621.396.67 : 621.396.9 **1911**

Moulded Plastic Radar Scanners and Stressed Components.—(*Engineering, Lond.*, 2nd Jan. 1953, Vol. 175, No. 4536, pp. 28–29.) The 14-ft radar reflector described consists of a sandwich-like construction having outer layers of asbestos-fibre material impregnated with phenolic resin and a resin-impregnated paper-honeycomb core. It is as strong as, stiffer than, and weighs half as much as a reflector made of Al alloy; resistance to weathering is good.

621.396.677 **1912**

Reception Diagrams of Rhombic Aerials in a Vertical Plane.—J. Dufour. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st March 1953, Vol. 31, No. 3, pp. 65–72. In French.) Measurements were made of the received signal strength on the ground, at Châtonnaye, using an airborne transmitter. Results obtained with two slightly different rhombic aerials were compared with the theoretical values for frequencies of 5, 10, 15, 20, 25 and 30 Mc/s. Good agreement was found. There is a strong ground reflection at 6–7 km from the station, giving rise to marked interference for angles of incidence $< 8°$ from the horizontal.

621.396.677 **1913**

A Theory of Plane Reflectors in Microwave Antenna Systems.—H. L. Knudsen & M. Andreasen. (*Trans. Dan. Acad. tech. Sci.*, 1952, No. 3, pp. 3–57.) Values are calculated for the field reflected from an apparently circular reflector illuminated by a point radiator; they differ considerably from results obtained by Aasma. For the case of a finite-size radiator, the calculations are based on the assumption of rectangular radiator and reflector apertures. Curves are presented from which the reflected field and the gain can be read directly or determined by a combination of two readings. Errors introduced by the simplifying assumptions are discussed. Fresnel integrals and related functions are used in the analysis; relevant tables and curves are given.

621.396.677 : 621.392.26 **1914**

Second-Order Beams of Slotted-Waveguide Arrays.—H. Gruenberg. (*Canad. J. Phys.*, Jan. 1953, Vol. 31, No. 1, pp. 55–69.) Second-order beams due to slot offset have escaped detection because they are not located in the plane containing the waveguide axis, where the radiation pattern is usually measured. The patterns of the second-order beams for a waveguide with staggered slots are analysed by considering an approximately equivalent arrangement of two parallel linear arrays separated by twice the weighted mean offset. The second-order beams can be suppressed by using (*a*) an array with all slots aligned and appropriate corrugations in the waveguide wall, or (*b*) a conventional waveguide array fitted with a horn incorporating a parallel-plate section (3343 of 1952).

621.396.677 : 621.392.26 **1915**

Theory of Waveguide-Fed Slots radiating into Parallel-Plate Regions.—L. Lewin. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, p. 232.) Simpler alternative expressions are derived for integrals introduced in the original paper by Gruenberg (3343 of 1952).

621.396.677.029.62 **1916**

Theory of Artificial Slot Antennas.—A. Ataman. (*Bull. tech. Univ. Istanbul*, 1951, Vol. 4, No. 1, pp. 71–89. In English.) The term 'artificial slot' is applied to a radiator comprising a dielectric rod of rectangular cross-section, lying on a conducting surface and having two sides covered with metal plates between whose upper edges an electric field is established. Such devices are useful for the frequency range 100–300 Mc/s, and may have advantages over a true slotted aerial for use in high-speed aircraft. Analysis is given, treating the arrangement as a uniformly loaded transmission line. A determination is made of the properties of the dielectric required to give satisfactory radiation efficiency; high permeability and low losses are desirable. A numerical calculation is made for a $\lambda/2$ aerial to operate at 200 Mc/s with a slot width of 2 cm; for a material with a dielectric constant of 10 the slot depth is 0·5 cm.

621.396.677.5 : 621.318.132 **1917**

Receiving Properties of a Wire Loop with a Spheroidal Core.—J. R. Wait. (*Canad. J. Technol.*, Jan. 1953, Vol. 31, No. 1, pp. 9–14.) The relative gain of a loop aerial with spheroidal core is calculated, assuming core losses to be negligible, an assumption which is justified for ferromagnetic ceramics at frequencies of the order of 200 kc/s or lower. The magnetic properties of modern ferromagnetic materials are used to good advantage when the spheroid is highly elongated or very much flattened.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.011.22/.23 : 621.315.512 **1918**

Internal Alternating-Current Resistance and Reactance of Conductors of Circular Cross-Section.—P. M. Prache. (*Câbles & Transm.*, Jan. 1953, Vol. 7, No. 1, pp. 28–33.) A numerical table is presented for simple and accurate calculations for solid conductors and for thin or thick tubes. Proximity effect is neglected.

621.3.014/.016 : 621.3.012.1 **1919**

Vector Representation in the Time Plane of Electrical Potential Difference, Current and Power varying Sinusoidally in Time.—G. Kouskoff. (*Rev. gén. Élect.*, Feb. 1953, Vol. 62, No. 2, pp. 86–90.) The varying magnitudes are considered, according to a method originally used by Fresnel, as the resultant of two imaginary vectors of equal and constant length, rotating at the same rate in opposite senses. The imaginary plane containing these vectors is called the 'time plane'. The impedances of a circuit to the two vector components of a sinusoidally varying current are defined, and the method of representing power, i.e., the product of voltage and current, is explained.

621.3.015.7 : 621.387.4 **1920**

A New Pulse-Analyzer Design.—C. W. Johnstone. (*Nucleonics*, Jan. 1953, Vol. 11, No. 1, pp. 36–41.) Description, with detailed circuit diagrams, of a single-channel analyser which serves as the basic design for multichannel analysers, details being given of a 10-channel analyser. Positive pulses are accepted in the amplitude range 3–103 V plus the sum of channel widths. The width and position of the channels can be changed quickly without requiring recalibration. The design is simple and relatively few valves are required.

621.316.86 : 537.312.6 **1921**

Resistor Temperature Coefficients.—F. A. Paul. (*Tele-Tech*, Jan. 1953, Vol. 12, No. 1, pp. 52–53, 120.) Tests were carried out on four types of pyrolytic-carbon-film resistor and one type of metal-film resistor, several samples of each type, of different resistance ratings, being used. The results obtained for the temperature range from − 30° to + 120°C are shown graphically. The temperature coefficients of the carbon-film resistors are considerably lower than those of carbon-composition resistors. The coefficients are negative and much greater than those of wire-wound resistors, though this is not the case for borocarbon-film resistors [2365 of 1951 (Grisdale et al.)].

621.318.4.011 **1922**

Determination of Voltage, Current, and Magnetic Field Distributions together with the Self-Capacitance, Inductance and H.F. Resistance of Single-Layer Coils.—A. E. S. Mostafa & M. K. Gohar. (*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 537–547.) A theoretical investigation is made which is applicable to coils of intermediate lengths. The number and magnitudes of the harmonics are calculated, and their effect on the self-capacitance is indicated. Experimental results obtained by other workers support the theoretical results.

621.318.42 : 538.221 **1923**

Ferrite Core Inductors.—H. A. Stone, Jr. (*Bell Syst. tech. J.*, March 1953, Vol. 32, No. 2, pp. 265–291.) Design of inductors for communication equipment is considered particularly from the point of view of the best use of the properties of ferrites. Advantages of ferrite compared with metal cores for high-frequency low-power applications include (*a*) higher Q values, (*b*) smaller volume, and (*c*) greater ease of adjustment.

621.318.42 : 621.311.6 **1924**

Miniaturization of Airborne Filter Chokes.—W. E. Tanner. (*Electronics*, April 1953, Vol. 26, No. 4, pp. 180–183.) A calculation chart is given for chokes using 7-mil laminations of 4% Si steel with square stack; use of the chart is illustrated by numerical examples.

621.319.4 **1925**

The Power Factor and Capacitance of Mica Capacitors at Low Frequencies.—P. R. Bray. (*J. sci. Instrum.*, Feb. 1953, Vol. 30, No. 2, pp. 49–51.) Experimental results confirm an empirical law of the form af^m (m negative and fractional) for the power factor over the range 1–30 c/s at normal temperatures. They also confirm a relation between frequency, power factor and capacitance. Power factors as high as 0·01 have been found at 1 c/s, corresponding to increases of nearly 2% in capacitance over the values at higher frequencies.

621.392.2 : 621.3.015.3 **1926**

Calculation of Transient Phenomena in Electrically Short Networks by means of Fourier Integrals.—E. Adam. (*Öst. Z. Telegr. Teleph. Funk Fernsehtech.*, Jan.–April 1953, Vol. 7, Nos. 1–4, pp. 1–10 & 36–40.) Fourier integrals are applied to the determination of the frequency spectra of (*a*) periodic functions, (*b*) nonperiodic functions, including step functions. The results are used in discussion of the distortion and initial conditions in networks to which an impulse voltage is applied.

621.392.5 **1927**

Design of Practical Linear Networks with Optimum Signal/Noise Ratios.—K. Halbach. (*Helv. phys. Acta*, 15th Feb. 1953, Vol. 26, No. 1, pp. 65–74. In German.) A general method is described for the design of networks for which the relation between the input and output signals is represented by linear equations, the frequency spectra of signal and noise being assumed known. The application of the method of analysis in the design of the optimum ionization-chamber amplifier is illustrated, and the signal/noise ratios attainable are compared with those for an RC discriminating network and a delay-line clipping circuit.

621.392.5 **1928**

Applications of T Networks.—M. Alixant. (*Radio tech. Dig.*, *Édn franç.*, 1952, Vol. 6, No. 6, pp. 301–316.) Adaptation of paper by Lavagnino (3032 of 1952) incorporating additional material. 53 references.

621.392.5 **1929**

Synthesis of Transfer Functions with Poles Restricted to the Negative Real Axis.—L. Weinberg. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 207–216.) A procedure for the synthesis of general RC transfer functions by means of unbalanced networks is described. The transfer function need not be minimum-phase, but may have zeros anywhere in the complex plane except on the positive real axis. Use is made of techniques described by Guillemin (2462 of 1949), but the problem is simplified by use also of a network theorem due to Adler, enabling zero shifting to be performed in two directions from within the total network. In an example worked out, 26 network elements are used, whereas the Guillemin procedure would require 66.

621.392.5 : 538.652 : 546.289 **1930**

Hall-Effect Modulators and "Gyrators" employing Magnetic-Field-Independent Orientations in Germanium.—W. P. Mason, W. H. Hewitt & R. F. Wick. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 166–175.) The application of the Hall effect in Ge to the measurement of magnetic flux has been described previously [3172 of 1948 (Pearson)]. Further applications are now described to (*a*) a product modulator, in which the current corresponding to one signal is passed through the Ge crystal while that corresponding to the other is used to produce the magnetic field, and (*b*) a circuit element with non-reciprocal transmission properties, or gyrator. In these applications a crystal orientation is used for which the transverse magnetoresistance effects are zero and the variation of the Hall-effect coefficient with flux up to 20 000 gauss is $\ngtr 2\%$. The experimental determination of this orientation is described.

621.392.52 **1931**

The Development of the Electrical Filter by K. W. Wagner's Methods.—T. Laurent. (*Arch. elekt. Übertragung*, March 1953, Vol. 7, No. 3, pp. 126–135.) Wagner's method of filter design, which is based on consideration of the filter as a ladder of matched reflection-free sections, is compared with methods developed by Zobel, Cauer and others; it is concluded that the principles laid down by Wagner have lost none of their original validity or usefulness.

621.392.52 **1932**

Some Designs of Ladder Filter. Results Obtained and Methods of Calculation.—D. Starynkevitch. (*Câbles & Transm.*, Jan. 1953, Vol. 7, No. 1, pp. 3–15.) The principle of matching half-sections and transforming impedances in designing filters with a minimum number of components is illustrated in two examples: a narrow-band band-pass filter for 612 kc/s, and a filter with a 4-Mc/s pass band centred on 10 Mc/s. Formulae relating to the transformation of T-type quadripoles to Π-type and vice versa, and to various types of quadripoles for impedance matching, are collected in appendices.

621.392.52 : [621.392.26 + 621.315.212 **1933**

U.H.F. Band-Pass Filters.—J. C. Simon & G. Broussaud. (*Ann. Radioélect.*, Jan. 1953, Vol. 8, No. 31, pp. 3–19.) A direct method is developed for designing waveguide and coaxial-line filters; the characteristics of a 3-cavity filter are calculated. Transverse obstacles comprising sets of thin pins are shown to be better than diaphragms, windows or single pins from the point of view of losses and of manufacture and adjustment. Cavities with Q values of 100–200 can easily be obtained using four pins of diameter 1–2 mm. Design charts are given, and several types of filter are described and illustrated.

621.392.52.011.21 **1934**

Admittance and Transfer Function of a Multimesh Resistance-Capacitance Filter Network.—B. K. Bhattacharyya. (*Indian J. Phys.*, Nov. 1952, Vol. 26, No. 11, pp. 563–574.) The impedance function of an n-mesh RC network is expressed as a recurring continued fraction which is then resolved into the quotient of two polynomials, the admittance function being the reciprocal of this quotient. The transfer function is then determined. The corresponding formulae for an n-mesh CR network are derived.

621.392.52.029.64 : 621.396.611.4 **1935**

Determination of the Bandwidth of Band-Pass Filters for Centimetre Waves.—E. Ledinegg & P. Urban. (*Arch. elekt. Übertragung*, Feb. 1953, Vol. 7, No. 2, pp. 99–105.) Theory developed previously (1115 of 1951) is used to analyse the band-pass-filter operation of an arbitrary arrangement of coupled cavity resonators. A detailed treatment is given for the system comprising two stagger-tuned coupled resonators.

621.392.53 **1936**

Spectrum Equalization.—G. G. Gouriet. (*Wireless Engr*, May 1953, Vol. 30, No. 5, pp. 112–123.) The transfer characteristics of nearly all forms of linear quadripoles can be equalized as regards both amplitude and phase by adding to the response function its successive time derivatives or integrals. The method may be applied to systems for which the equivalent passive quadripole is not realizable, e.g., a scanning aperture. Application of the method to servo-control and television is discussed.

621.392.54 **1937**

U.H.F. Magnetic Attenuator.—F. Reggia. (*Radio & Telev. News, Radio-Electronic Engng Section*, April 1953, Vol. 49, No. 4, pp. 12–14, 24.) Construction details and performance curves are given for attenuators of the type previously described (1237 of 1952).

621.392.54 : 621.392.26 **1938**

Cut-Off Attenuators for Waveguide Circuits.—G. Klätte. (*Fernmeldetech. Z.*, Feb. 1953, Vol. 6, No. 2, pp. 86–89.) An equivalent-circuit analysis and report of measurements on short and long cut-off sections providing attenuation respectively less than and greater than 15 db. Beyond a certain length the reduction in attenuation due to reflections at the junction is constant, so that calibration measurements on long sections are unnecessary.

621.396.6 + 621.385] : 629.13.05 **1939**

Reliability of Airborne Electronic Components.—B. G. Bromber & R. D. Hill, Jr. (*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 513–516.) An analysis is made of typical failures. Reliability may be improved by modifications to present-day components and by substitution of less vulnerable elements, such as transistors and magnetic amplifiers.

621.396.611.1 **1940**

Forced Oscillations with Nonlinear Restoring Force.—C. Hayashi. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 198–207.) Both transient and steady-state oscillations are studied. The original differential equation characterized by a nonlinear term is transformed to the following first-order differential equation:—

$$dy/dx = Y(x,y)/X(x,y).$$

Following Poincaré and Bendixson, the singularities and the integral curves of this equation are discussed, the former being correlated with the steady states and the latter with the transient states of oscillation. The integral curves yield the relation between the initial conditions and the steady-state solutions. Fundamental and subharmonic oscillations of order $\frac{1}{3}$ are investigated. The theoretical results are compared with measurements made on a circuit containing a saturable iron core; satisfactory agreement is found.

621.396.611.1 **1941**

Response of a Series of Resonant Circuits to an Applied E.M.F. whose Frequency is a Linear Function of Time.—J. Marique. (*Ann. Télécommun.*, Feb. 1953, Vol. 8, No. 2, pp. 43–50.) A formula is derived for the response of two or three RLC circuits in series to an e.m.f. of unit amplitude represented by the expression $e(t) = \exp.[j(\omega_0 t + \epsilon t^2)]$, where ϵ is half the frequency-sweep speed. The fluctuations in the response curve of a single circuit are very much reduced when several circuits are connected in series. The increase of selectivity obtainable is investigated, and frequency-sweep speeds permissible for one, two and three circuits are determined.

621.396.611.4 : 621.315.612.4 : 621.396.67 **1942**

Quasi-degenerated Modes in High-ϵ Dielectric Cavities.—H. M. Schlicke. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 187–191.) A theoretical and practical investigation is made of resonators comprising solid circular cylinders composed of materials such as titanates, having permittivities of 2 500–10 000, with or without metallization of the surfaces. As a consequence of the high permittivities, cavity-resonator techniques can be used in the v.h.f. range. For cylinders with the ends not metallized, quasi-degenerate TE modes can be realized. Tuning can be effected by inserting magnetic rods or by applying conductive disks externally. A design for an aerial developed from the $TE_{010}^{\infty\infty}$-mode resonator comprises a dielectric spiral coiled round a magnetic rod. Practical disadvantages inherent in these high-permittivity dielectrics are indicated.

