WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

MAY 1953

VOL. 30 No. 5 THREE SHILLINGS AND SIXPENCE

'VARIAC' voltage regulating transformers

Reg'd Trade Mark

With a 'VARIAC' voltages are instantly and minutely adjustable from 0-Line Voltage, or in some cases up to 17% above line voltage. Type 50-B 'VARIAC,' as illustrated left, is often operated in a 3-gang assembly on 3-phase work to control 21Kva.

SERIES 50 'VARIAC' TRANSFORMERS.

Type 200 C.U.H. 'VARIAC'

Type 100-R 'VARIAC'

SPECIFICATIONS

Type	Load Rating	Input Voltage	Current: Rated	Current: Maximum	Output Voltage	No-Load Loss	Net Price £ s. d.*
50-A	5 kva.	115 v.	40 a.	45 a.	0-135 v.	65 watts	44 18 6
50-B	7 kva.	230/115 v.	20 a.	31 a.	0-270 v.	90 watts	44 18 6

* All 'VARIAC' prices plus 20% as from 23rd Feb. 1952

PROMPT DELIVERY

Write for catalogue V549 which gives full details of 'VARIAC' transformers and suggestions for use.

CLAUDE LYONS LIMITED

ELECTRICAL AND RADIO LABORATORY APPARATUS, Etc.