621.396.615 : 621.316.729 **1943**

The Method of Analytical Signals. Study of the Synchronization of Amplitude-Limited Oscillators.—J. Daguet. (*Ann. Télécommun.*, Jan. 1953, Vol. 8, No. 1, pp. 2–10.) A method based on that of Ville (1020 of 1950) is used to determine the frequency limits within which synchronization can be effected for a single-tuned self-limiting valve oscillator. The synchronization range is given by $2\Delta\omega/\omega < E_0/QE$ where $\Delta\omega$ is the difference between the frequency of the synchronization voltage E_0 and the natural frequency ω of the oscillator, and E is the amplitude of the oscillation in the steady state. The phase angle between the two voltages varies from 0 for $\Delta\omega = 0$ to 90° for $\Delta\omega = \Delta\omega_{max}$. A system with wide synchronization range is discussed; this incorporates a phase discriminator whose output, proportional to the phase angle between synchronization and oscillator voltages, is applied to a reactance valve which in turn controls oscillator frequency.

621.396.615 : 621.392.4/.5 **1944**

The Use of Admittance Diagrams in Oscillator Analysis.—H. J. Reich. (*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 522–528.) A digest of the available information on this technique.

621.396.615 : 621.396.822 : 529.786 **1945**

Effect of Background Noise on the Frequency of Valve Oscillators. Ultimate Accuracy of Electronic Clocks.—A. Blaquière. (*Ann. Radioélect.*, Jan. 1953, Vol. 8, No. 31, pp. 36–80.) Fuller account of work noted previously (2163 of 1952, 968 of April, and back references).

621.396.615.17 **1946**

How to design Bistable Multivibrators.—R. Pressman. (*Electronics*, April 1953, Vol. 26, No. 4, pp. 164–168.) The design procedure described is intended to ensure reliable operation in spite of deviations of resistors from nominal values, variations of supply voltage, and deterioration of valve-cathode emission. Formulae are given for determining the appropriate values of coupling capacitance. Triggering networks for dealing with pulses of different amplitude and duration are shown.

621.396.645 **1947**

The Effective Bandwidth of Video Amplifiers.—F. Tischer. (*Kungl. tek. Högsk. Handl., Stockholm*, 1953, No. 63, pp. 1–32.) Expanded version of 3050 of 1952.

621.396.645 : 621.396.615.142.2 **1948**

Fluctuation Noise in a Microwave Superregenerative Amplifier.—T. S. George & H. Urkowitz. (*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 516–521.) The theory of operation of a superregenerative amplifier is reviewed; Rice's representation of noise current by a Fourier series (2169 of 1945 and back references) is used in the expression for the amplifier output. A study is made of the particular conditions when a reflex klystron is used in the amplifier; expressions are derived for the noise figure in terms of the klystron parameters. The overall noise figure can be reduced by introducing beam current, with its associated shot noise, during the quiescent interval.

621.396.645.018.424 **1949**

Calculation of Compensated Wide-band Amplifiers.—H. Laett. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st March 1953, Vol. 31, No. 3, pp. 72–80. In German and French.) Loss of amplification with increasing frequency, due to the output capacitance of the amplifier valve, is compensated by including inductance in the circuit. Three arrangements are discussed, namely parallel compensation, series compensation and double compensation. Abacs to facilitate calculations are presented.

621.396.645.35 **1950**

D.C. Amplifiers with Negative Feedback.—A. Ehmert. (*Z. angew. Phys.*, Jan. 1953, Vol. 5, No. 1, pp. 24–33.) Methods are described for automatically compensating the input impedance of current amplifiers or the input admittance of voltage amplifiers. Details are given of the design and performance of several circuits for measurement purposes, in which very high input impedance with low capacitance is achieved.

621.396.645.371 : 621.317.733 **1951**

The Wien Bridge as a Frequency-Determining Element in Selective Amplifiers.—H. J. Stöhr. (*Funk u. Ton*, Jan. 1953, Vol. 7, No. 1, pp. 27–33.) Analysis of the balance condition in a bridge circuit suppressing the amplifier feedback voltage at a fixed frequency.

621.396.662.029.63 **1952**

Coaxial-Cavity Tuning Element for U.H.F.—(*Radio & Telev. News, Radio-Electronic Engng Section*, April 1953, Vol. 49, No. 4, pp. 15–16, 30.) The design is described of a unit which can be used in television tuners and test instruments for the 470–890-Mc/s band. The unit consists essentially of a metal cylinder with an axial conductor having a gap at the centre to form a variable capacitor for tuning. An accurately machined low-loss dielectric tube separates core and cylinder and serves as a close-fitting guide for the tuning plunger. Applications of the unit in a signal generator, a frequency-sweep generator, a wavemeter, and a grid-dip meter are described briefly.

621.396.665 : 621.316.86 **1953**

A.G.C. by means of Miniature NTC Resistors with Heating Element.—G. H. Schouten. (*Electronic Applic. Bull.*, Feb. 1951, Vol. 12, No. 2, pp. 33–37.) The negative-temperature-coefficient resistors are surrounded by the heating element and enclosed in an evacuated glass tube, the resistor being included in the input circuit of an amplifier and the heating element in the output circuit to obtain efficient a.g.c. Practical circuit details are given and operating characteristics of the NTC resistors are shown graphically.

621.397.645.029.62 **1954**

Fundamental Problems of H.F. and I.F. Amplifiers for TV Reception: Part 3 — Feedback and Practical Considerations following on the Theory.—A. G. W. Uitjens. (*Electronic Applic. Bull.*, Feb. 1951, Vol. 12, No. 3, pp. 41–64.) A detailed discussion is presented of the effects in television amplifiers of feedback (*a*) via the cathode-grid capacitance, (*b*) via the anode-grid capacitance, (*c*) via the anode-cathode capacitance. The necessary formulae are derived for an amplifying stage in which all three types of feedback are present, so that their interactions can be investigated theoretically. The detailed discussion is, however, confined to systems in which only one form of feedback is present. The theory is illustrated by practical examples in amplifier design.

621.392.52 **1955**

Filter Design Data for Communication Engineers. [Book Review]—J. H. Mole. Publishers: E. & F. N. Spon, London, 252 pp., 63s. (*Wireless Engr*, May 1953, Vol. 30, No. 5, pp. 129–130.) The book is intended to supplement existing textbooks by providing charts, tables and formulae in convenient form; it is concerned mainly with image-parameter (Zobel) filters.

GENERAL PHYSICS

530.12 **1956**

The Relativistic Electromagnetic Equations in a Material Medium.—N. W. Taylor. (*Aust. J. Phys.*, March 1953, Vol. 6, No. 1, pp. 1–9.) The general relativistic e.m. equations for a material medium are expressed in the form of a single four-vector density equation. The field tensor has six different complex components instead of three, as in the case of a free medium. The classical equations are obtained by separating the real and imaginary parts.

530.145 : 621.314.7 **1957**

Transistors: Theory and Application: Part 2 — Energy Levels in Transistor Electronics.—A. Coblenz & H. L. Owens. (*Electronics*, April 1953, Vol. 26, No. 4, pp. 138–141.) A simplified exposition of some of the fundamentals of quantum mechanics relevant to an understanding of transistor operation.

530.145.6 : 537.311.33 : 621.396.11 **1958**

Some Particular Features of Tropospheric Propagation and their Analogies in Wave Mechanics.—Ortusi. (See 2112.)

537.122 : 621.317.318 **1959**

A Precise Determination of the Charge of the Electron from Shot Noise.—L. Stigmark. (*Ark. Fys.*, 26th Oct.

1952, Vol. 5, Parts 5/6, pp. 399–426.) The electron charge e is calculated from the shot fluctuations of saturation current in a specially constructed diode connected across a tuned circuit resonant at 600 kc/s. From precision measurements of circuit parameters and the mean-square value of shot noise, the final result obtained is $e = (4{\cdot}797 \pm 0{\cdot}012) \times 10^{-10}$ e.s.u.

537.311.33 **1960**

Electron Spin in Semiconductors.—E. A. Guggenheim. (*Proc. phys. Soc.*, 1st Jan. 1953, Vol. 66, No. 397A, pp. 121–122.) Theory is developed showing that, starting from equilibrium electron distribution expressed in terms of absolute activity, it is possible correctly to take account of electron spin.

537.523/.525 **1961**

High-Frequency Discharges in Gases.—G. D. Morgan. (*Sci. Progr.*, Jan. 1953, Vol. 41, No. 161, pp. 22–41.) Discussion of the main characteristics and the mechanism of h.f. discharges, indicating their practical applications. 70 references.

537.525 : 537.533 **1962**

Field Emission of Electrons in Discharges.—F. L. Jones & E. T. de la Perrelle. (*Proc. roy. Soc. A*, 22nd Jan. 1953, Vol. 216, No. 1125, pp. 267–279.) Substantial emission of 10^4 to 10^5 electrons/sec was obtained from cathodes of oxidized Ni and W with electric fields of about 100 kV/cm. By relating this emission to the electric field by the Fowler-Nordheim equation, the effective work function and emitting area of the source of the electrons for oxidized Ni and W were estimated as about 0·5 eV and 10^{-13} cm² respectively. These results are discussed.

537.533 **1963**

Field Electron Emission and Work Function of Crystal Surfaces.—M. Drechsler & E. W. Müller. (*Z. Phys.*, 20th Jan. 1953, Vol. 134, No. 2, pp. 208–221.) The field close to the surface is determined by measurements on models in an electrolyte tank. Formulae are derived for the density of the field-emission current. These are verified by field-electron-microscope observations on W crystals.

537.562 : 538.122 **1964**

Plasma in a Magnetic Field.—A. Schlüter. (*Ann. Phys., Lpz.*, 15th July 1952, Vol. 10, No. 8, pp. 422–429.) The results obtained by considering plasma (*a*) from the electron-motion point of view, (*b*) on the basis of kinetic theory, are discussed and reconciled.

537.562 : 538.56 **1965**

The Relation between Various Types of Plasma Oscillation.—A. Schlüter. (*Ann. Phys., Lpz.*, 15th July 1952, Vol. 10, No. 8, pp. 418–421.) A dispersion relation is derived which applies to plasma oscillations, electron and ion oscillations of the Larmor type and to magneto-hydrodynamic waves.

538 : 621.3.01 **1966**

Definition of Magnetic Quantities.—G. Oberdorfer. (*Arch. elekt. Übertragung*, March 1953, Vol. 7, No. 3, pp. 136–142.) A critical examination is made of the nomenclature hitherto used for magnetic quantities, and proposals are made for definitions which fit in with modern ideas without unnecessarily disturbing established usage. Precise definitions are given of field strength, polarization, magnetization, susceptibility and magnetizability.

538.221 **1967**

Some Magnetic Properties of Metals: Part 5 — Magnetic Behaviour of a Cylindrical System of Electrons for All Magnetic Fields.—R. B. Dingle. (*Proc. roy. Soc. A*, 7th Jan. 1953, Vol. 216, No. 1124, pp. 118–142.) The Schrödinger equation is solved for an electron moving in a uniform magnetic field H, the boundary of the system being a cylinder with its axis along the direction of the field. Two entirely different types of wave function are possible, one type leading to the small Landau diamagnetism of large systems (Part 1 : 2489 of 1952), the other to the larger diamagnetism of small systems (Part 4 : 1005 of April). Taking account of the occupied states of both types, the steady contributions to the magnetic susceptibility are determined for low, high and intermediate temperatures.

538.221 **1968**

Collective Electron Ferromagnetism: a Generalization of the Treatment and an Analysis of Experimental Results.—K. L. Hunt. (*Proc. roy. Soc. A*, 7th Jan. 1953, Vol. 216, No. 1124, pp. 103–117.) A term involving the fourth power of the magnetization is introduced into Stoner's expression for the energy associated with magnetization. If parameter values are suitably chosen, the properties of Ni show a high degree of co-ordination, and the magnetization/temperature curves for Ni-Co and Ni-Cu alloys can be interpreted simply.

538.3 **1969**

Tentative Theory of Nonlinear Electrodynamics: Part 2.—K. Bechert. (*Ann. Phys., Lpz.*, 15th July 1952, Vol. 10, No. 8, pp. 430–448.) Part 1: 618 of 1951.

538.561 : 537.533/.534 **1970**

Production of Radio Waves by means of the Tcherenkov Effect.—C. A. Klein. (*Ann. Télécommun.*, Feb. 1953, Vol. 8, No. 2, pp. 38–42.) The Tcherenkov effect consists in the emission of e.m. radiation by a particle travelling through a medium with a velocity greater than that of light. The essential results of Frank & Tamm's theory of the effect (*C. R. Acad. Sci. U.R.S.S.*, 1937, Vol. 14, pp. 109–114) are quoted and references given to accounts of experimental verifications of the theory, using electrons and also protons. The possibility of producing e.m. waves in the range between the far infra-red and u.h.f. by means of the effect in a narrow channel is discussed. It is concluded that intense sources of e.m. waves should result from the use of powerful beams consisting of packets of electrons. Simple arrangements should suffice for cm and mm waves, but difficulties will certainly be experienced in the case of still shorter waves.

538.566 : 535.42 **1971**

A Rigorous Treatment of the Diffraction of Electromagnetic Waves by a Slit.—R. Müller & K. Westpfahl. (*Z. Phys.*, 6th Feb. 1953, Vol. 134, No. 3, pp. 245–263.) Wave-polarization components parallel to and perpendicular to the slit are considered. An integral equation for the electric field strength in the slit is found by the method of Levine & Schwinger (83 and 1897 of 1950), and an exact solution is obtained by developing the kernel in a power series of the product of wave number and slit width. The far-field intensity and the transmission factor of the slit are calculated and compared with the results of Morse & Rubenstein (905 of 1939). The relation of the work to that of Sommerfeld (Vorlesung über theoretische Physik, Bd IV, Optik, §39) and of Groschwitz & Hönl (2183 of 1952) is discussed.

538.566 : 535.42 **1972**

The Three-Dimensional Problem of the Diffraction of Monochromatic Electromagnetic Waves.—D. Z. Avazashvili. (*C. R. Acad. Sci. U.R.S.S.*, 1st Jan. 1952, Vol. 82, No. 1, pp. 29–32. In Russian.) The distribution of the e.m. field in space for a given distribution of field at a boundary surface is discussed, and conditions are established for the existence of a solution obtained previously (*Trudy Tbilisskovo Matematicheskovo Instituta*, 1940, Vol. 8, p. 109).

538.566 : 621.318.423 : 621.385.029.6 1973

The Propagation of Electromagnetic Waves along a Conical Helix with Variable Pitch.—G. Hellgren. (*Chalmers tek. Högsk. Handl.*, 1953, No. 130, 13 pp.) Theoretical analysis. Expressions are derived for the reflection coefficient, which may be practically zero, and for the impedance characteristics.

538.63 1974

Galvanomagnetic Effects in Conductors.—D. K. C. MacDonald & K. Sarginson. (*Rep. Progr. Phys.*, 1952, Vol. 15, pp. 249–274.) A review of the Hall effect and magnetoresistance in conductors, with primary reference to metals (including ferromagnetic materials); semiconductors are mentioned briefly. A physical survey of the whole field is first made; in the second part a more mathematical treatment is given of some of the major problems involved. Over 60 references.

538.632 1975

Hall Effect.—O. Lindberg. (*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, p. 507.) Correction to paper noted in 713 of March.

538.652 1976

Magnetostriction.—E. W. Lee. (*Sci. Progr.*, Jan. 1953, Vol. 41, No. 161, pp. 58–77.) Discussion of magnetostriction phenomena in single crystals and in multicrystal materials. Three effects are distinguished: (*a*) form effect, (*b*) 'forced' magnetostriction, (*c*) spontaneous linear magnetostriction.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.5 : 621.396.9 1977

On the Nature of the Decay of a Meteor Trail.—J. Feinstein. (*Proc. phys. Soc.*, 1st Sept. 1952, Vol. 65, No. 393B, p. 741.) Critical discussion of the theories of Kaiser & Closs (2208 of 1952) and of Greenhow (2493 of 1952).

523.5 : 621.396.9 1978

On the Decay of Radio Echoes from Meteor Trails.—T. R. Kaiser & J. S. Greenhow. (*Proc. phys. Soc.*, 1st Feb. 1953, Vol. 66, No. 398B, pp. 150–151.) Discussion shows that observed phenomena are explicable by the theories of Kaiser & Closs (2208 of 1952) and of Greenhow (2493 of 1952). Many points of disagreement between observation and Feinstein's theory (1885 of 1951 and 1977 above) are noted.

523.5 : 621.396.9 1979

An Experimental Study of Radio Reflections from Meteor Trails.—R. L. Closs, J. A. Clegg & T. R. Kaiser. (*Phil. Mag.*, March 1953, Vol. 44, No. 350, pp. 313–324.) The dependence of the echoes on the polarization of the incident wave has been investigated and the existence of resonance scattering with transverse polarization verified.

523.72 1980

Thermal Theories of the High-Intensity Components of Solar Radio-Frequency Radiation.—J. H. Piddington. (*Proc. phys. Soc.*, 1st Feb. 1953, Vol. 66, No. 398B, pp. 97–104.) Thermal theories of the origin of enhanced r.f. radiation from regions which occasionally attain brightness temperatures of 10^{10} deg K or more are discussed. None of the theories is found capable of explaining the available observational data. It is concluded that all three radiation components are generated by the ordered (nonthermal) motion of electrons.

523.72 : 523.746 1981

A Method of Analysis of the Directivity of Solar Radio Emission from Sunspots.—T. Takakura. (*Nature, Lond.*, 7th March 1953, Vol. 171, No. 4349, p. 445.)