180 Tottenham Court Road, London, W.1; and 76 Oldhall Street, Liverpool 3, Lancs.

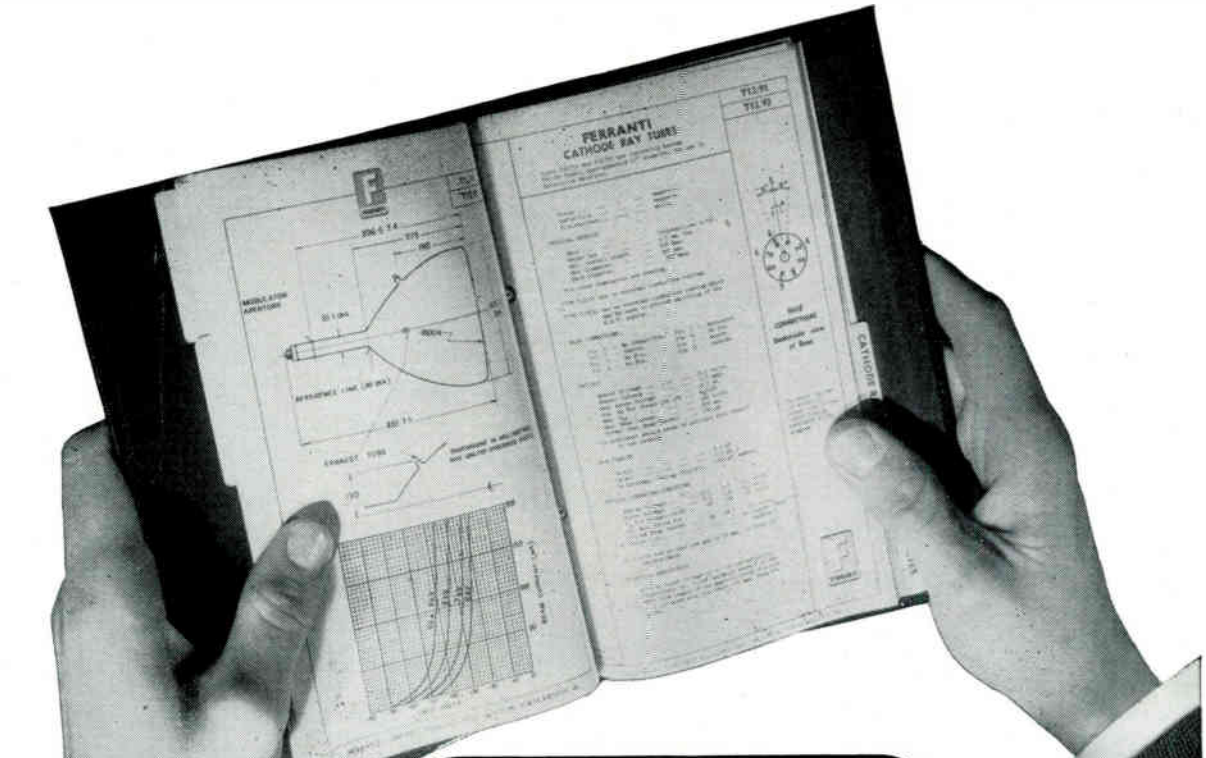

MAGNETIC MATERIALS Extensive research and manufacturing facilities have established Mullard as the leading producers of magnetic materials. They were the first, for example, to introduce Ferroxcube, the world's most efficient magnetic ferrite; 'Ticonal' anisotropic permanent magnets, renowned for their high stability and high energy output; and Magnadur, an entirely new type of permanent magnet with the insulating properties of a ceramic. The wealth of experience gained from these developments is available to all users of magnetic materials through the Mullard advisory service. An enquiry to the address below will put a team of specialised engineers at your disposal.
Mullard
Mullard
'TICONAL' PERMANENT MAGNETS · MAGNADUR (Formerly Ferroxdure) PERMANENT MAGNETS · FERROXCUBE MAGNETIC CORE MATERIAL
COMPONENT DIVISION, CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2
Mullard Ferroxcube being extruded into rods for H.F. cores.

A Technical Handbook for Electronic Engineers

This Handbook contains the fullest information about all types of Ferranti Valves and Cathode Ray Tubes, giving for each type *complete* data such as physical details, base connections, ratings, operating conditions, with graphs, etc., where necessary. The whole is a most valuable book of reference to the electronics engineer. It is in loose-leaf form, so that new data can readily be inserted.

Price 5/-

Additional data sheets will be sent to subscribers from time to time



FERRANTI LTD

MOSTON • MANCHESTER 10

***London Office*: KERN HOUSE**

36 KINGSWAY, W.C.2

FERRANTI

FE155

Decade Capacitance Units Type B-23 for Panel Mounting

THESE self-contained units employ hermetically sealed mica capacitors, and in consequence a high stability is attained. The individual capacitance steps are normally adjusted to an accuracy of ±1%, but can be adjusted to ±0.1% if requested (except for the lowest values), thus providing a decade unit which can also be used as a standard when occasion demands. Designed for panel mounting, these units find many applications in A.C. bridges, A.F. oscillators, and other instruments.

Specification

Accuracy:	0.001 µF steps ±5% (±1% for an extra charge.) 0.01 µF and 0.1 µF steps ±1% (±0.1% for an extra charge).
Stability:	Within ±0.1%.
Temp. Coeff:	−20 to +50 parts in 10^6 per °C.
Power factor:	Less than 0.0005 at 1000 c/s.
Insulation:	10,000 megohm-microfarads.
Wkg voltage:	250 volts peak.

For further details write for Publication 2654

MUIRHEAD & CO., LTD.
PRECISION ELECTRICAL INSTRUMENT MAKERS
BECKENHAM • KENT • ENGLAND

Phone: BECkenham 0041 Telegrams & Cables: MUIRHEAD BECKENHAM

PRECISION MUIRHEAD ELECTRICAL INSTRUMENTS

49B

TELCONNECTORS

co-axial cable terminations

Type TZ.57.A1 for use with AS.57.A1 cable.

The terminations illustrated are available for use with Telcon lead or aluminium sheathed co-axial cables. Where supplied for use with air-spaced cables, the attachment shown enables the cable to be flushed with dry air or pressurised gas.