523.72 : 531.758 : 523.745 1982

An Estimate of the Density and Motion of Solar Material from Observed Characteristics of Solar Radio Outbursts.—H. K. Sen. (*Aust. J. Phys.*, March 1953, Vol. 6, No. 1, pp. 67–72.) Theory previously given by Feinstein & Sen (104 of 1952) is extended and applied to the observations made in Australia by Wild & McCready (1629 of 1951) and by Wild (1630, 2169 and 2170 of 1951) of the spectra of solar r.f. outbursts in the range 70–130 Mc/s. The dispersion equation, involving the velocity of solar material erupting into a static corona and the temperatures and densities of the material and of the corona, enables the velocity of the material to be estimated as about 500 km/s, with a particle density of about 10^8 cm^3.

523.74/.75 : [550.38 + 551.510.5 1983

Solar and Terrestrial Relationships.—D. H. McIntosh. (*Met. Mag., Lond.*, Jan. 1953, Vol. 82, No. 967, pp. 11–15.) The general problem of the relation between solar activity on the one hand and meteorological, geomagnetic and ionospheric phenomena on the other is reviewed, with special reference to an account by Scherhag (*Wetterkarte*, No. 74, 14th March 1952) of events which he interprets as being related to an intense solar eruption on 24th February 1952. No such flare has been reported. It is concluded that no clear evidence has yet been given of a direct relation between solar phenomena and meteorological effects.

523.746"1952.10/.12" 1984

Provisional Sunspot-Numbers for October to December, 1952.—M. Waldmeier. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, p. 112.)

538.122 : 523 1985

The Origin of Magnetic Fields in Moving Plasma.—L. Biermann. (*Ann. Phys., Lpz.*, 15th July 1952, Vol. 10, No. 8, pp. 413–417.) Discussion indicates that diffusion effects produce sufficiently large e.m.f.'s in rotating masses of ionized gas to account for the existence of solar and stellar magnetic fields.

550.372 : 621.396.11 1986

Effect of a Large Dielectric Constant on Ground-Wave Propagation.—Wait & Campbell. (See 2113.)

550.38"1952.10/.12" 1987

Cheltenham [Maryland] Three-Hour-Range Indices *K* for October to December 1952.—R. R. Bodle. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, p. 112.)

550.385"1952.07/.12" 1988

Principal Magnetic Storms [July–Dec. 1952].—(*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 113–115.)

550.386 1989

International Data on Magnetic Disturbances, Third Quarter, 1952.—J. Bartels & J. Veldkamp. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 109–111.)

551.510.3 : 535.325 1990

The Constants in the Equation for Atmospheric Refractive Index at Radio Frequencies.—E. K. Smith, Jr, & S. Weintraub. (*J. Res. nat. Bur. Stand.*, Jan. 1953, Vol. 50, No. 1, pp. 39–41.) The formula for scaled-up refractivity N for air s $N = (K_1/T)\ [p + K'_2(e/T)]$, where K_1, K'_2 are constants. The value proposed for K_1 is derived from recent reliable microwave and optical measurements of the refractive index of dry air by Barrell (*J. opt. Soc. Amer.*, 1951, Vol. 41, pp. 295–299), Birnbaum et al. (1426 of 1951) and Essen & Froome (1371 of 1952), after adjustment to allow for an average amount of CO_2 in the composition of the air. K'_2 is derived from two other constants obtained from measurements of the dielectric constant of water vapour by Birnbaum & Chatterjee [2269 of 1952 (please note additional author)]. A table of values of the constants used by various workers from 1933 to 1952 is given, with comments on discrepancies.

551.510.52 **1991**

The Geographical and Height Distribution of the Gradient of Refractive Index.—B. R. Bean. (*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 549–550.) Charts are presented of the February and August distributions of the effective earth's radius factor over the U.S.A., and of the vertical distribution of refractive-index gradient for warm, temperate and cold climates.

551.510.535 **1992**

Long-Delay Ionospheric Echoes at 150 kc/s.—J. J. Gibbons, R. L. Schrag & A. H. Waynick. (*Nature, Lond.*, 7th March 1953, Vol. 171, No. 4349, pp. 444–445.) A report of results obtained at Pennsylvania State College Ionosphere Research Laboratory, using a vertical-incidence pulse transmitter with 2-MW peak power. Recordings with a 5-min exposure were made every half-hour from 2000 to 0400 L.M.S.T. of the signals received on an aerial system suitable for receiving circularly polarized waves. Three records obtained on 9th November 1952 showed an isolated echo corresponding to a reflection height of about 900 km. The echo only appeared on the records of the extraordinary wave. Similar records were obtained on two subsequent nights. Possible explanations of these long-delay echoes are considered; they may be due to reflections from a region above the height of maximum ionization of the F_2 region.

551.510.535 **1993**

On the Comparative Increases of the F_1 and F_2 Ionizations from Sunspot Minimum to Sunspot Maximum.—M. Ghosh. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 41–51.) The proportionate increase of ionization, from the epoch of sunspot minimum to sunspot maximum, is not the same for the F_1 as for the F_2 layer, being of the order of 1·6 for the former and 3·0 for the latter. Assuming (*a*) the F region to be due to ionization of atomic oxygen, (*b*) an increase in temperature with height above the F_1 maximum, (*c*) an effective recombination coefficient decreasing rapidly with height, calculations are made for three different ionosphere models, the results being in each case in satisfactory agreement with observations.

551.510.535 : 523.78 **1994**

Effect of the Solar Eclipse of 25th February 1952 on the Ionosphere E Layer in Equatorial Africa.—S. Estrabaud. (*C. R. Acad. Sci., Paris*, 23rd Feb. 1953, Vol. 236, No. 8, pp. 833–835.) A report and discussion of observations of E-layer critical frequencies at Bangui. The critical frequency of the E_2 layer decreased suddenly at the commencement of the eclipse and was soon masked by that of the E_1 layer. A graph of the observed values of f_0E shows that the effects of the eclipse were certainly perceptible some 5 to 20 minutes before the first contact. An explanation of the observed effects is based on the assumption of two solar regions more active than the rest, one in the corona near the western edge of the disk, the other near the eastern edge.

551.510.535 : [537.29 + 538.69 **1995**

Electromagnetic Effects in the Ionosphere: Effects of Crossed Constant-Magnetic and Alternating-Electric Fields.—R. Jancel & T. Kahan. (*C. R. Acad. Sci., Paris*, 23rd Feb. 1953, Vol. 236, No. 8, pp. 788–790.) The effect of the crossed fields on the distribution of the velocities of the free electrons in an ionized gas is studied by means of the general equation of Boltzmann, collisions between electrons being assumed negligible. The result obtained includes, as particular cases, those of Druyvestyn (1930 Abstracts, p. 350 and 1700 of 1935), Chapman & Cowling (The Mathematical Theory of Nonuniform Gases) and Margenau (3246 of 1946).

551.510.535 : 551.55 : 621.396.9 **1996**

A Study of Winds in the Ionosphere by Radio Methods.—J. H. Chapman. (*Canad. J. Phys.*, Jan. 1953, Vol. 31, No. 1, pp. 120–131.) Report of an investigation made using Mitra's method (96 of 1950). The measurements were made in Ottawa, and later in Montreal, and covered a period of a year. At a nominal height of 110 km (E layer) the speed of the wind showed a mean daily variation of approximately half-day period and about 40 m/s amplitude. This variation can be explained on the basis of tidal oscillations in the atmosphere. A variation corresponding to lunar atmospheric tides has also been detected at this level. The winds in the F region appear to increase in speed with increase of magnetic activity; this effect is not observed in the E region except during severe ionospheric disturbances.

551.510.535 : 551.594.12 **1997**

A Procedure for the Determination of the Vertical Distribution of the Electron Density in the Ionosphere.—L. A. Manning. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 117–118.) Comment on 409 of February (Kelso).

551.510.535 : 621.3.087.4 **1998**

An Ionosphere Recorder for Low Frequencies.—J. C. Blair, J. N. Brown & J. M. Watts. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 99–107.) Based on h.f. recorder design, this beat-frequency instrument covers the range 50 kc/s–1 Mc/s and uses a single-loop aerial about 350 ft long by 150 ft high. Sample records are reproduced.

551.594.5 **1999**

Radio Measurements and Auroral Electron Densities.—P. A. Forsyth. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 53–66.) Simultaneous recordings of 56- and 106·5-Mc/s echoes from auroral clouds were made at Saskatoon. A large number of echoes at 56 Mc/s were found for which there were no corresponding echoes at 106·5 Mc/s, and the echo amplitude ratio for the two frequencies varied widely. Critical reflections from small volumes of intense ionization seem the most probable explanation of these observations, where intense auroral displays are concerned. This would involve electron densities of the order of $10^8/cm^3$ in small volumes of the aurora for periods of time short in comparison with the duration of the display.

551.594.5 + 523.5 + 551.510.535] : 621.396.9 **2000**

Long-Duration Echoes from Aurora, Meteors, and Ionospheric Back-Scatter.—D. W. R. McKinley & P. M. Millman. (*Canad. J. Phys.*, Feb. 1953, Vol. 31, No. 2, pp. 171–181.) A report of radar echoes of unusual types observed in the course of the Ottawa meteor-research programme. 20-μs pulses with a peak power of 200–400 kW were radiated on a frequency of 33 Mc/s. Some of the echoes were correlated with visual observations of aurora. The extremely long duration (9 min to over 30 min) of some meteor echoes was probably caused by abnormal ionospheric conditions. Weak semipermanent echoes (duration up to or over 1 hour) are attributed to reflection at vertical or near-vertical incidence from irregularities in the lower ionosphere, possibly the same as those responsible for the long-range propagation reported by Bailey et al. (2581 of 1952).

LOCATION AND AIDS TO NAVIGATION

621.396.9 **2001**

High-Quality Radar Picture Display Unit.—R. T. Petruzzelli. (*Tele-Tech*, Jan. 1953, Vol. 12, No. 1, pp. 54–57 . . 102.) A description is given, with block diagrams, of equipment providing television pictures of the p.p.i. display of airport-surveillance radar, Type ASR-2, together with mapping and d.f. information. Two independent channels, each terminating in its own 12-in. display unit, enable different areas round the airport to be monitored. A 30-in. display for plotting purposes is also provided. The conversion from the p.p.i. display to standard 525-line 30-frame television scan is effected by means of the graphechon storage tube [1539 of May (Dyall et al.)]. The display control consoles include all controls for the radar set normally found on the original radar indicator. The plotting display console has no control over the radar set and can merely switch its mixer amplifier to accept the signals from either of the two channels.

621.396.9 **2002**

A Special Type of Pulse Modulation for the Transmission of Radar Pictures (Sampling).—E. Roessler. (*Fernmeldetech. Z.*, Feb. 1953, Vol. 6, No. 2, pp. 78–79.) The principles of a sampling system for bandwidth reduction are described. See 1921 (Otto) and 3430 (McLucas) of 1952. It is proposed to introduce, in German, the term 'Durchmusterung' for this sampling process.

621.396.9 : [551.578 + 551.594.22 **2003**

Frontal Precipitation and Lightning Observed by Radar.—J. S. Marshall. (*Canad. J. Phys.*, Feb. 1953, Vol. 31, No. 2, pp. 194–203.) Patterns obtained by radar methods at wavelengths of 3·2 cm and 10·7 cm are shown and discussed. Observations in vertical section were made by scanning at angles of elevation up to 30°.

621.396.9 : 551.578.1 **2004**

Radar Observations of Rain from Non-freezing Clouds.—R. S. Styles & F. W. Campbell. (*Aust. J. Phys.*, March 1953, Vol. 6, No. 1, pp. 73–85.) A detailed account, with photographs of typical displays, of results obtained with airborne radar equipment.

621.396.9 : 621.396.65.029.64 **2005**

Remote Display of Radar Pictures.—R. F. Hansford & G. J. Dixon. (*Wireless World*, May 1953, Vol. 59, No. 5, pp. 218–222.) Description of the Decca Radar Link, Type 2, designed for transmission of information from a radar site to a distant point where it can again be displayed on a radar indicator without loss of detail. The wavelength used is about 9 cm, and the transmitter power 0·5 W. Negative a.m. is used for the video signals and positive modulation on a time basis for the synchronizing pulses and bearing information. The transmitter r.f. unit is housed in a watertight box mounted behind the paraboloid aerial on an 80-ft mast. The transmitter valve is a v.m. Heil-type valve. A similar aerial arrangement is used with the receiver, which has a reflex-klystron local oscillator. Full test facilities are included. Reliable transmission is provided over a distance up to 20–30 nautical miles. Repeater stations may be interpolated in the link.

621.396.9 : 621.396.67 **2006**

Moulded Plastic Radar Scanners and Stressed Components.—(See 1911.)

621.396.9 : 778.5 **2007**

Cinematographic Recording of Panoramic Radar Images.—M. J. de Cadenet. (*Ann. Télécommun.*, Jan. 1953, Vol. 8, No. 1, pp. 19–27.) A method developed by the C.N.E.T. in France for recording television images is adapted. A detailed description is given of camera equipment with servomechanism for synchronizing camera operation with aerial rotation.

621.396.93.088 **2008**

More on Direction Finders.—H. G. Hopkins. (*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 548–549.) Comment on 142 of 1952 (Hansel). It is recommended that the term 'unwanted' should be reserved for the component which introduces errors when the direction finder is operated on a uniform unobstructed site. The proposed distinction between primary and secondary instrumental polarization errors is also criticized.

621.396.932/.933 **2009**

Decca Charts.—H. C. Freiesleben. (*Telefunken Ztg*, Jan. 1953, Vol. 26, No. 98, pp. 49–53.) A detailed description is given of the method of computing Decca curves in which the differences of the distances of a number of points on the earth's surface from the transmitters are first calculated, the points corresponding to round values of the differences being then found by interpolation.

621.396.933 **2010**

Radio Navigation and Air Traffic Safety Measures.—O. J. Selis. (*Tijdschr. ned. Radiogenoot.*, March 1953, Vol. 18, No. 2, pp. 59–87.) A survey of present methods and trends both for en-route navigation and for approach and landing, with special reference to installations in Holland.

MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 **2011**

Methods of Obtaining High Vacua by Ionization.—H. Schwarz. (*Le Vide*, Nov. 1952, Vol. 7, No. 42, pp. 1262–1266.) Analysis shows that no true pumping effect can be obtained with a simple d.c. discharge. In the system described a ring-shaped anode has a potential of 2 kV or more and a second annular electrode beyond it is at cathode potential. Four outlet tubes fitted with auxiliary electrodes are spaced around the anode. A weak magnetic field imparts a helical motion to the electrons beyond the anode. Pressures lower than 5×10^{-6} mm Hg are obtained.

535.212 : 546.482.21 **2012**

Study of the Infrared Photoluminescence of Copper-Activated Cadmium Sulphide.—E. Grillot & P. Guintini. (*C. R. Acad. Sci., Paris*, 23rd Feb. 1953, Vol. 236, No. 8, pp. 802–804.) The photoluminescence of CdS-Cu comprises a band in the infrared between 0·7 and 1·4 μ, with a maximum at 1·02 μ.

535.215 : 546.817.221 **2013**

The Photovoltaic Effect in Natural Lead Sulphide.—R. Lawrance. (*Aust. J. Phys.*, March 1953, Vol. 6, No. 1, pp. 124–125.) Correction to paper abstracted in 1930 of 1952.

535.215.2 : 546.28 **2014**

Long-Wavelength Infrared Photoconductivity of Silicon at Low Temperatures.—B. V. Rollin & E. L. Simmons. (*Proc. phys. Soc.*, 1st March 1953, Vol. 66, No. 399B, pp. 162–168.)

535.215.3 : 538.639 **2015**

Theory of the Photomagnetoelectric Effect.—P. Aigrain & H. Bulliard. (*C. R. Acad. Sci., Paris*, 9th Feb. 1953, Vol. 236, No. 6, pp. 595–596.) An approximate theory is developed which assumes the charge carriers of the two different types in semiconductors to have equal mobilities and which gives values of the photomagnetoelectric potential difference in good agreement with the experimental results reported by Kikoin & Noskow (1934 Abstracts, p. 507).

535.215.3 : 538.639 : 546.289 : 548.55 **2016**

Experimental Results on the Photomagnetoelectric Effect.—P. Aigrain & H. Bulliard. (*C. R. Acad. Sci., Paris*, 16th Feb. 1953, Vol. 236, No. 7, pp. 672–674.) Measurements were made on small plates, 0·1 to 1 mm thick, cut from single crystals of Ge of various degrees of purity, the illuminated face being in general well polished chemically. Various methods of measurement are described. The results obtained confirm the theory previously given (2015 above).

535.343 + 535.32 **2017**

Inter-relation between Optical Constants for Lead Telluride and Silicon.—T. S. Moss. (*Proc. phys. Soc.*, 1st Feb. 1953, Vol. 66, No. 398B, pp. 141–144.)

535.343 **2018**

The Optical Constants of Lead Sulphide, Lead Selenide and Lead Telluride in the 0·5–3-μ Region of the Spectrum.—D. G. Avery. (*Proc. phys. Soc.*, 1st Feb. 1953, Vol. 66, No. 398B, pp. 134–140.)

535.343 : 546.23 **2019**

The Optical Absorption and Reflection of Amorphous and Hexagonal Selenium.—J. Stuke. (*Z. Phys.*, 20th Jan. 1953, Vol. 134, No. 2, pp. 194–207.) Measurements were made on thin layers, using wavelengths between 300 and 1 200 mμ, at temperatures in the range − 180°C to + 100°C. At the transformation from the amorphous to the hexagonal form the absorption constant increases over the whole of the wave-range investigated. For hexagonal Se a strong absorption band is observed at 2·2 eV. The absorption and reflection measurements show good agreement.