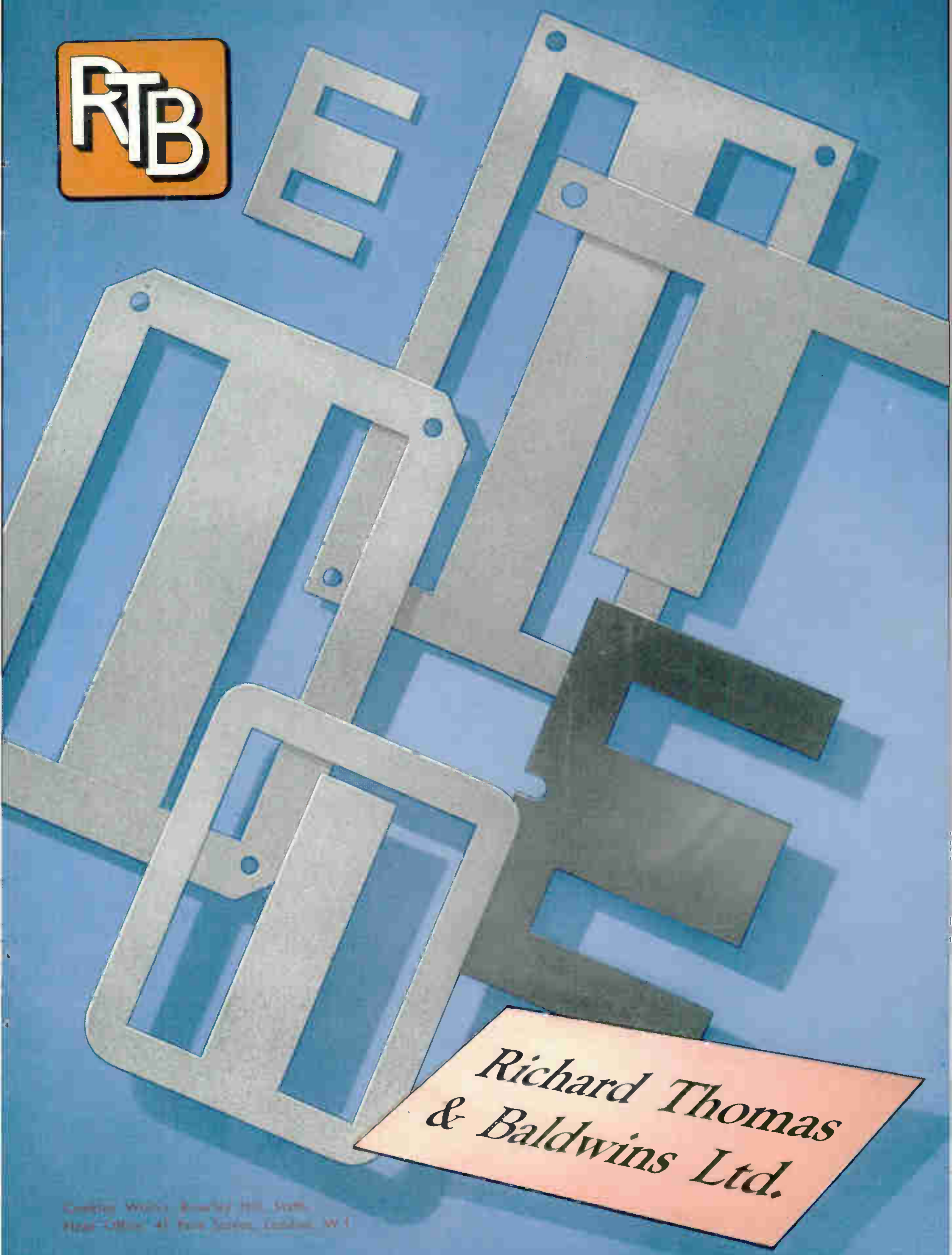
All types are readily available in various sizes and combinations. Write for publication T/1.

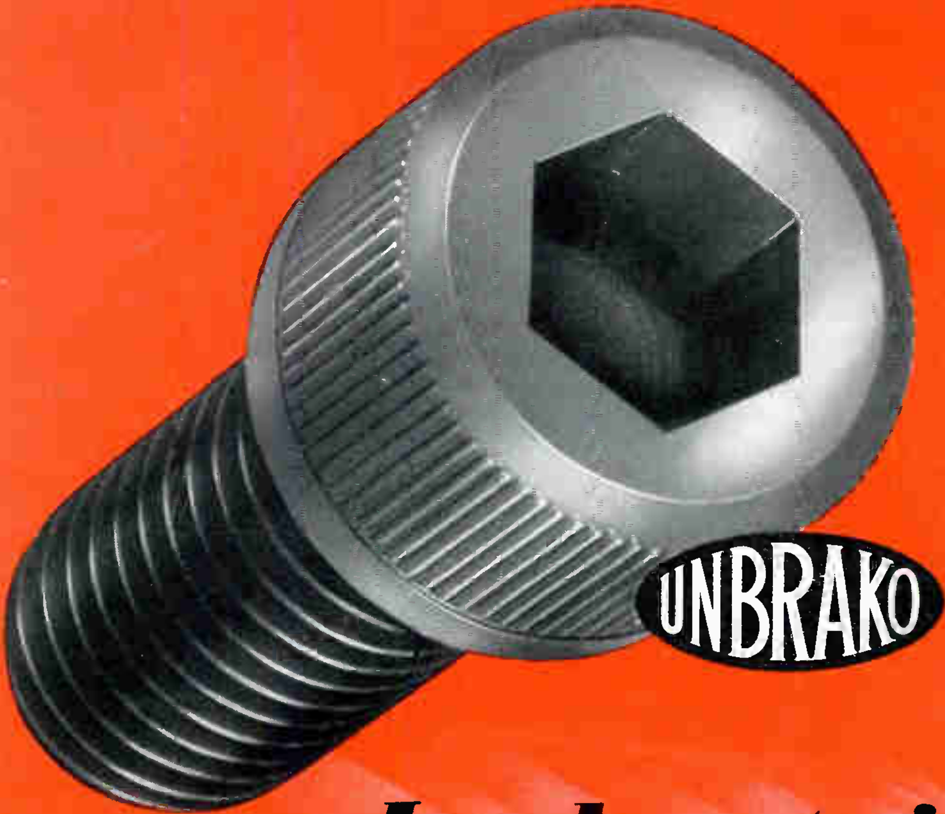
TELCON YOUR GUARANTEE

Type T.35.L for use with PT.35.1 cable.

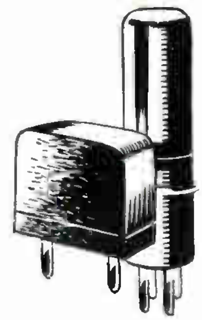
TELCON RF cables

THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD
Head Office: 22 OLD BROAD STREET, LONDON, E.C.2
Tel: LONdon Wall 7104
All enquiries to: TELCON WORKS, GREENWICH, S.E.10
Tel: GREenwich 3291


RTB
Richard Thomas
& Baldwins Ltd.


UNBRAKO

Communication assured with G.E.C. QUARTZ CRYSTAL UNITS



From take-off to touch-down, the safety of the aircraft is dependent on trouble-free radio contact being maintained. The components used in the radio equipment must be the best obtainable.

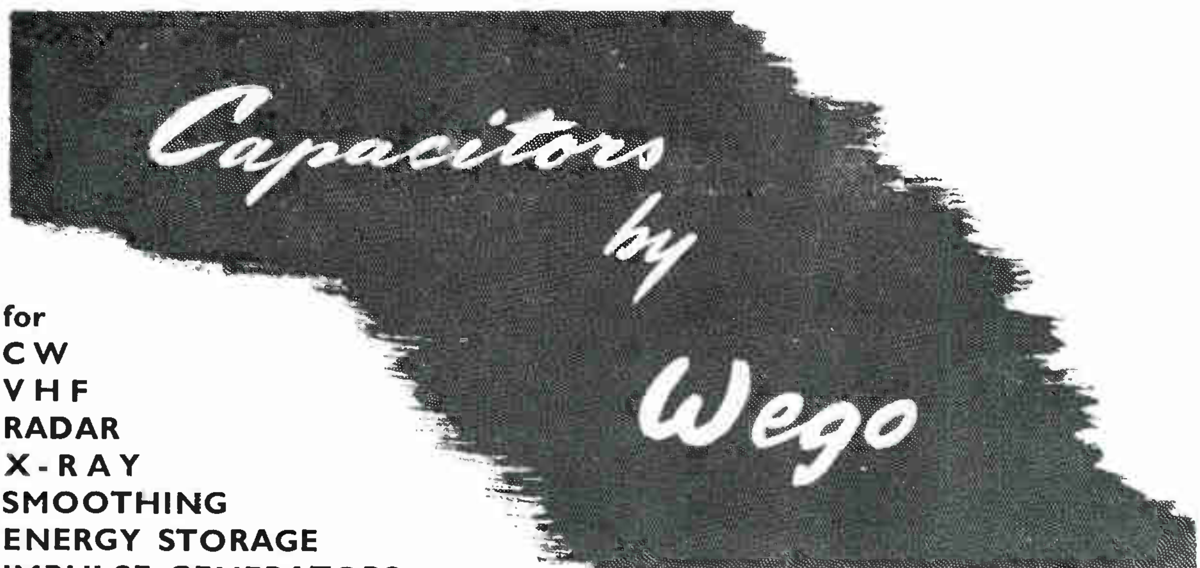
For reliable communications under all conditions use G.E.C. Quartz Crystal Units.