535.343 + 537.312.5] : 546.817.221 **2020**

Absorption Spectra of Lead Sulphide at Different Temperatures.—W. Paul & R. V. Jones. (*Proc. phys. Soc.*, 1st March 1953, Vol. 66, No. 399B, pp. 194–200.)

535.37 **2021**

Induced Conductivity in Luminescent Powders: Part 2—A.C. Impedance Measurements.—H. Kallmann, B. Kramer & A. Perlmutter. (*Phys. Rev.*, 15th Feb. 1953, Vol. 89, No. 4, pp. 700–707.) A.c. impedance changes induced by ultraviolet, infrared, X-ray and γ-ray irradiation of (Zn:Cd)S powders agree with the results previously obtained with d.c. [3438 of 1952 (Kallmann & Kramer)].

535.37 : 546.472.21 **2022**

The Influence on the Luminescence of ZnS Phosphors of Lattice Defects caused by Pounding.—I. Broser & W. Reichardt. (*Z. Phys.*, 20th Jan. 1953, Vol. 134, No. 2, pp. 222–244.) An investigation is made of the reduction of luminescence of ZnS-Cu phosphors as the fineness of the material increases. Formulae derived are discussed in relation to theories of radiationless transitions.

535.37 : 546.472.21 **2023**

Optical Measurements on Electroluminescent Zinc Sulfide.—J. F. Waymouth. (*J. electrochem. Soc.*, Feb. 1953, Vol. 100, No. 2, pp. 81–84.) Results of measurements of absorption and emission spectra are reported.

535.37 : 546.472.21 **2024**

On the Nature of Fluorescent Centers and Traps in Zinc Sulfide.—H. A. Klasens. (*J. electrochem. Soc.*, Feb. 1953, Vol. 100, No. 2, pp. 72–80.) The impurity levels in the energy diagram of a ZnS phosphor are considered to be localized S^{2-} levels lifted above the filled S^{2-} band due to the presence of monovalent positive or trivalent negative activator ions in the lattice. Electron traps are formed similarly by the replacement of S ions by monovalent negative ions or of Zn^{2+} ions by trivalent positive ions. The emission characteristics of ZnS phosphors seem to be more a property of the lattice than of the activator.

537.224 **2025**

Plastic Electrets.—H. H. Wieder & S. Kaufman. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 156–161.) Previously proposed explanations of the electret mechanism are discussed and measurements on specimens made of plexiglas, lucite and nylon are reported. The experimental results support the view that there exist two decaying polarizations of opposite sense due to ionic migration (*a*) within the dielectric and (*b*) across the electrode/dielectric interface [see 4055 of 1944 (Gross)].

537.226 **2026**

Variation with Time of the Dielectric Properties of Ferroelectric Ceramics.—D. M. Kazarnovski. (*Zh. tekh. Fiz.*, April 1952, Vol. 22, No. 4, pp. 553–558.) A report of observations covering a period of three years. It appears that the dielectric constant of ferroelectric ceramics decreases with time; methods for stabilizing it are discussed.

537.226.2 : 546.212-16 **2027**

Anisotropy of the Dielectric Constant of Ice.—F. Humbel, F. Jona & P. Scherrer. (*Helv. phys. Acta*, 15th Feb. 1953, Vol. 26, No. 1, pp. 17–32. In German.) Dielectric constant ϵ and loss angle δ were measured as a function of temperature and frequency for square plates cut from large single crystals. The difference between the values of ϵ for directions parallel and perpendicular to the *c*-axis decreases with temperature decrease. The variation of ϵ and δ with frequency is similar to that found for polycrystalline ice.

537.311.33 **2028**

Theory of Mixed Semiconductors.—O. Madelung & H. Welker. (*Z. angew. Phys.*, Jan. 1953, Vol. 5, No. 1, pp. 12–14.) For simple *n*- or *p*-type semiconductors the carrier concentrations and mobilities can be easily found from the measured values of conductivity and Hall coefficient. For mixed semiconductors further measurements are required; the thermoelectric power and the variation of the resistance with the strength of an applied magnetic field are suitable properties for this purpose. Formulae relating the various parameters are discussed. The Hall coefficient depends on the strength of the magnetic field and may change its sign at high field strength.

537.311.33 **2029**

A Conductive Ceramic for Microwave Applications.—(*Engineer, Lond.*, 6th March 1953, Vol. 195, No. 5067, p. 363.) 'Caslode' is the name given to a semiconductor with a dielectric constant of about 20 and a loss angle between 10° and 20° at a wavelength of 3·2 cm, suitable for use without water-cooling as a dummy load in waveguides.

537.311.33 **2030**

Semiconductor Properties of the Systems K-Sb, Cs-Sb, K-In and Cs-In.—R. Suhrmann & C. Kangro. (*Natur-*

wissenschaften, Feb. 1953, Vol. 40, No. 4, pp. 137–138.) Graphs are given which show (*a*) log χ for K-Sb compounds with varying proportions of K from 0 to 100%, (*b*) log χ plotted against 1/T for values of 1/T in the range $3–9 \times 10^{-3}$ for the compounds Cs_3Sb and K_3Sb, χ being the specific conductivity and T the absolute temperature. For intrinsic semiconduction, the energy levels in K_3Sb, KSb and Cs_3Sb are respectively 0·79, 0·88 and 0·56 eV. For lattice-defect semiconduction, the levels are 0·23 and 0·16 eV respectively for K_3Sb and Cs_3Sb. For K-In and Cs-In compounds also, the temperature coefficient of resistance is negative; for Cs_2In_3 the resistance drops by a factor of about 10^4 between 83° and 287°K, the corresponding drop for K_3In being only from 82 to 37·7Ω.

537.311.33 : 546.27.03 **2031**

Study of the Properties of Boron.—J. Lagrenaudie. (*J. Phys. Radium*, Jan. 1953, Vol. 14, No. 1, pp. 14–18.) Continuation of work noted in 1696 of June. Conductivity measurements at temperatures up to 700°C yield a value of about 1·28 eV for the intrinsic energy. The material should be useful for thermistors. Thin layers are transparent in the infrared, with an absorption threshold at a wavelength near 1 μ. Only very weak rectifying effects were observed; measurements on single crystals are required before conclusions can be reached about the practical possibilities of the material for rectifiers.

537.311.33 : 546.289 **2032**

A Thermoelectric Study of the Electrical Forming of Germanium Rectifiers.—M. Kikuchi & T. Onishi. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 162–166.) Experimental methods described by Granville & Hogarth (161 of 1952) were applied. Remarkable improvements in the I/V characteristics were obtained by applying appropriate alternating forming voltages. Using *n*-type crystals, the thermoelectric current observed on the etched surface was converted by the forming from *n*-type to *p*-type. The dependence of the thermo-e.m.f. on the contact pressure is greatly increased by the forming. The results indicate that a substance with relatively high resistivity and *p*-type thermo-e.m.f. is formed between the point contact and the Ge surface.

537.311.33 : 546.289 **2033**

Plastic Deformability of Germanium at Relatively High Temperatures.—L. Graf, H. R. Lacour & K. Seiler. (*Z. Metallkde*, March 1953, Vol. 44, No. 3, pp. 113–114.) Experiments on single crystals of purity > 99·999% are reported. At temperatures > 600°C plastic deformation without time lag was obtained. The appearance of slip lines indicates that an actual lattice translation occurs. Variation of resistivity caused by heat treatment is greatly reduced if the specimens are simultaneously subjected to plastic deformation. See also 1403 of May (Gallagher).

537.311.33 : 546.289 **2034**

Pressure-Welded *p-n* Junctions in Germanium.—R. G. Shulman & D. M. Van Winkle. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, p. 224.) A mechanically strong weld is obtained by applying local pressure at the surfaces to be joined. Pressures of about 1 000 kg/cm² are obtained with moderate forces by making the contact area extremely small; this is achieved by making one contact surface optically flat and the other of controlled roughness. Characteristics of junctions prepared by this process are shown; their h.f. response is better than that of units prepared by drawing or diffusion.

537.311.33 : 546.289 : 621.396.822 **2035**

Shot Noise in Germanium Filaments.—R. H. Mattson & A. van der Ziel. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, p. 222.) The correctness of the noise formula previously derived [1936 of 1952 (Herzog & van der Ziel)] is verified by further measurements of greater accuracy over an extended frequency range.

537.311.33 : 546.817.221 **2036**

Transistor Action and Related Phenomena in Lead-Sulphide Specimens from Various Sources.—C. A. Hogarth. (*Proc. phys. Soc.*, 1st March 1953, Vol. 66, No. 399B, pp. 216–220.) Examination of a large number of specimens of PbS has indicated a maximum free-carrier concentration at 290°K of $2 \times 10^{17}/cm^3$ if transistor action is to be found. This leads to a value of 0·65 eV for the width of the forbidden band at 290°K. Transistor action was only observed in *p*-type specimens and was always associated with good rectification and a strong photovoltaic effect.

537.311.33 : 546.817.221 **2037**

The Electronic Band Structure of PbS.—D. G. Bell, D. M. Hum, L. Pincherle, D. W. Sciama & P. M. Woodward. (*Proc. roy. Soc. A*, 24th March 1953, Vol. 217, No. 1128, pp. 71–91.) The cellular method is used to determine electronic wave functions of the Bloch type for PbS.

537.311.33 : 621.314.632 **2038**

The Theory of Solid Rectifiers.—A. I. Gubanov. (*Zh. tekh. Fiz.*, March 1952, Vol. 22, No. 3, pp. 381–393.) A theory is proposed based on the assumption that the barrier layer is a thin semiconducting layer with a conductivity of the type opposite to that of the main body of the rectifier. From a solution of the Poisson's and diffusion equations the current/voltage characteristic of the rectifier is determined. A numerical example is given for the case of a Cu_2O rectifier; the theoretical curve for the dependence of the rectifier resistance on voltage shows good agreement with experimental curves.

537.311.33 : 621.396.822 **2039**

Noise in Semiconductors at Very Low Frequencies.—B. V. Rollin & I. M. Templeton. (*Proc. phys. Soc.*, 1st March 1953, Vol. 66, No. 399B, pp. 259–261.) Previous measurements by Kronenberger (2879 of 1951) showed that down to frequencies of about 0·2 c/s the mean-square noise voltage per unit bandwidth is inversely proportional to the frequency *f*. A method is described by which measurements on pyrolytic carbon resistors have been made at much lower frequencies. The noise is recorded on slow-running magnetic tape, which is then joined to form a closed loop. The loop is run through the pickup head at normal speed and the noise spectrum analysed with a standard type of a.f. wave analyser. By varying the recording speed, measurements were made for frequencies from 10^{-4} to 10 c/s. The results obtained show that even at the lowest frequency the 1/*f* law is still obeyed fairly closely. A special arrangement is described for obtaining the amplification necessary for recording the noise voltages at the very low frequencies used.

537.311.33 : 621.396.822 **2040**

Shot Noise in Semiconductors.—A. van der Ziel. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 222–223.) A calculation is made of the shot noise generated in a semiconductor by d.c., assuming that the numbers of free electrons and holes fluctuate independently, and the average drift path is short compared with the length of the specimen. An examination is made of the special cases of electron conductors, mixed conductors, intrinsic semiconductors in which electrons and holes disappear by surface trapping, and intrinsic semiconductors in which electrons and holes disappear only by recombination.

538.221 **2041**

Magnetic After-Effects associated with Initial Permeability and Barkhausen Jumps.—R. Feldtkeller & G. Sorger. (*Arch. elekt. Übertragung*, Feb. 1953, Vol. 7, No. 2, pp. 79–87.) A discussion of the Jordan, Richter and Ewing effects observed in relaxation processes in ferromagnetic materials; the first two are associated with the initial permeability and the last is associated with the Barkhausen jumps. The Richter and Ewing effects both depend on the diffusion of foreign atoms.

538.221 **2042**

Applications and Properties of Ferroxcube.—(*Electronic Applic. Bull.*, May 1952, Vol. 13, No. 5, p. 80.) Correction to paper noted in 750 of March.

538.221 **2043**

Ferrites.—A. Fairweather, F. F. Roberts & A. J. E. Welch. (*Rep. Progr. Phys.*, 1952, Vol. 15, pp. 142–172.) A description is given of the physical and chemical structure of ferrites, and of their preparation, with an outline of Néel's theory of ferromagnetism and of the Kramers-Anderson theory of super-exchange spin coupling. Possible mechanisms which may account for the observed rather steep fall of permeability with increase of frequency, and for the associated energy absorption, are discussed. The dielectric properties of ferrites, of interest in h.f. applications, are considered. The observed very strong dispersion and absorption may be interpreted in terms of the inhomogeneous microphysical structure of the sintered material, which is known to be sensitive to the oxygen content and heat treatment. The very-low-frequency dielectric absorption may be due to adsorbed moisture. The semiconducting properties are discussed briefly. Over 150 references.

538.639 : 538.245 **2044**

On the Temperature Dependency of Magneto-resistance Effect of Iron Single Crystal.—Y. Gondo & Z. Funatogawa. (*J. phys. Soc. Japan*, Jan./Feb. 1952, Vol. 7, No. 1, pp. 41–43.)

538.652 : 548.55 **2045**

Measurement of Magnetostriction in Single Crystals.—R. M. Bozorth & R. W. Hamming. (*Phys. Rev.*, 15th Feb. 1953, Vol. 89, No. 4, pp. 865–869.) A simplified procedure is given for determining the five magnetostriction constants of a ferromagnetic single crystal of the cubic type.

539.153 : 537.311.1 **2046**

The Band Structure of Metals.—G. V. Raynor. (*Rep. Progr. Phys.*, 1952, Vol. 15, pp. 173–248.) The development of the electron theory of metals is briefly reviewed and the electronic structures of a selection of monovalent and polyvalent metals are surveyed, Na and Cu being discussed in detail. Difficulties arising in connection with the calculation of electronic interactions, particularly in the case of divalent and trivalent metals, are discussed. The nature of transitional metals is considered in detail. The possibility of extending the theory to alloys is discussed, particularly for alloys based on Cu and on Ni. Over 80 references.

546.321.85-842 : 548.0 : [537 + 539.32 **2047**

The Properties of KH_2PO_4 below the Curie Point.—H. M. Barkla & D. M. Finlayson. (*Phil. Mag.*, Feb. 1953, Vol. 44, No. 349, pp. 109–130.) Report of an investigation of the dielectric, piezoelectric and elastic properties of KH_2PO_4 crystals at temperatures down to 20°K. A second transition occurs at a temperature about 60° below the Curie point (122°K), and marks the onset of a steep rise of coercive field with decreasing temperature. A qualitative domain theory is presented to account for the main features of the ferroelectric state in KH_2PO_4

546.321.85-842 : 548.73 **2048**

X-Ray Analysis of the Ferroelectric Transition in KH_2PO_4.—B. C. Frazer & R. Pepinsky. (*Acta cryst., Camb.*, 10th March 1953, Vol. 6, Part 3, pp. 273–285.) Report of detailed investigation of the tetragonal structure at 4° above the transition temperature of 122°K, and of the orthorhombic structure 6° below this temperature.

546.821 : 538.632 **2049**

The Hall Effect in Titanium.—G. W. Scovil. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 226–227.) Preliminary report of measurements made by a d.c. method at a temperature of about 100°C.

547.476.3 : 537.226 **2050**

The Effect of Electric Field on the Domain Structures in Rochelle Salt.—M. Marutake. (*J. phys. Soc. Japan*, Jan./Feb. 1952, Vol. 7, No. 1, pp. 25–29.)

549.212 : 537 **2051**

The Electrical Properties of Graphite.—G. H. Kinchin. (*Proc. roy. Soc. A*, 24th March 1953, Vol. 217, No. 1128, pp. 9–26.) Report of measurements made, over a wide range of temperatures, of the Hall coefficient and resistivity of a range of multicrystal graphites with different crystal sizes and of a single crystal of Travancore graphite.

621.315.61 : 621.793 : 669.21/.23 **2052**

The Production and Testing of Precious-Metal Coatings on Insulating Materials.—A. Keil & G. Offner. (*Fernmeldetech. Z.*, Feb. 1953, Vol. 6, No. 2, pp. 73–77.) Methods of metallizing the surfaces of plastics and ceramics are outlined and suitable methods of assessing the properties of such coatings, particularly as regards resistivity, adhesion and soldering, are suggested.

621.315.612.4 : 546.431.824-31 **2053**

Transition Energy and Volume Change at Three Transitions in Barium Titanate.—G. Shirane & A. Takeda. (*J. phys. Soc. Japan*, Jan./Feb. 1952, Vol. 7, No. 1, pp. 1–4.)

621.315.616 : 547-128† **2054**

Silicones — and Insulation.—(*Elect. Times*, 8th Jan. 1953, Vol. 123, No. 3192, pp. 47–49.) Illustrated note of applications of silicone rubber as sheathing and insulating tape.

621.315.616.1 **2055**

Electrical Properties of Rubber.—J. Granier. (*C. R. Acad. Sci., Paris*, 23rd Feb. 1953, Vol. 236, No. 8, pp. 786–788.) Experiments are described which show that the d.c. conductance and the dielectric constant and loss angle at 1 kc/s of rubber decrease considerably when the material is subjected to increasing compressional, tensile, or shearing forces with resulting distortion. When the material is compressed in a cavity which prevents distortion, little or no change is observed in the dielectric constant and loss angle. An explanation of these results is suggested.

778.37 **2056**

Isotransport Camera for 100 000 Frames per Second.—C. D. Miller & A. Scharf. (*J. Soc. Mot. Pict. Telev. Engrs*, Feb. 1953, Vol. 60, No. 2, pp. 130–144.) Description of equipment developed by the Battelle Memorial Institute and available for loan to other research organizations.

MATHEMATICS

621.392.5 : 538.652 : 681.142 **2057**

Magnetostrictive Sonic Delay Line.—H. Epstein & O. Stram. (*Rev. sci. Instrum.*, March 1953, Vol. 24, No. 3, pp. 231–232.) Description of a recirculating storage unit using a thin-wall Ni tube as the magnetostrictive element, with suitable transducer coils enclosed in ferrite cups whose length is adjusted to correspond to the half wavelength of a 600-kc/s vibration in the Ni tube. Experimental delay lines giving delays of 100 μs and 800 μs have been constructed. Operational characteristics are listed.

681.142 **2058**

High-Speed Product Integrator.—A. B. Macnee. (*Rev. sci. Instrum.*, March 1953, Vol. 24, No. 3, pp. 207–211.) A method of using a high-speed analogue computer to evaluate product integrals is described.

681.142 **2059**

Resistance Network Analog Computer.—(*Tech. News Bull. nat. Bur. Stand.*, Feb. 1953, Vol. 37, No. 2, pp. 19–21.) Description of a computer of the type developed by Liebmann (1954 of 1950 and 2839 of 1952).

681.142 **2060**

The Electronic Discrete Variable Computer.—S. E. Gluck. (*Elect. Engng, N.Y.*, Feb. 1953, Vol. 72, No. 2, pp. 159–162.) Outline description of the EDVAC, a binary computer having a mercury-delay-line storage system of large capacity. See also 434 (Goodman) and 1357 (Gray) of 1952.

681.142 : 538.221 **2061**

Ferrites speed Digital Computers.—D. R. Brown & E. Albers-Shoenberg. (*Electronics*, April 1953, Vol. 26, No. 4, pp. 146–149.) The use of ferrite toroids in storage units of the matrix type [2258 of 1952 (Papian)] leads to increased speed and reliability of operation. Differences in the hysteresis curves required for storage and for switching purposes are discussed. A pulse method of testing the toroids is described. A particular Mg ferrite (MF-1118) used at the M.I.T. has a saturation flux density of 2 000 gauss and a coercivity of 1·5 oersted.

MEASUREMENTS AND TEST GEAR

535.32 : 538.56.029.64 **2062**

The Refractive Indices of Water Vapour, Air, Oxygen, Nitrogen, Hydrogen. Deuterium and Helium.—L. Essen. (*Proc. phys. Soc.*, 1st March 1953, Vol. 66, No. 399B, pp. 189–193.) The method described by Essen & Froome (1707 of 1951) was used in measurements at 9·2 kMc/s. The results for water vapour, air, O_2 and N_2 agree with the values previously found at 24 kMc/s. The values for H_2 and D_2 are respectively 2% and 3% higher than the calculated values of Ishiguro et al. (*Proc. phys. Soc.*, 1st March 1952, Vol. 65, No. 387A, pp. 178–187.)

621.3.018.41(083.74) **2063**

The Microwave Frequency Standard.—L. J. Rueger & A. E. Wilson. (*Radio & Telev. News, Radio-Electronic Engng Section*, March 1953, Vol. 49, No. 3, pp. 5–7 . . 41.) An account is given of standardized equipment at the National Bureau of Standards for providing a calibration service for frequencies from 300 Mc/s to 40 kMc/s, and of developmental equipment to extend the range to 75 kMc/s. The standard microwave frequencies are derived directly from one of the stable 100-kc/s crystal oscillators maintained by the N.B.S. Harmonic frequencies at 10-Mc/s intervals are provided up to 5 kMc/s, at 50-Mc/s intervals to 25 kMc/s, and at 250-Mc/s intervals to 40 kMc/s, the gaps being bridged by means of a precision variable-frequency oscillator. Frequency meters are calibrated under conditions as close as possible to those of normal use. Details are given of the methods adopted.

621.3.018.41(083.74) : [621.314.7 + 621.396.611.21 **2064**

Precision Transistor Oscillator.—(*Tech. News Bull. nat. Bur. Stand.*, Feb. 1953, Vol. 37, No. 2, pp. 17–19.) A frequency standard contained in a tube of length 7 in. and diameter 1¾ in. is described. It comprises an oscillator using a Type-2517 junction transistor, a high-precision 100-kc/s GT-cut quartz-crystal unit [see 1083 of April (Griffin)] and a long-life Hg cell. The transistor in an earthed-emitter circuit produces an output of 0·8 V across a tuned circuit connected to the collector electrode. The crystal driving current is taken from the junction of two capacitors forming an attenuator between the collector and earth. Performance is comparable to that of a standard valve oscillator. For another account see *Electronics*, May 1953, Vol. 26, No. 5, pp. 206 . . 214.

621.317.32.087.4 **2065**

The Suitability of the 'Fixed Level' Recording Method for Propagation Research.—G. Boré & W. Rappaport. (*Fernmeldetech. Z.*, Jan. 1953, Vol. 6, No. 1, pp. 33–36.) The design of an u.s.w. field-strength recorder is outlined. Its principle is that described by Ferrari (*A.E.G. Mitt.*, Nov./Dec. 1951, Vol. 41, pp. 299–302), a pulse being generated whenever the integral of the measured quantity over a specified time reaches a fixed level. The average interval between pulses is inversely proportional to the mean amplitude of the measured quantity. A method of evaluating the maximum error is illustrated. By means of a subsidiary relay-operated circuit, the number and duration of short-period fluctuations above and below a fixed level can be recorded.

621.317.335.3 : 537.226.2/.3 **2066**

A Standing-Wave Method for Measuring Electromagnetic Absorption in Polar Liquids at Frequencies of the order 3 × 10⁹ c/s.—V. I. Little. (*Proc. phys. Soc.*, 1st March 1953, Vol. 66, No. 399B, pp. 175–184.) Description of a simple method, with typical results for the absorption coefficient and dielectric constant of water and of dioxan with small admixtures of water and of ethyl alcohol.

621.317.335.3.029.64 **2067**

New Method of Measurement of the Complex Dielectric Constant of Solids and Liquids at Centimetre Wavelengths.—J. Le Bot & S. Le Montagner. (*C. R. Acad. Sci., Paris*, 2nd Feb. 1953, Vol. 236, No. 5, pp. 469–471.) A method is described which requires only very small quantities of the material under test. Solid samples in the form of rods, or liquid samples contained in thin-walled glass tubes are arranged as shunt elements transverse to the larger sides of a rectangular waveguide. Using a short-circuited waveguide section and fixed detector, the positions of a movable piston are found for minimum readings with and without the sample. From the piston displacement and the values of the minima the admittance of the shunt is determined and hence, by means of simple formulae, the dielectric constant of the sample is calculated.

621.317.335.3.029.64 **2068**

Results of Measurements of Dielectric Constants at 9 500 Mc/s by a New Method.—S. Le Montagner & J. Le Bot. (*C. R. Acad. Sci., Paris*, 9th Feb. 1953, Vol. 236, No. 6, pp. 593–594.) Using the method previously described [2067 above (Le Bot & Le Montagner)] measurements were made on polyethylene, plexiglas and nonpolar and polar liquids, including water. Results are tabulated and compared with figures obtained by other workers. The sensitivity of the method is such that the addition of even 1% of water to pure dioxan is clearly detectable.

621.317.335.3.029.64 **2069**

The Theory of Measurements of Dielectric Constants at Centimetre Wavelengths.—N. V. Kotosonov. (*Zh. tekh. Fiz.*, March 1952, Vol. 22, No. 3, pp. 530–536.) A general formula (6) is derived for the reflection coefficient of a two-layer dielectric filling a waveguide. From this, assuming that the second layer is air, another formula (7) is derived for the reflection coefficient for any position of the sample in the waveguide. Two methods for measuring the dielectric constant of layers of liquid and solid dielectrics are proposed and optimum conditions of measurement are established.

621.317.336.015.7 : 621.315.212 **2070**

The Response to Television and Testing Pulses of Cables with Nonuniform Characteristic Impedance.—H. Kaden. (*Arch. elekt. Übertragung*, March & April 1953, Vol. 7, Nos. 3 & 4, pp. 157–162 & 191–198.) The effect of the nonuniformities is that the cable output corresponding to a step-voltage input is distorted into a tailing-off form. The tail is due to (*a*) double internal reflections and (*b*) reflections at the cable ends in combination with single internal reflections. Effect (*a*) is proportional to the product of the nonuniformity function and its second derivative; it varies linearly with time for short cables and exponentially for long cables. Effect (*b*) depends on the first derivative of the nonuniformity function; it varies as the square root of the time for short cables and exponentially for long cables. Methods are described for measuring the nonuniformity function and its first and second derivatives; pulses of alternate polarity are used. The correlation range of the nonuniformities is determined; the smaller its value, the longer is the pulse tail. The relation between the autocorrelation function of the nonuniformities and the frequency spectrum of the reflected pulse is discussed in an appendix.

621.317.34.029.63/.64 **2071**

Measurement of the Centimetre-Wave Propagation Coefficient of Quadripoles.—W. Klein. (*Fernmeldetech. Z.*, Jan. 1953, Vol. 6, No. 1, pp. 25–33.) Methods of measuring the attenuation and phase coefficients of linear passive quadripoles at centimetre wavelengths are described. Limits are defined within which the node-displacement method of Weissfloch (711 of 1943) is applicable to low-loss quadripoles. Transmission characteristics of a 4-cavity filter for 2·03 kMc/s, with a 30-Mc/s pass band, are shown. The determination of input impedance from the s.w.r. and the open- and short-circuit impedances is illustrated, with reference to the Smith diagram for the above filter and for a travelling-wave-valve helix.

621.317.341 : 621.315.212.2 **2072**

Measurement of the Attenuation of Coaxial Lines (from 1 to 4 000 Mc/s).—H. Jassin. (*Câbles & Transm.*, Jan. 1953, Vol. 7, No. 1, pp. 16–27.) Three measurement techniques are described: (*a*) frequencies up to 40 Mc/s, use of a h.f. bridge; (*b*) 50–400 Mc/s, comparison of output powers of different lengths of identical line (for equal inputs); (*c*) above 500 Mc/s, measurement of standing-wave ratios. Typical attenuation/frequency curves for rigid and for flexible lines are shown.

621.317.35 **2073**

A Highly Selective Frequency-Spectrum Analyser.—H. Lange. (*NachrTech.*, Dec. 1952, Vol. 2, No. 12, pp. 471–473, 476.) Description and circuit details of an instrument for frequency analysis in the range 30 c/s–20 kc/s. A frequency is selected by adjustment of a 60–80-kc/s Colpitts oscillator. The difference-frequency signal derived is applied successively to two differential bridge circuits each containing a 60-kc/s crystal. Amplitudes of 20 mV–100 V can be measured; at 1 V, maximum error is about 1%.

621.317.4.029.5 : 538.221 **2074**

High-Frequency Calibration of Magnetic Materials.—(*Engineer, Lond.*, 27th Feb. 1953, Vol. 195, No. 5066, pp. 329–330.) A brief account of National Bureau of Standards methods for determining the r.f. permeability and loss factor of ferrites and iron powders in the frequency range 50 kc/s–30 Mc/s. The primary calibration standard is a nonmagnetic coaxial line of variable length and high dimensional accuracy; the magnetic characteristics of a sample are determined from measurements of the lengths of line required to give the same value of inductance with and without the sample inserted. A secondary standard rugged enough to be used in a factory production line is an r.f. permeameter with a transformer comprising a reference toroid acting as primary and a short coaxial line acting as secondary.

621.317.7 : 621.396.82 **2075**

Aircraft Radio-Interference Measurements.—M. M. Newman, R. C. Schwantes & J. R. Stahmann. (*Elect. Engng, N.Y.*, Jan. 1953, Vol. 72, No. 1, pp. 36–40.) A double-beam high-speed oscillograph suitable for measurements of either atmospheric or man-made noise is described. One channel has a 10-Mc/s amplifier, the other a 0·1–250-Mc/s distributed-type wide-band amplifier. A 25-kV intensification potential is provided to facilitate photography of the trace. Two methods for more rapid noise analysis are briefly mentioned.

621.317.715 **2076**

A Moving-Coil Galvanometer of Extreme Sensitivity.—K. Copeland, A. C. Downing & A. V. Hill. (*J. sci. Instrum.*, Feb. 1953, Vol. 30, No. 2, pp. 40–44.) The galvanometer movement is strongly overdamped, but the short natural period of the coil compensates for this, and full deflection is reached in a few seconds. The very light Cu coil, wound on a Cu frame, is suspended by flat CdCu wires kept taut by two flat-rolled springs, a construction facilitating careful balancing. Hill's photoelectric deflection amplification method (3175 of 1948) is used. Tests show that the mean of 7 readings is reasonably certain to be accurate to within 4×10^{-11}A under normal laboratory conditions.

621.317.715 **2077**

The Brownian Fluctuations of a Coupled Galvanometer System.—A. V. Hill. (*J. sci. Instrum.*, Feb. 1953, Vol. 30, No. 2, pp. 44–45.) When two galvanometers are coupled by a photocell and amplifier combination, the fluctuations of the primary instrument are reduced by the inertia and damping of the second. A formula is derived for the r.m.s. value of the fluctuations observed on the second galvanometer and is applied to calculations for particular cases.

621.317.725 **2078**

A High-Resistance Direct-Voltage Valve Voltmeter with a Measurement Range of − 500 to + 500 V.—A. Ehmert & R. Mühleisen. (*Z. angew. Phys.*, Feb. 1953, Vol. 5, No. 2, pp. 43–47.) The instrument described has an input impedance of about $5 \times 10^{13}\Omega$ and an input capacitance of about 0·3 pF; it is suitable for measurements of current down to about 10^{-12}A and determinations of capacitance down to 0·1 pF. The calibration curve is practically linear, the slope being 125 μA/500 V. The equipment is mains operated, and is compensated against mains voltage fluctuations.

621.317.725 : 621.396.645 **2079**

An Electrometer Valve Voltmeter of Wide Range.—A. W. Brewer. (*J. sci. Instrum.*, March 1953, Vol. 30, No. 3, pp. 91–92.) A d.c. voltmeter with a range of $\pm$ 500 V and a rapid response suitable for atmospheric-electricity measurements is obtained by modifying Farmer's circuit (3337 of 1942) so that the electrometer valve and the associated ordinary valve both act as cathode followers, two further ordinary pentodes being used as 'tail' valves.

621.317.76.029.63 : 621.396.615.14 **2080**

U.H.F. Grid-Dip Meter.—A. E. Hylas & W. V. Tyminski. (*Electronics*, April 1953, Vol. 26, No. 4, pp. 175–177.) Oscillators for the frequency range 390–1 000 Mc/s are discussed. This range lies above that of self-oscillation of the valve used, and is attained by means of series-capacitance tuning as described by Pettit (2452 of 1950). The capacitance is distributed to form a balanced circuit, thus providing a maximum-current point on the probe at a location which remains fixed as the oscillator is tuned.

621.317.799 : 621.396.822.029.64 **2081**

Noise Comparator for Microwaves.—J. J. Freeman. (*Radio & Telev. News, Radio-Electronic Engng Section*, March 1953, Vol. 49, No. 3, pp. 11 . . 49.) Secondary standards of noise power used at the National Bureau of Standards consist of klystrons or fluorescent tubes; these are calibrated in terms of the noise power of a matched load at a known temperature by means of a 'noise bridge' which is a modified form of Dicke's radiometer (475 of 1947). The method of calibration is described, with details of the microwave switch, quarter-wave plate and waveguide transducer used for calibrations at 9 kMc/s.

621.395.625(083.74) : 621.396.822 **2082**

Standards on Sound Recording and Reproducing: Methods of Measurement of Noise, 1953.—(*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 508–512.) Standard 53 I.R.E. 19S1.

621.396.622.6 : 621.317.3 **2083**

Testing U.H.F.-TV Mixer Crystals.—N. DeWolf. (*Electronics*, April 1953, Vol. 26, No. 4, pp. 156–160.) To evaluate the effect of Ge-crystal mixers on the overall noise figure of receivers, the conversion loss and noise temperature must be determined. For simplicity, the wide-band conversion loss as defined by Torrey & Whitmer (2989 of 1948) is adopted. Laboratory equipment is described consisting essentially of an u.h.f. receiver adapted for the measurement of conversion loss, noise temperature and r.f. and i.f. crystal admittances. Local-oscillator frequency is 900 Mc/s and the i.f. is 30 Mc/s. A Wollaston wire bolometer is used for the output-power measurements. A complete set of measurements can be made in 5 min. Simpler a.f. methods for production testing are also described.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.321.9.001.8 : 532.574 **2084**

Electronic Flowmeter.—(*Tech. News Bull. nat. Bur. Stand.*, Feb. 1953, Vol. 37, No. 2, pp. 30–31.) The principle of the instrument described is the phase comparison of ultrasonic waves before and after transmission over a fixed distance in a fluid. Transmitter and receiver are identical magnetostriction or piezoelectric transducers, and their connections to the phase meter are interchanged periodically by a rotary commutator or electronic switch. The difference between the two phase shifts is a measure of the flow velocity. Applications include the measurement of air currents and of slow or rapid flow of fluids in pipes.

534.321.9.001.8 : 538.652 : 534.232 **2085**

A High-Frequency Reciprocating Drill.—E. A. Neppiras. (*J. sci. Instrum.*, March 1953, Vol. 30, No. 3, pp. 72–73.) A high-Q magnetostriction transducer is used in conjunction with a step-up velocity transformer to produce intense vibrations at a low ultrasonic frequency, for drilling or cutting hard brittle materials. See also 1988 of 1952 (Kuris).