Write to-day for list Q.C. 5012(R)

SALFORD ELECTRICAL INSTRUMENTS LTD

A Subsidiary of THE GENERAL ELECTRIC CO. LTD. OF ENGLAND

PEEL WORKS · SILK STREET · SALFORD 3 · LANCS.

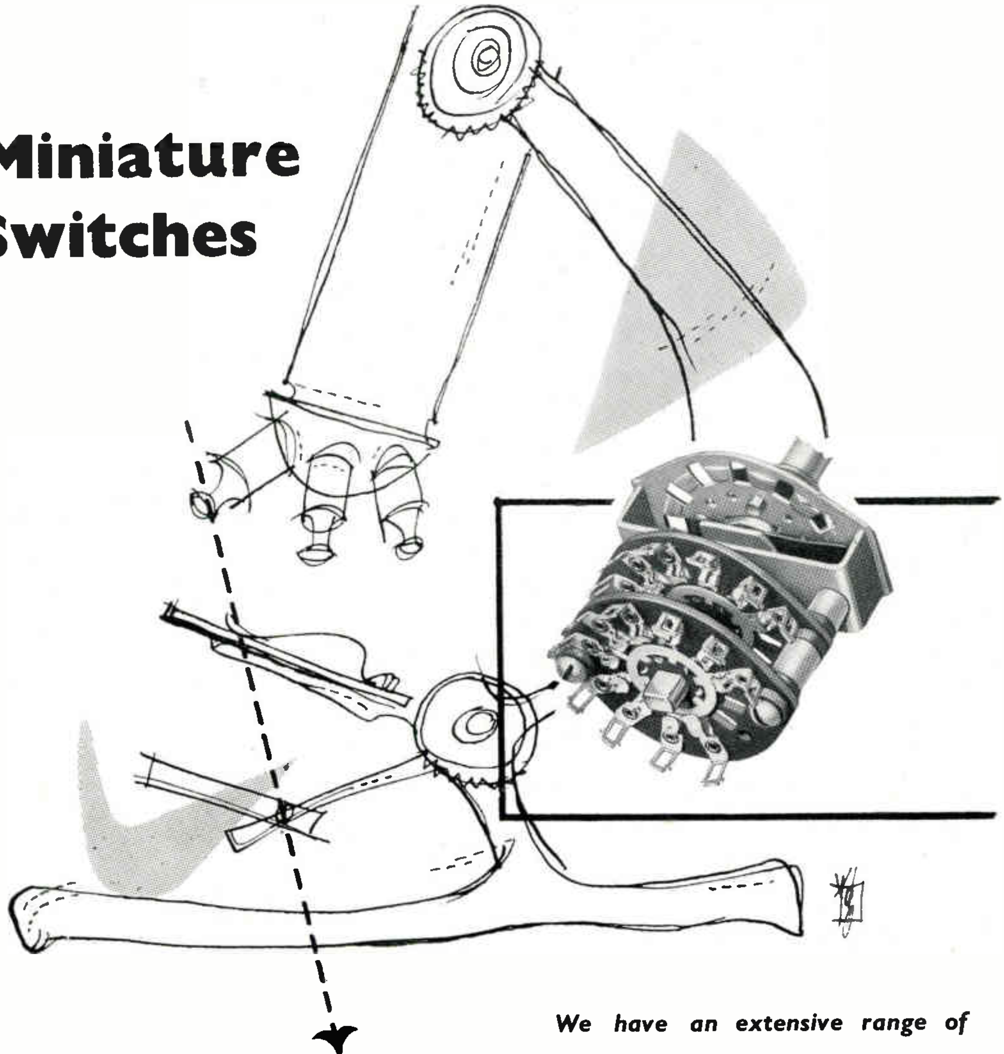


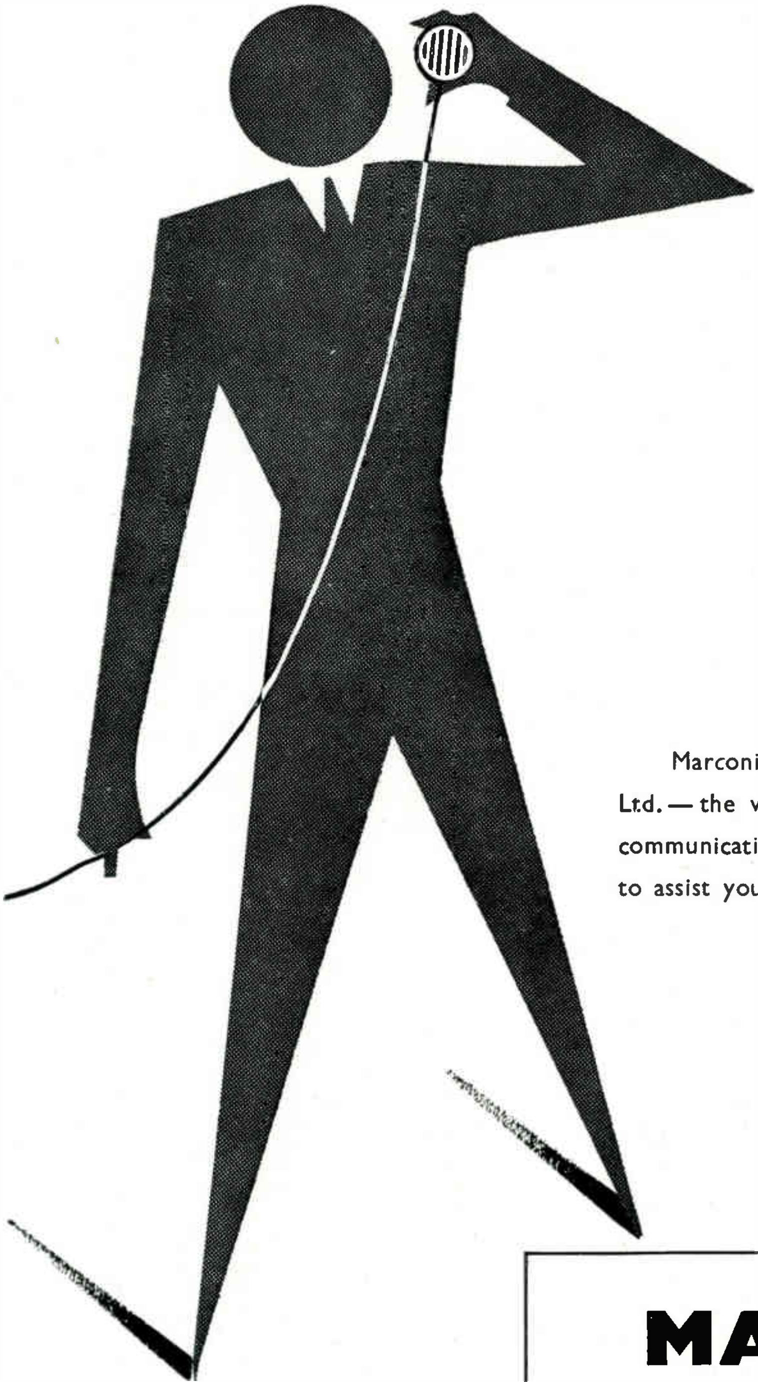
for
CW
VHF
RADAR
X-RAY
SMOOTHING
ENERGY STORAGE
IMPULSE GENERATORS
AND OTHER ELECTRONIC APPLICATIONS

Full information will be supplied on request.

WEGO CONDENSER CO. LTD.

BIDEFORD AVENUE, PERIVALE, GREENFORD, MIDDLESEX. Telephone : Perivale 4277.





Marconi's Wireless Telegraph Company Ltd. — the world's most experienced radio communication engineers — are always ready to assist you with positive help and advice.

MARCONI mobile radio

PLANNED • INSTALLED SERVICED

MARCONI'S WIRELESS TELEGRAPH COMPANY LTD · CHELMSFORD · ESSEX

WIRELESS ENGINEER

The Journal of Radio Research and Progress

Managing Editor: HUGH S. POCOCK, M.I.E.E.
Editor: W. T. COCKING, M.I.E.E. Technical Editor: Professor G. W. O. HOWE, D.Sc., LL.D., M.I.E.E.