538.56.029.63 : 534.222.2 **2086**

Reflection of Microwaves by Explosion-Wave Fronts.—B. Koch. (*C. R. Acad. Sci., Paris*, 16th Feb. 1953, Vol. 236, No. 7, pp. 661–663.) A sharp discontinuity of the electron density of the medium occurs at the front of an explosion wave. Measurements of the velocity of such a wave have been made by means of the Doppler effect for 23-cm waves reflected from the wave front. The mean value of the velocity thus determined is about 3·5% greater than that given by classical methods. A possible explanation of the discrepancy is given.

621.316.7 **2087**

Processes in Regulating Systems with Time Delay.—K. Küpfmüller. (*Arch. elekt. Übertragung*, Feb. 1953, Vol. 7, No. 2, pp. 71–78.) An investigation is made of the processes consequent on a disturbance of equilibrium in static and astatic systems. Rules for optimum design are derived.

621.38.001.8 : 621.95 **2088**

Electronic Prevention of Drill Breakage.—(*Engineering, Lond.*, 27th Feb. 1953, Vol. 175, No. 4544, pp. 278–279.) To prevent breakages when drilling deep holes in Al, a device is used which reverses the drill when the torque exceeds a given amount. The torque-control unit consists essentially of an unbalanced Wheatstone-bridge circuit in which the galvanometer is replaced by the grid circuit of a valve.

621.384.6 **2089**

Ion Optics in Long High-Voltage Accelerator Tubes.—M. M. Elkind. (*Rev. sci. Instrum.*, Feb. 1953, Vol. 24, No. 2, pp. 129–137.)

621.384.611 **2090**

Phase Stability of the Microtron.—C. Henderson, F. F. Heymann & R. E. Jennings. (*Proc. phys. Soc.*, 1st Jan. 1953, Vol. 66, No. 397B, pp. 41–49.) The permissible variation in energy or magnetic field for stable acceleration in an electron cyclotron is calculated and the results are discussed in relation to resonant-cavity design.

621.384.611/.612 **2091**

Perturbations in the Magnetic Deflector for Synchrocyclotrons.—K. J. Le Couteur. (*Proc. phys. Soc.*, 1st Jan. 1953, Vol. 66, No. 397B, pp. 25–32.)

621.384.612 **2092**

The Proton Synchrotron at Birmingham University.—(*Engineer, Lond.*, 20th & 27th Feb. 1953, Vol. 195, Nos. 5065 & 5066, pp. 271–274 & 305–307.) Outline description of design and construction. See also 700 of 1951 (Hibbard).

621.384.612 **2093**

A 35-Million-Volt Synchrotron.—O. Wernholm. (*Ark. Fys.*, 26th Oct. 1952, Vol. 5, Parts 5/6, pp. 565–580.) Description of the construction and operation at the Royal Institute of Technology, Sweden, of a synchrotron producing an electron beam with energies continuously variable from 3 to 35 MeV.

621.385.833 **2094**

Potential and Field of a Cylindrical Electrostatic Lens with Three Slits.—M. Laudet. (*Cah. Phys.*, Jan. 1953, No. 41, pp. 73–80.) Analysis for a system comprising three pairs of half-planes at different potentials.

621.385.833 **2095**

An Electrostatic Single Lens permitting Rigorous Calculation.—P. Schiske. (*Nature, Lond.*, 7th March 1953, Vol. 171, No. 4349, pp. 443–444.)

621.385.833 2096
Determination of the Trajectory of an Electron by Successive Differentiations.—É. Durand. (*C. R. Acad. Sci., Paris*, 2nd Feb. 1953, Vol. 236, No. 5, pp. 471–473.)

621.385.833 2097
Astigmatism of Electron Lenses.—S. Leisegang. (*Optik, Stuttgart*, 1953, Vol. 10, Nos. 1/3, pp. 5–14.)

621.385.833 2098
Investigation of the Asymmetry of [electron] **Lenses with Magnetic Pole-Pieces using Rays with Slightly Subtelescopic Path** [im schwach unterteleskopischen Strahlengang].—F. Lenz & M. Hahn. (*Optik, Stuttgart*, 1953, Vol. 10, Nos. 1/3, pp. 15–27.)

621.385.833 2099
A Simple Approximate Formula for the Field Distribution along the Axis of Magnetic Electron Lenses with Unsaturated Pole-Pieces.—H. Bremmer. (*Optik, Stuttgart*, 1953, Vol. 10, Nos. 1/3, pp. 1–4.)

621.385.833 2100
The Adjustment of Spherically Corrected Electron-Optical Systems.—R. Seeliger. (*Optik, Stuttgart*, 1953, Vol. 10, Nos. 1/3, pp. 29–41.)

621.385.833 2101
Special Construction Features of an Electrostatic [electron] **Microscope for the Laboratory.**—H. Bethge. (*Optik, Stuttgart*, 1953, Vol. 10, Nos. 1/3, pp. 137–142.)

621.385.833 : 538.221 2102
Remanence in Soft-Iron Circuits of Magnetic Electron Lenses.—B. v. Borries, F. Lenz & G. Opfer. (*Optik, Stuttgart*, 1953, Vol. 10, Nos. 1/3, pp. 132–136.)

621.385.833 : 621.311.6 2103
High-Frequency High-Voltage Equipment for [electron] **Microscope with Intermediate Accelerator.**—S. Panzer. (*Optik, Stuttgart*, 1953, Vol. 10, Nos. 1/3, pp. 107–110.)

621.387.42 2104
Factors influencing the Life of Self-Quenching Counters.—S. S. Friedland & H. S. Katzenstein. (*Rev. sci. Instrum.*, Feb. 1953, Vol. 24, No. 2, pp. 109–112.)

621.387.424 2105
Ethylene and Ethyl Alcohol as Quenching Agents in External-Cathode Geiger Counters.—R. L. Chasson & M. L. MacKnight. (*Rev. sci. Instrum.*, March 1953, Vol. 24, No. 3, pp. 212–213.)

621.387.424 2106
Construction of Maze-Type Counters [with external cathode], **and their Characteristics from 0° to 50°C.**—R. Favre & C. Haenny. (*Helv. phys. Acta*, 15th Feb. 1953, Vol. 26, No. 1, pp. 53–64. In French.)

621.387.464 2107
A Method of Increasing the Effective Resolution of Scintillation Counters.—K. G. Standing & R. W. Peelle. (*Rev. sci. Instrum.*, March 1953, Vol. 24, No. 3, pp. 193–195.)

PROPAGATION OF WAVES

538.566 2108
Higher-Order Approximations in Ionospheric Wave Propagation.—C. O. Hines. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 95–98.) Feinstein's results (2608 of 1950), though mathematically correct, are not directly applicable to the physical problem for which they were intended. Similar treatment, but assuming real solutions only, is here developed. Certain results previously obtained, in particular those concerning resonance, are found for certain orders of approximation, but the general validity of the approach is found to be doubtful.

621.391.3 2109
The Fields of an Electric Dipole in a Semi-infinite Conducting Medium.—J. R. Wait & L. L. Campbell. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 21–28.) Expressions for the electric and magnetic fields at all points inside the conductor are developed in terms of Thomson's functions, the approximations made implying frequencies < 100 kc/s and observation of the fields at distances much less than the free-space wavelength. Curves are shown plotting each field against a parameter involving conductivity, angular frequency and radial distance from the source. An example for 30-kc/s propagation in sea water is worked out.

621.396.11 2110
Ionospheric Storm-Warning Services. Assessment of their Value.—C. M. Minnis. (*Wireless Engr*, May 1953, Vol. 30, No. 5, pp. 103–108.) It is suggested that the usefulness of a set of forecasts should be measured in terms of their economic value for a communication system. A figure of merit is derived which expresses the increase in economic value resulting from use of a set of forecasts. This figure includes a parameter representing the effects of ionospheric disturbances and depending also on the type of system operated and on the geographic location of the circuit; its value is unity for a perfect set of forecasts.

621.396.11 2111
Theoretical Curves for Resonance Interaction between Electromagnetic Waves Incident Vertically on the Ionosphere.—M. Motzo. (*Nuovo Cim.*, 1st March 1952, Vol. 9, No. 3, pp. 213–219.) Bailey's theory of gyro-interaction (9 of 1939) is extended to the case of vertical incidence. The curves obtained in this case have only a single resonance peak.

621.396.11 : 530.145.6 : 537.311.33 2112
Some Particular Features of Tropospheric Propagation and their Analogies in Wave Mechanics.—M. Ortusi. (*Ann. Radioélect.*, Jan. 1953, Vol. 8, No. 31, pp. 81–95.) Classical theory of tropospheric propagation is summarized, and the limits within which it is valid are discussed. The problem is shown to be mathematically analogous to that of determining particle trajectories in wave mechanics. The waves associated with the electron and hole aspects of the elementary particle are shown to correspond with particular cases of propagation in Gamow and Eckersley modes. The analogy is developed by comparing the form of a potential barrier separating solid media with the refractive-index profile for an atmospheric column including an inversion layer. The discussion indicates the manner in which holes are created inside barrier layers.

621.396.11 : 550.372 2113
Effect of a Large Dielectric Constant on Ground-Wave Propagation.—J. R. Wait & L. L. Campbell. (*Canad. J. Phys.*, March 1953, Vol. 31, No. 3, pp. 456–457.) Curves are plotted showing variation of field strength with distance from transmitter for values of ground dielectric constant ranging from 2 to 200, assuming a value of $0{\cdot}1 \times 10^{-14}$ e.m.u. for the ground conductivity. Vertically polarized radiation of frequency 200 kc/s is assumed. At great distances from the transmitter, high values of dielectric constant give rise to great increase of field strength.

621.396.11 : 551.510.535 **2114**

Magneto-ionic Multiple Splitting determined with the Method of Phase Integration.—W. Pfister. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 29–40.) The method used involves a first-order W.K.B. approximation with an integration path in the complex plane. The propagation constant is represented on a four-sheeted Riemann surface corresponding to up-going and down-coming waves of ordinary and extraordinary types of polarization. The branch points connecting the sheets represent the reflection points or the coupling points. When suitable integration paths around the branch points are chosen, five fundamental magneto-ionic components are found. Numerical calculations for moderate magnetic latitude based on an ionosphere model with Chapman distribution of electrons and exponential decrease of collision frequency are made and the results presented in curves showing virtual height and absorption for the five components found.

621.396.11 : 551.510.535 **2115**

Ionosphere Critical Frequencies at Oblique Incidence.—H. Poeverlein. (*Z. angew. Phys.*, Jan. 1953, Vol. 5, No. 1, pp. 15–19.) The dependence of m.u.f. on the inclination of the geomagnetic field and on the direction of wave propagation is investigated on the basis of previously prepared graphs showing (*a*) the ratio of critical frequency at vertical incidence to that at oblique incidence, as a function of angle of incidence, and (*b*) the ratio of critical frequency without magnetic field (identical with that of the ordinary ray in the E–W plane) to that of the ordinary ray in the plane of the magnetic meridian, also as a function of the angle of incidence. For low frequencies (0·75 Mc/s) the latter ratio has a rather high value at the magnetic equator.

621.396.11.029.55 **2116**

Observations at Calcutta of Pulses Transmitted from Delhi.—S. S. Baral & A. K. Saha. (*Indian J. Phys.*, Nov. 1952, Vol. 26, No. 11, pp. 521–538.) An account of observations during November 1950 and May–June 1951 of transmissions at frequencies of 17·74 and 21·7 Mc/s. Possible modes of propagation are discussed; it is concluded that the signals are received by single reflection from the F_2 layer and that multiple reflections from the F_2 layer or single reflections from the E and F_1 layers are not involved. The signal attenuation in the Delhi–Calcutta path is estimated and the results are tabulated. Statistical analysis of the fluctuations of the received signals indicates greater stability for the lower ordinary ray than for the upper ordinary (Pedersen) ray.

621.396.11.029.55 **2117**

Extended-Range Radio Transmission by Oblique Reflection from Meteoric Ionization.—O. G. Villard, Jr., A. M. Peterson, L. A. Manning & V. R. Eshleman. (*J. geophys. Res.*, March 1953, Vol. 58, No. 1, pp. 83–93.) Tests show that communication can be maintained between low-power stations approximately 1 200 km apart at frequencies around 14 Mc/s when no detectable F-, E- or sporadic-E layer reflections are taking place. The average signal level is 10 db above noise level, and the signal appears to come from the direction of the transmitter, a continual small shift suggesting that there is no single point of reflection. Tests involving three transmission paths of differing lengths were made to determine total duration of discernible meteor-trail echoes. Results showed increased echo durations over oblique paths and thus support the theory that the signals are obliquely reflected from diffuse meteor trails.

621.396.11.029.62/.63 **2118**

Graphs relating to the Propagation of Ultrashort Waves between Points within Visible Range.—L. Sacco. (*Poste e Telecomunicazioni*, Feb. 1953, Vol. 21, No. 2, pp. 55–71.) Various graphs are presented for facilitating design calculations for u.s.w. and microwave links, and for determining the best wavelength from the point of view of efficiency and stability of operation in relation to meteorological and geographical factors.

621.396.11.029.62 : 551.510.535 **2119**

Scattering of 56-Mc/s Radio Waves from the Lower Ionosphere.—P. A. Forsyth, B. W. Currie & F. E. Vawter. (*Nature, Lond.*, 21st Feb. 1953, Vol. 171, No. 4347, pp. 352–353.) Radar records made during 1952 at Saskatoon show persistent scatter echoes with a diurnal and seasonal variation. Similar observations at Ottawa by McKinley & Millman on 33 Mc/s are also mentioned (see 2000 above).

621.396.812.3 **2120**

Some Studies on Random Fading Characteristics.—R. B. Banerji. (*Proc. phys. Soc.*, 1st Feb. 1953, Vol. 66, No. 398B, pp. 105–114.) Critical examination of the theory of random signals reflected from the ionosphere indicates that the velocity distribution of fading is independent of the power spectrum of the reflected wave. The effect produced on the velocity distribution of fading by superposing a steady signal on a randomly fading wave is found to be small, resulting in only a very slight increase of the velocity of fading. An alternative method is given for determining the autocorrelation function of the fading pattern, from which the power spectrum of the reflected wave can be derived by inverse Fourier transformation. This provides an alternative method of determining the velocity of drift of ionospheric irregularities.

RECEPTION

621.396.62 **2121**

The Design of a Comparator A.M./F.M. Broadcast Receiver.—F. H. Beaumont. (*J. Brit. Instn Radio Engrs*, March 1953, Vol. 13, No. 3, pp. 131–148.) Discussion of the design of a superheterodyne receiver to meet a specification drawn up by the B.B.C. for making subjective comparisons of a.m. and f.m. transmissions in the frequency band 87·5–95 Mc/s. The choice of circuits for r.f. amplifier, frequency changer, i.f. amplifier, detector, discriminator, noise limiters and a.f. stages is dealt with in detail.

621.396.62 : 621.396.664 **2122**

An Automatic-Scanning Receiver for Radio Monitoring.—F. J. M. Laver, F. M. Billinghurst & F. J. Lee. (*P. O. elect. Engrs' J.*, Jan. 1953, Vol. 45, Part 4, pp. 149–153.) The tuning frequency of a sensitive communication receiver is swept over a predetermined band of width up to 1 Mc/s once every two minutes by means of a drive unit mechanically coupled to the tuning spindle. A continuous permanent record is obtained on electro-sensitive paper of all signals received above a given strength in any desired frequency band between 4 and 27·5 Mc/s.

621.396.62 : 621.396.812 **2123**

Highly Stable Receiver for Space Waves.—G. Bartels. (*NachrTech.*, Jan. 1953, Vol. 3, No. 1, pp. 28–29.) For investigations of the lower ionosphere, field-strength measurements are made on long-wave transmissions over paths of some hundreds of kilometres. A simple 4-valve receiver is used comprising h.f. stage, mixer with quartz-controlled oscillator, i.f. amplifier and crystal detector, and d.c. valve voltmeter bridge with recording instrument. The sensitivity is about 0·3 mV/m for full-scale deflection of a 1 mA/150 mV instrument.

621.396.621 : 621.396.822 : 519.272 **2124**

The Detection of Weak Signals by Correlation Methods.—P. Rudnick. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2,

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pp. 128–131.) Comparison of an autocorrelation system with a conventional detection system comprising band-pass filter, rectifier and low-pass filter indicates that for the same detection threshold the former system has to be far more complex. An alternative system involving multiplication of the incoming signal by a local sinusoidal signal is shown to be closely parallel to the conventional system.

621.396.621.029.55 : 621.396.822 **2125**

Dependence of the Signal/Noise Ratio of Short-Wave Receivers on the Input Voltage.—K. Fischer. (*Telefunken Ztg*, Jan. 1953, Vol. 26, No. 98, pp. 43–48.) In receivers with a.g.c. it is preferable, so far as signal/noise ratio is concerned, for the gain control to be effected in the later stages, but from the point of view of cross modulation the regulation should be effected at the receiver input. In order to determine the best compromise between these conflicting requirements, experiments were carried out with circuit arrangements in which the gain control could be applied to different groups of valves. With such arrangements cross-modulation can be reduced with an accompanying reduction of the signal/noise ratio, or the latter increased at the expense of cross-modulation sensitivity, so that the optimum circuit for particular conditions can be adopted.