Volume 30 · Number 5

CONTENTS

MAY 1953

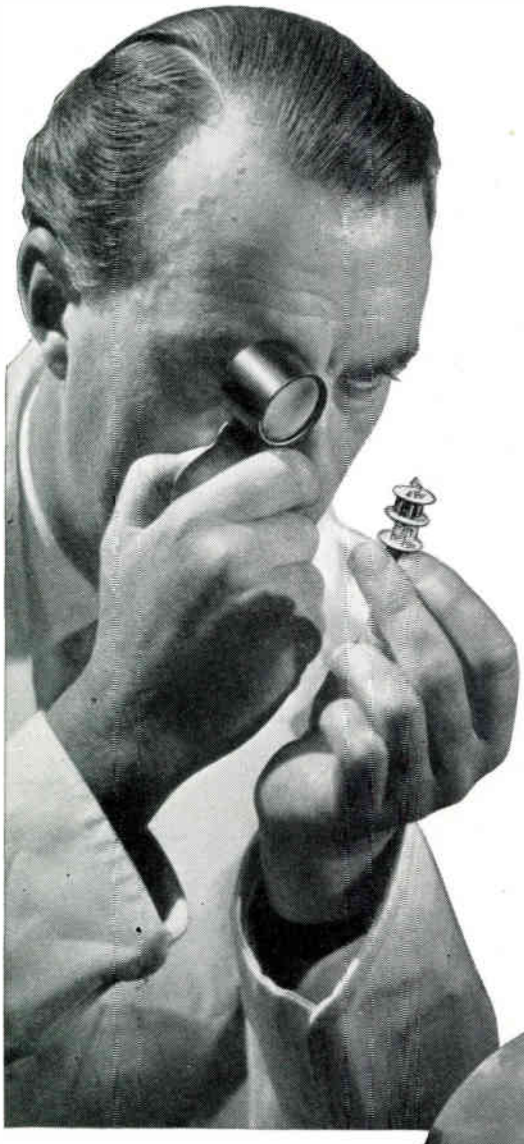
Published on the sixth of each month

Annual Subscription: Home and overseas, 1 year £2 4s. 6d.; 6 months £1 2s. 3d.; Canada and U.S.A. $7.00

Editorial, Advertising and Publishing Offices: Dorset House, Stamford Street, London, S.E.1
Telephone: Waterloo 3333 (60 *lines*) · *Telegrams: Wirenger, Sedist, London*

BRANCH OFFICES AT BIRMINGHAM · MANCHESTER AND GLASGOW

New mass production techniques will satisfy demand for communications and industrial valves with "Plus" qualities

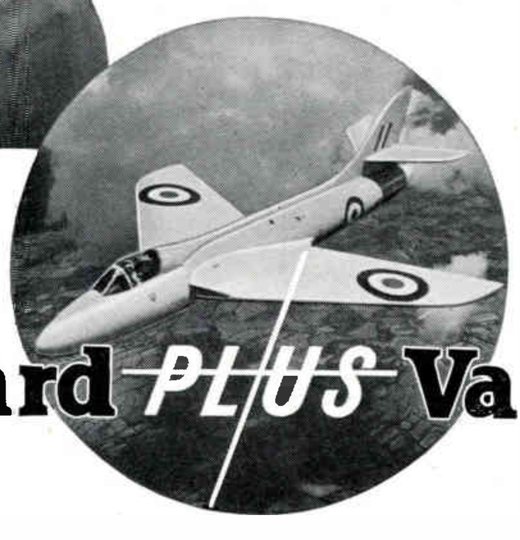


THE development of valves capable of withstanding severe operating conditions has occupied the attention of designers on both sides of the Atlantic for some years. Considerable progress has been made in strengthening or "ruggedising" electrode structures, but the mass production of such valves has presented serious difficulties.

There is a growing demand for these valves in military and industrial equipment, and the problem of producing them economically is, therefore, of major importance.

Mullard are solving the problem by a completely new approach to design techniques, manufacturing methods and personnel relations. New jigs and tools, new high speed machines, new testing apparatus, and new operator training systems have been devised. The results of the first stage of development are already exceeding expectations. In what is probably the most efficient electronic tube factory in the world, valves designed for use under exceptionally rigorous conditions are being manufactured by mass production methods. Mullard have designated these types "Plus" valves.