621.396.621.54 **2126**

Problems concerning Tracking Calculations in the Superheterodyne.—J. Mohrmann. (*Funk u. Ton*, Jan. 1953, Vol. 7, No. 1, pp. 1–9.) Critical discussion of tracking methods, underlining errors and omissions involved. See also 2323 of 1952.

621.396.621.54 : 621.396.822 **2127**

Noise Factor and its Relation to the Sensitivity of a Superheterodyne Receiver with Crystal Mixer.—E. Willwacher. (*Telefunken Ztg*, Jan. 1953, Vol. 26, No. 98, pp. 33–42.) Noise factor is defined and a formula is derived for the noise factor of a series arrangement of n quadripoles, each of which may add to the input noise. Analysis is presented for a mixer stage, an equivalent circuit being utilized. The results enable the optimum sensitivity of a superheterodyne receiver to be calculated. Numerical calculations are in good agreement with experimental values.

621.396.622.6 : 621.317.3 **2128**

Testing U.H.F.-TV Mixer Crystals.—DeWolf. (See 2083.)

621.396.622.71 **2129**

Calculation of the Efficiency and Damping of Diode Detectors.—H. H. van Abbe. (*Electronic Applic. Bull.*, May 1952, Vol. 13, No. 5, pp. 65–71.) See 1195 of April.

621.396.662.029.63 **2130**

Automatic Tuning Devices in Microwave Receivers.—G. Voigt. (*NachrTech.*, Dec. 1952, Vol. 2, No. 12, pp. 456–459.) The principles of an automatic system are described whereby the mean i.f. is maintained at the centre frequency of the demodulation characteristic. The control voltage is derived from the d.c. component of the discriminator. Methods of correcting for frequency fluctuations (*a*) up to ± 250 kc/s, (*b*) up to 0·5–1 Mc/s, are outlined.

621.396.828 **2131**

Eliminating Interference caused by Railway Systems fed with Single-Phase Current at 15 kV.—J. Meyer de Stadelhofen. (*Tech. Mitt. schweiz. TelephVerw.*, 1st Feb. 1953, Vol. 31, No. 2, pp. 33–52. In French.) Report of investigations made by the Swiss Post Office and Swiss Railways to determine the extent of radio interference caused by the electric traction system and to find means for reducing it. As regards the Sottens, Beromünster and Monte Ceneri stations, operating in the frequency range 500–800 kc/s, the interference can be reduced to 1/10–1/30 of its original value by simple means.

621.396.828 **2132**

A 'Codan' for A.M. Receivers.—J. B. Rudd. (*Proc. Instn Radio Engrs, Aust.*, Feb. 1953, Vol. 14, No. 2, pp. 33–40.) The 'Codan' (carrier-operated-devices-anti-noise) is an auxiliary circuit device which selects a wanted carrier out of noise at an i.f. stage by means of a narrow-band filter and operates a relay to open the audio circuit. It can operate with signal/noise ratios < 1. A practical unit is described which uses a double-heterodyne process and a band-pass delay line to overcome the effects of frequency drift. Performance figures are given.

621.396.828 : 621.327.43 **2133**

Suppression of Radio Interference from Fluorescent Lamps over the Frequency Range 150 kc/s–1·5 Mc/s.—J. Meyer de Stadelhofen. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Aug. 1952, Vol. 30, No. 8, pp. 239–248. In French and German.) R.f. processes in fluorescent-lamp circuits are analysed. For satisfactory suppression of interference, both a mains filter and a screen round the tube are essential. The ballast coil should be arranged symmetrically and should have low-capacitance windings. Measurement results indicate that interference can be reduced to a tenth of its original value, even in unfavourable circumstances, using simple means.

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11 **2134**

Symposium on Information Theory, London, September 1950.—(*Trans. Inst. Radio Engrs*, Feb. 1953, PGIT-1, 208 pp.) Full report of the proceedings at the symposium noted in 984 of 1951 (Jackson).

621.39.001.11 **2135**

The Information Content of an Electromagnetic Signal.—D. Gabor. (*Arch. elekt. Übertragung*, Feb. 1953, Vol. 7, No. 2, pp. 95–99.) The amount of information that can be extracted from the signal by means of a valve is limited by (*a*) spontaneous fluctuations of the signal, (*b*) shot effect, and (*c*) a phenomenon resulting from the quantum nature of the e.m. field, in accordance with which an electron interchanging energy with the signal field affects the phase of the field by an indeterminate amount, even when the resultant energy exchange is zero. The amount of information obtainable by simultaneous measurement of amplitude and phase is thus of an order no greater than would be obtained by means of an ideal photon counter, which is insensitive to phase changes. See also 208 of 1951.

621.39.001.11 **2136**

Optimum Linear Shaping and Filtering Networks.—R. S. Berkowitz. (*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 532–537.) Analysis is made to derive the optimum transfer characteristics for the transmitter and receiver of a linear communication system, assuming power levels and overall distortion to be fixed. Formulae are derived based on two different criteria, namely (*a*) the mean-square value of the receiver-output noise component, and (*b*) the probability that the receiver-output-noise component exceeds a given value at least once during a given observation period. The choice of criterion appropriate in a particular case depends on the mechanism by which the receiver output is converted into information.

621.392.001.11 **2137**

Analytical Signals with Limited Spectrum: Part 2.—J. A. Ville. (*Câbles & Transm.*, Jan. 1953, Vol. 7, No. 1, pp. 44–53.) Applications of the theory developed previously (1020 of 1950) are made to the determination of the relation between phase change and attenuation in a linear network as a function of frequency and to analysis of the limiting distortion compensation practicable in the presence of noise. The synthesis of a signal by superposition of cos²-type signals (2933 of 1951) is related to the problem of resolution of a signal by means of Shannon's formula; the synthesis can be simplified by referring signals of the sin t/t type to cos²-type signals by suitable regrouping of terms. See also 1177 of April (Jouguet).

621.394.324 **2138**

Progress in Teleprinter Technique.—K. Reche. (*Elektrotech. Z., Edn A*, 1st Jan. 1953, Vol. 74, No. 1, pp. 4–10.) Recent developments resulting in faster, more certain and more economical operation are described, with details of typical equipment.

621.396.029.6 : 621.396.8 : 519.2 **2139**

Problems of U.S.W. Coverage.—F. von Rautenfeld & H. W. Fastert. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, Jan./Feb. 1953, Vol. 5, Nos. 1/2, pp. 9–17.) Methods previously considered for determining the effective service area of a v.h.f. transmitter [213 (Gressmann & Kaltbeitzer) and 214 (Grosskopf) of January] are illustrated by detailed calculations for the f.m. transmitters at Lingen and Nordhelle, 156 km apart, for both co-channel and adjacent-channel operation. See also 197 of January (Bangen & Fastert).

621.396.43 + [621.396.65 : 621.397.26 **2140**

The State of Development of Directional Radio Equipment and the Planning of Directional Radio Links in the German Federal Republic.—K. O. Schmidt. (*Fernmeldetech. Z.*, Feb. 1953, Vol. 6, No. 2, pp. 51–58.) Illustrated review of features of television relay equipment and multichannel f.m. and p.p.m. telephony systems.

621.396.619.13 : 621.396.41 **2141**

Calculation of the Distortion of a Frequency-Modulated Wave.—J. P. Vasseur. (*Ann. Radioélect.*, Jan. 1953, Vol. 8, No. 31, pp. 20–35.) Formulae are derived which are applicable for calculating both the distortion due to variation with frequency of the delay produced by an amplifier, and that due to the superposition on the main signal of echo signals caused by reflection in aerial feeders, etc. The analysis applies to both low and high modulation rates and to both single-frequency and composite signals. In multiplex systems frequency distortion may give rise to crosstalk; a formula due to Lewin (986 of 1951) is used to calculate the magnitude of this effect for the case of slow modulation.

621.396.619.16 **2142**

Pulse Distributors.—H. Oberbeck. (*Telefunken Ztg*, Jan. 1953, Vol. 26, No. 98, pp. 23–32.) In multichannel p.m. systems, different types of equipment for distributing the pulses to the various channels are required according to the type of modulator and demodulator used. Descriptions are given of the basic principles and special features of various types of pulse distributor, detailed accounts of which have been published previously.

621.396.65 **2143**

Radio-Telephone Link between Turkey and the West.—(*Engineer, Lond.*, 6th March 1953, Vol. 195, No. 5067, p. 363.) Brief details of transmitter and receiver installations at Ankara providing a new radiotelephone link with Western Europe and the U.S.A., and an extension of existing radiotelegraph facilities.

621.396.65 : 621.396.41 : 621.396.619.24 **2144**

Single-Sideband Multichannel Operation of Short-Wave Point-to-Point Radio Links: Part 1—General Survey.—W. J. Bray & D. W. Morris. (*P.O. elect. Engrs' J.*, Oct. 1952, Vol. 45, Part 3, pp. 97–103.) The principles of s.s.b. working are outlined, its advantages are pointed out and the basic techniques used for multichannel telegraphy and telephony are described.

621.396.65 : 621.396.61/.62 **2145**

Single-Sideband Multichannel Operation of Short-Wave Point-to-Point Radio Links: Part 2.—Owen & Ewen. (See 2175.)

621.396.65 : 621.396.619.16 **2146**

Transmission Performance Figures for Directional P.P.M. Systems.—P. Barkow. (*Fernmeldetech. Z.*, Jan. 1953, Vol. 6, No. 1, pp. 2–11.) Tests have been conducted on p.p.m. systems operating in Germany. Performance figures are compared with C.C.I.F. specifications based on data for carrier-current systems. Noise figures of equipment for long-distance and local traffic are analysed and the permissible noise levels throughout a communication chain are discussed in relation to transmitter power, receiver sensitivity and bandwidth.

621.396.65 : 621.397.6 **2147**

The Decimetre-Wave Beam Radio Equipment FREDA I.—Behling, Brühl & Willwacher. (See 2160.)

621.396.712 + [621.396.712 : 621.396.66 **2148**

Transmitting and Monitoring Stations of the N.W.D.R.—(*Tech. Hausmitt. NordwDtsch. Rdfunks*, Jan./Feb. 1953, Vol. 5, Nos. 1/2, pp. 18–21.) A list is given of the N.W.D.R. medium-wave, s.w., u.s.w. and television transmitting stations, as at 1st January 1953, with details of height above sea level, frequency, type of modulation, power, type of aerial, programme, and date of commencing operation. The equipment of the monitoring stations Wittsmoor, Hamburg and Norderney is also listed.

621.396.72.029.62 **2149**

Transmitter and Studio for Private U.S.W. Stations.—Tetzner. (See 2178.)

SUBSIDIARY APPARATUS

621-526 **2150**

Synthesis of Servomechanisms by Root Locations.—D. W. Russell & C. H. Weaver. (*Elect. Engng, N.Y.*, Jan. 1953, Vol. 72, No. 1, p. 41.) Summary only.

621.311.6 **2151**

The Cockcroft-Walton Voltage-Multiplying Circuit.—E. Everhart & P. Lorrain. (*Rev. sci. Instrum.*, March 1953, Vol. 24, No. 3, pp. 221–226.) The original circuit (see *Proc. roy. Soc. A*, 1932, Vol. 136, p. 619) is studied by considering it as a transmission line. Losses are examined, and formulae are developed for the voltage efficiency for a given size of capacitor and number of stages. Two modifications to improve voltage efficiency are discussed; the first is the use of a loading coil at the h.v. end of the line, the other is the inclusion of inductors in series with each of the capacitors.

621.311.62 **2152**

Improved Variable Power Supply.—W. Creviston. (*Radio & Telev. News*, April 1953, Vol. 49, No. 4, pp. 42 . . 115.) A modification of Walker's circuit (3562 of 1952) is described which provides direct-voltage outputs from

50 to 300 V, together with heater supplies. Inherent regulation is as good at 50 V as at 300 V.

621.314.632 2153
Hermetically Sealed Magnesium Copper-Sulfide Rectifiers.—M. Gamble. (*Elect. Mfg*, Oct. 1951, Vol. 48, No. 4, p. 132.) Short note on the construction methods used for this type of rectifier, which has an operating range from − 70° to + 200°C or higher.

621.314.632/.634 2154
Advanced Developments in Metallic Rectifiers.—W. F. Bonner & F. J. Oliver. (*Elect. Mfg*, Oct. 1951, Vol. 48, No. 4, pp. 128–133 . . 288.) Discussion of improvements relative to higher operating voltage, smaller size, operation at high and at low temperatures, and higher efficiency, largely resulting from requirements of the Services. Se rectifiers are particularly considered.

621.314.671 2155
New Rectifier Tube for Extremely High Power and Voltage Levels.—T. H. Rogers. (*Elect. Engng, N.Y.*, Jan. 1953, Vol. 72, No. 1, pp. 51–56.) This valve has a Th-W filament with catenary configuration and a cylindrical anode of Ta coated with W powder. Its characteristics are:—anode dissipation rating, 1·5 kW; peak current rating, 10 A; maximum peak inverse voltage, 110 kV.

621.315.616 : 621.355.2 2156
Microporous Thermoplastic Separators for Lead Acid Batteries.—(*Engineer, Lond.*, 13th March 1953, Vol. 195, No. 5068, pp. 386–387.) Brief account of the manufacture and properties of 'Porvic', a P.V.C. sheet material. A similar account is given in *Plastics*, April 1953, Vol. 18, No. 189, pp. 104–106.

621.355.2 2157
Addition Agents for Negative Plates of Lead-Acid Storage Batteries: Part 2—Pure Organic Compounds.—E. J. Ritchie. (*J. electrochem. Soc.*, Feb. 1953, Vol. 100, No. 2, pp. 53–59.) The best results were obtained with carbohydrates and some of the homologous phenolic compounds.

TELEVISION AND PHOTOTELEGRAPHY

621.317.336.015.7 : 621.315.212 2158
The Response to Television and Testing Pulses of Cables with Nonuniform Characteristic Impedance.—Kaden. (See 2070.)

621.397.26 : 621.396.65] + 621.396.43 2159
The State of Development of Directional Radio Equipment and the Planning of Directional Radio Links in the German Federal Republic.—Schmidt. (See 2140.)

621.397.26 : 621.396.65 2160
The Decimetre-Wave Beam Radio Equipment FREDA I.—H. Behling, G. Brühl & E. Willwacher. (*Telefunken Ztg*, Jan. 1953, Vol. 26, No. 98, pp. 4–22.) The name FREDA signifies 'frequenzmodulierte Dezimeteranlage'. The equipment is designed for the Hamburg-Cologne link, the operating frequency being 1 755 + *n*.60 Mc/s for the different channels. A description is given, with block diagrams, of the arrangements at the terminal transmitting and receiving stations and at a relay station. Details of the construction of the transmitter h.f. oscillator, mixer and amplifier stages are illustrated by photographs. Modulator and demodulator schematic circuit diagrams are given and performance data are summarized. Transmitter power is 5 W and the gain of the 3-m parabolic reflector, with dipole feed, relative to an elementary dipole, is 1 060. Signal/noise ratio for the television channel is good.

621.397.335 2161
Synchronization and Pulse Technique in Television.—J. Günther. Correction slip inserted in Nov./Dec. issue of *Tech. Hausmitt. NordwDtsch. Rdfunks* gives a corrected diagram for Fig. 1 of paper abstracted in 1153 of April.

621.397.5 : 535.623 2162
Recent Advances in Colour Television.—F. W. de Vrijer. (*Tijdschr. ned. Radiogenoot.*, March 1953, Vol. 18, No. 2, pp. 105–112. In English.) Systems and apparatus developed in the U.S.A. are discussed.

621.397.61/.62 2163
Storage and Picture-Difference Methods in Television Reception.—F. Schröter. (*Arch. elekt. Übertragung*, Feb. 1953, Vol. 7, No. 2, pp. 63–70.) Use of a storage method at the receiver eliminates the need to transmit 'redundant' information, i.e. signals corresponding to picture points which have undergone no change since the previous scan. A description is given of a particular type of storage tube using a 2–3-μ thick insulating target with a mesh-type anode on the scanned face and a mesh-type photocathode on the other face. Such a tube can provide a flicker-free picture of good brightness with a frame frequency of 16 per sec. For use in converting pictures brought by line to a broadcasting station, the tube can be modified by including the photocathode in a Farnsworth-type dissector arrangement. Reception by this method combines satisfactorily with transmission by picture-difference methods using two-speed scanning, leading to a substantial reduction of the required bandwidth and transmitter power.

621.397.61 2164
Television Camera Equipment of Advanced Design.—L. L. Pourciau. (*J. Soc. Mot. Pict. Telev. Engrs*, Feb. 1953, Vol. 60, No. 2, pp. 166–180.) Descriptions are given of the servo circuits and mechanical design features of a television camera chain in which lens selection and focus are remotely controlled. Special emphasis is laid on convenient grouping of controls.

621.397.61 : 621.396.619.23 2165
Spiral-Beam Tube modulates 1 kW at U.H.F.—Cuccia. (See 2188.)

621.397.61(494) 2166
Justification of the Choice of the Dôle as Site for a Television Transmitter.—H. Laett & J. Dufour. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Sept. 1952, Vol. 30, No. 9, pp. 264–270. In French.) See 246 of January (Laett).

621.397.611.2 2167
Some New Aspects of the Construction and Application of the Image Iconoscope.—H. Bruining. (*Le Vide*, Nov. 1952, Vol. 7, No. 42, pp. 1248–1255.) Recent improvements in design are described, including the use of (*a*) a close-mesh grid in front of the photocathode to eliminate ion spots, (*b*) an L-type cathode in the electron gun. A focusing system providing variable magnification is discussed. Methods of target stabilization are noted.

621.397.62 2168
Application of the ECL80 and EQ80 Tubes in Flywheel Synchronization Circuits.—A. Boekhorst, P. D. van der Knaap & P. A. Neeteson. (*Electronic Applic. Bull.*, May 1952, Vol. 13, No. 5, pp. 72–80.) Full details are given of two practical arrangements. The first uses a

Type-ECL80 triode-pentode in the phase-discriminator circuit and effects comparison between pulses at incoming synchronizing frequency and local line-timebase frequency; the second uses a Type-EQ80 enneode and effects comparison between pulses at incoming synchronizing frequency and a sawtooth voltage at local line frequency. Additional features for suppressing the effects of interference on the synchronization are described.

621.397.62 **2169**

Television Converter.—C. A. Marshall. (*Wireless World*, May 1953, Vol. 59, No. 5, pp. 223–226.) Detailed description of a frequency-converter unit for use with nontunable television receivers. The particular values of circuit components given are for adapting a Channel-1 receiver (45 Mc/s vision, 41·5 Mc/s sound) to Channel-3 reception (56·75 Mc/s vision, 53·25 Mc/s sound), but the general design is not restricted to these channels.

621.397.62 : 535.88 **2170**

Special Problems in Television Large-Picture Installations.—E. Schwartz. Correction slip inserted in the Nov./Dec. issue of *Tech. Hausmitt. NordwDtsch. Rdfunks* gives a corrected diagram for Fig. 1 of paper abstracted in 1168 of April.

621.397.621.2 : 621.385.832 **2171**

Transfer Characteristics and Mu Factor of Picture Tubes.—K. Schlesinger. (*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 528–532.) The characteristics of television-receiver-tube guns are analysed, taking account of the variation with grid voltage of the active cathode area. The value of gamma lies between 2·4 and 2·5 for various structures, while the value of the amplification factor is strongly influenced by changes in system parameters. The theoretical results were verified experimentally.

621.397.645.029.62 **2172**

Fundamental Problems of H.F. and I.F. Amplifiers for TV Reception: Part 3 — Feedback and Practical Considerations following on the Theory.—Uitjens. (See 1954.)

621.397.82 **2173**

Television Reception and Interference.—W. Werner. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, Jan./Feb. 1953, Vol. 5, Nos. 1/2, pp. 1–8.) Methods are suggested for reducing interference from c.w. signals which produce effects in the i.f. band, and also from impulse voltages. Radiation from the deflection system of the receiver c.r. tube and from the receiver local oscillator is discussed, practical methods of measuring it are noted and means found effective in reducing it are described. Screening of the picture tube to reduce X-ray emission is also mentioned.

621.397.82 **2174**

A Combining Unit for Superimposing Two Television Pictures on the Same Cathode-Ray Tube.—D. Wray. (*P. O. elect. Engrs' J.*, Jan. 1953, Vol. 45, Part 4, pp. 172–174.) Apparatus is described by means of which another waveform can be combined with the television signal without loss of synchronism. The effect on the picture of various types of interference can be simulated. The delay occurring in a long-distance looped television transmission system is evidenced by the displacement between the two pictures observed simultaneously when the signal generated at the transmitter is combined with that received after travelling round the loop.

TRANSMISSION

621.396.61/.62 : 621.396.65 **2175**

Single-Sideband Multi-Channel Operation of Short-Wave Point-to-Point Radio-Links: Part 2.—F. C. Owen & A. B. Ewen. (*P. O. elect. Engrs' J.*, Jan. 1953, Vol. 45, Part 4, pp. 154–159.) The present equipment is an improved form of that previously described [2395 of 1948 (Bray et al.)]; it generates a low-power independent-sideband signal comprising two 6-kc/s channels, one on each side of a reduced-level 3·1-Mc/s pilot carrier, suitable for application to the final modulator and power-amplifier stages of a s.w. transmitter. Alternatively a single-channel d.s.b. signal can be generated. The associated monitor receiver is designed to accept signals from the transmitter drive unit at 3·1 Mc/s or from the power-amplifier stages at radiation frequency. Part 1: 2144 above (Bray & Morris).

621.396.61.026.446.029.53 : 621.396.97 **2176**

Megawatt A.M. Broadcast Transmitter.—J. O. Weldon. (*Tele-Tech*, Jan. 1953, Vol. 12, No. 1, pp. 50–51 . . 116.) Illustrated description of equipment comprising two identical 500-kW transmitters whose outputs are combined to feed 1 MW to the aerial system. Four Machlett 250-kW Type-ML5682 valves are used in the power amplifier of each transmitter, with four more in the output stage. Grid-bias modulation of the first Type-ML5682 valve is effected by means of four Type-805 valves in parallel constituting the output stage of the a.f. amplifier. Operating characteristics in the frequency range 540–1 600 kc/s were found consistently good.

621.396.619.11 **2177**

The Impulse Modulator.—H. Moss. (*J. Brit. Instn Radio Engrs*, March 1953, Vol. 13, No. 3, pp. 150–159.) A highly linear amplitude modulator is achieved by using a negative-feedback circuit in which the valve anode current is arranged to be as nearly as possible proportional to the anode voltage and applying rectangular on-off switching pulses to the valve grid at carrier frequency, the modulating voltage being applied to the anode. The modulated r.f. output is taken from a resonant load in series with the valve. 100% depth of modulation can be obtained without requiring residual carrier neutralization. Harmonic distortion, modulation efficiency and linearity, and the influence of pulse mark/space ratio, are discussed.

621.396.72.029.62 **2178**

Transmitter and Studio for Private U.S.W. Stations.—K. Tetzner. (*Funk-Technik, Berlin*, March 1953, Vol. 8, No. 5, pp. 132–133.) Brief description of commercially produced equipment for use in local broadcasting stations owned by cultural institutions etc. in Germany. Transmitter powers range from 50 W to 250 W, the operating frequency being near 100 Mc/s. Studio equipment to satisfy basic requirements is outlined.

VALVES AND THERMIONICS

546.289 : 621.314.632 **2179**

Evaporated Point-Contact Rectifiers.—E. G. Roka, C. H. Jackson & R. P. Ulrich. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 228–229.) A study has been made of the effect on a Ge rectifier of replacing the 'whisker' contact by a contact comprising a very small area of evaporated silver. A significant improvement of the rectifying properties is observed. If the rectifier with whisker contact is subjected to alternating pulses of amplitude about 30 V, the reverse resistance is thereby increased and the substitution of the evaporated contact then produces no improvement.

546.289 : 621.385.2 **2180**

Negative Resistance in Germanium Diodes.—J. Kauke. (*Radio & Telev. News, Radio-Electronic Engng Section*, April 1953, Vol. 49, No. 4, pp. 8–10.) Ge diodes show negative-resistance effects at values of the reverse voltage somewhat higher than the rated continuous-working voltage. Applications of such effects in the production of a sawtooth-wave oscillator, a sine-wave oscillator, a lock-in circuit and a voltage divider are described.

621.383.27 : 621.387.464 **2181**

Photomultipliers Particularly Suitable for counting Scintillations.—É. Morilleau, H. Dormont & R. Champeix. (*C. R. Acad. Sci., Paris*, 2nd Feb. 1953, Vol. 236, No. 5, pp. 474–476.) Various measures adopted to obtain improved performance are indicated. Curved reflector-type Cu dynodes coated with Cs are used. By focusing the emission from the cathode on to a very small first dynode, a low value of background noise is achieved together with constant gain and optical screening of the cathode.

621.385 : 621.396.615.142 **2182**

Influence of the Lorentz Force on Space-Charge Waves in Electron Beams.—J. Labus. (*Arch. elekt. Übertragung*, Feb. 1953, Vol. 7, No. 2, pp. 88–94.) For a beam of infinite diameter there are two possible values of phase velocity of the space-charge waves. When the formula is modified to take account of finite beam diameter, an infinite number of values of phase velocity are found. On taking into account the effect of the Lorentz force on the motion of the electrons, the formula obtained is very little different from that for the infinite-diameter beam, and gives values of phase velocity nearly independent of beam diameter and nearly equal.

621.385.029.6 **2183**

Travelling-Wave Tubes.—R. Kompfner. (*Rep. Progr. Phys.*, 1952, Vol. 15, pp. 275–327.) The historical development of travelling-wave valves is described and a simple theory of their operation is outlined. More complete theory due to Pierce is sketched which permits calculation of the effects of attenuation, of non-synchronous velocities, and of space charge. Recent developments in the helix-type travelling-wave valve are described, such as Brillouin focusing of electron streams in axial magnetic fields, and noise characteristics of electron streams. Various types of travelling-wave valve are described and their special features are discussed. Wherever possible, attempts have been made to explain the modes of operation of the various types in simple physical terms. Over 140 references.

621.385.032.216 : 537.533.8 **2184**

Changes in Secondary and Thermionic Emission from Barium Oxide during Electron Bombardment.—J. Woods & D. A. Wright. (*Brit. J. appl. Phys.*, Feb. 1953, Vol. 4, No. 2, pp. 56–61.) Further experiments on BaO films (see 895 of March) are reported. Changes in secondary emission after 15–30 min bombardment depend on the film thickness and are due to a reduction process forming an excess of metal within the oxide. Thermionic emission also varies with thickness and there is a close correlation between the two types of emission in respect of decay and recovery effects.

621.385.1 : 621.396.822 **2185**

Noise in Gas Discharges.—A. van der Ziel. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, pp. 223–224.) Comment on 2670 of 1950 (Parzen & Goldstein) indicating that to make the noise-power formula there derived valid for all frequencies the term corresponding to shot noise requires modification. The theory of shot noise in semiconductors (2040 above) is applied. The revised formula indicates that the shot noise is much greater at low than at high frequencies.

621.396.615.141.2 **2186**

A 3 cm-Magnetron for Beacons.—G. A. Espersen & B. Arfin. (*Philips tech. Rev.*, Sept./Oct. 1952, Vol. 14, Nos. 3/4, pp. 87–94.) See 3184 of 1951.

621.396.615.141.2 **2187**

New Magnetron Oscillator with Interdigital Circuit.—A. Leblond, O. Doehler & R. Warnecke. (*C. R. Acad. Sci., Paris*, 5th Jan. 1953, Vol. 236, No. 1, pp. 55–57.) The oscillatory system of a multislot magnetron can be considered as a section of a line with periodic structure closed on itself [see 1543 of May (Leblond et al.)]; with such a system, in order to avoid the sudden frequency jump on passing from one oscillation mode to another, the phase velocity of the fundamental wave of the delay line constituted by the oscillatory system should be of opposite sign to the group velocity, and the dispersion should be relatively low. A suitable interdigital structure satisfying these requirements is described with which a peak h.f. output of 300 kW on 11-cm wavelength has been obtained from a valve operated with peak anode voltage of 22 kV, peak anode current 26 A and magnetic field 2 700 gauss.

621.396.619.23 : 621.397.61 **2188**

Spiral-Beam Tube Modulates 1 kW at U.H.F.—C. L. Cuccia. (*Electronics*, April 1953, Vol. 26, No. 4, pp. 130–134.) A modified form of the electron-beam coupler valve previously described (2975 of 1949) is used as a television modulator in the 800-Mc/s frequency range. Modulation is performed by means of five auxiliary electron beams in the output cavity; a 50-V modulator grid swing can control power output over a range of 98% of maximum (300 W with a beam voltage of 750 V). The device has good linearity, a bandwidth of 5 Mc/s and a transfer efficiency of 50%.

621.396.622.63 **2189**

Conductivity of and Flicker Effect in Crystal Detectors.—N. Nifontoff. (*Onde élect.*, Jan. 1953, Vol. 33, No. 310, pp. 58–61.) See 1047 of April and back references.

621.396.622.63 : 546.28 **2190**

Silicon Crystal Detectors.—J. M. Mercier & R. P. Musson-Genon. (*Onde élect.*, Jan. 1953, Vol. 33, No. 310, pp. 40–57.) An account of the methods of manufacture of Si detectors adopted by the Compagnie Française Thomson-Houston and of their characteristics and use as mixers in u.h.f. circuits. See also 2070 of 1951 (Mercier).

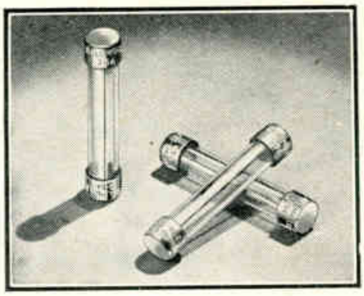
MISCELLANEOUS

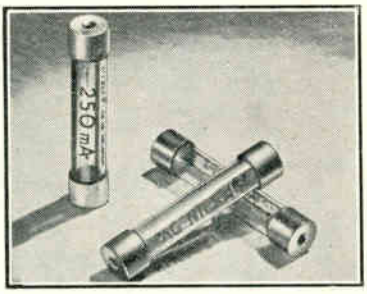
025.45 : 621.3 **2191**

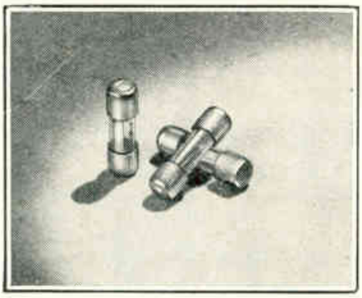
Work of the 3rd Meeting of the International Electrical Engineering U.D.C. Committee and the 1st Meeting of the Telecommunications Subcommittee of the International Federation for Documentation.—C. Frachebourg. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Jan. 1953, Vol. 31, No. 1, pp. 30–31. In French.) Brief note of the proceedings, with proposed revised classifications for the sections on aerials and radar.

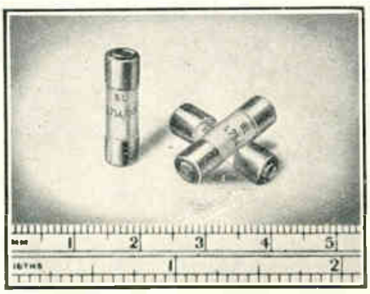
621.38/.39] : [002 + 026 + 025.45 **2192**

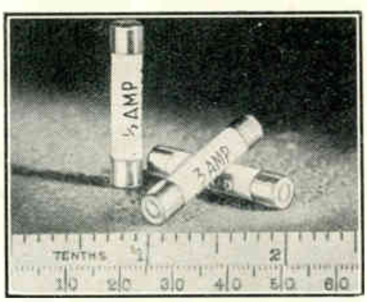
Radio and Electronic Engineering Literature.—(*J. Brit. Instn Radio Engrs*, Jan. 1953, Vol. 13, No. 1, pp. 65–75.) A report prepared by the Technical Committee of the British Institution of Radio Engineers as a guide to the main sources of information on modern developments, including abstracting services, Government publications, library facilities, patents, etc. A brief explanation is given of the working of the Patent Office Library and of the U.D.C. (Universal Decimal Classification) system as applied to radio and electronic engineering.











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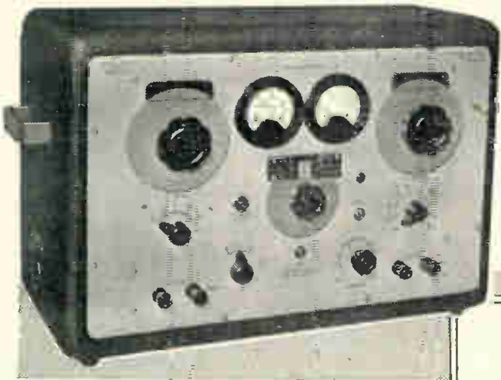

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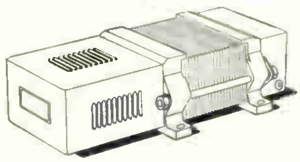

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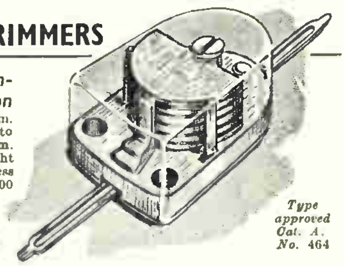

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Index to Advertisers

	PAGE
A. B. Metal Products, Ltd.	13
Adams Bros. & Burnley, Ltd.	22
Advance Components, Ltd.	26
Airmec, Ltd.	8
All-Power Transformers, Ltd.	6
Appointments	24, 26
B.B. Chemical Co., Ltd.	12
Belling & Lee, Ltd.	19
British Insulated Callender's Cables, Ltd.	10
British Physical Laboratories	22
Brookes Crystals, Ltd.	12
Bullers, Ltd.	Cover ii
Edison Swan Electric Co., Ltd., The	17
Enthoven Solders, Ltd.	3
Ferranti, Ltd.	25
Foyle, W. & G., Ltd.	24
Griffiths, Gilbart, Lloyd & Co. Ltd.	12
Hunt, A. H., (Capacitors), Ltd.	Cover iv
Lyons, Claude, Ltd.	1
Marconi Instruments, Ltd.	2
Marconi Wireless Telegraph Co., Ltd.	7
McGraw-Hill Publishing Co., Ltd.	8
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Muirhead & Co., Ltd.	6
Mullard, Ltd.	5, 16
Murex, Ltd.	18
Oxley Developments Co., Ltd.	26
Plessey Co., Ltd., The	4
Salford Electrical Instruments, Ltd.	20
Standard Telephones & Cables, Ltd.	11
Steatite & Porcelain Products, Ltd.	21
Sullivan, H. W., Ltd.	14
Telegraph Condenser Co., Ltd., The	Cover iii
Telegraph Construction & Maintenance Co., Ltd., The	20
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