Although urgent defence requirements are absorbing all production at the moment, details of the first available 'Plus' valves can be obtained on request. All these types are plug-in replacements of corresponding valves of normal construction.



Mullard PLUS Valves

Mullard

MULLARD LTD., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

MVT124

WIRELESS ENGINEER

Vol. 30 MAY 1953 No. 5

Transmission-Line Formulae

In the treatment of transmission-line problems one finds the formulae expressed in several different ways, and we recently came across an article* setting out the three different forms of solution. They are called, respectively, the exponential, the conventional hyperbolic, and the completely hyperbolic solutions. The usual basic formulae are

$$-\frac{\delta V}{\delta z} = (R + j\omega L)I = ZI \text{ and}$$

$$-\frac{\delta I}{\delta z} = (G + j\omega C)V = YV$$

in which z is the distance measured from the sending end, and R, L, G and C are the values per unit length. Hence

$$\frac{\delta^2 V}{\delta z^2} = (ZY)V \text{ and } \frac{\delta^2 I}{\delta z^2} = (ZY)I$$

Putting $p = \alpha + j\beta = \sqrt{(R + j\omega L)(G + j\omega C)} = \sqrt{(ZY)}$ for the complex propagation constant, and $Z_c = \sqrt{(Z/Y)}$ for the characteristic impedance of the line, l for the total length, and V_0 for the voltage at the sending end, it can be shown that

$$I_z = \frac{V_0}{Z_c}\left[\frac{e^{-pz} + Ke^{-p(2l-z)}}{1 - Ke^{-2pl}}\right]$$

$$\text{and } V_z = V_0\left[\frac{e^{-pz} - Ke^{-p(2l-z)}}{1 - Ke^{-2pl}}\right]$$

in which the complex reflection coefficient $K = \frac{Z_c - Z_t}{Z_c + Z}$ where Z_t is the impedance of the termination or load. The input impedance of a line of length l terminated in an impedance Z_t is therefore obtained by putting $z = 0$ in the above formulae:

$$Z_{in} = \frac{V_0}{I_0} = Z_c\left[\frac{1 - Ke^{-2pl}}{1 + Ke^{-2pl}}\right]$$

On making $l = \infty$ or $Z_t = Z_c$ this reduces to $Z_{in} = Z_c$, K vanishes, and the formulae become $I_z = I_0e^{-pz}$ and $V_z = V_0e^{-pz}$. Although this special case is very simple, the above formulae are, generally speaking, very cumbersome, but the conventional hyperbolic formulae are just as complicated.

Putting x for the distance from the receiving end, so that $x = l - z$, the formulae for I_z and V_z may be written

$$I_z = \frac{V_0}{Z_c}\left[\frac{Z_t \sinh px + Z_c \cosh px}{Z_c \sinh pl + Z_t \cosh pl}\right]$$

$$V_z = V_0\left[\frac{Z_t \cosh px + Z_c \sinh px}{Z_c \sinh pl + Z_t \cosh pl}\right]$$

Putting $x = l$, the total length of the line, we obtain for the input impedance

$$Z_{in} = \frac{V_0}{I_0} = Z_c\left[\frac{Z_t \cosh pl + Z_c \sinh p}{Z_t \sinh pl + Z_c \cosh pl}\right]$$

As before, on making $l = \infty$ or $Z_t = Z_c$ this reduces to $Z_{in} = Z_c$.

In the completely hyperbolic form of solution the terminal impedance is expressed in terms of hyperbolic functions by putting $Z_t = Z_c \coth \theta$ and $\theta = \rho + j\Phi$. The above formulae for I and

* "Transmission Line Theory and its Applications," Ronald King, *Journal of Applied Physics* (American), Vol. 14, p. 577, 1943.

V become

$$I_z = \frac{V_0}{Z_c}\left[\frac{\coth\theta\sinh px + \cosh px}{\sinh pl + \coth\theta\cosh pl}\right]$$

$$= \frac{V_0}{Z_c}\left[\frac{\sinh(\theta + px)}{\cosh(\theta + pl)}\right]$$

$$V_z = V_0\left[\frac{\coth\theta\cosh px + \sinh px}{\sinh pl + \coth\theta\cosh pl}\right]$$

$$= V_0\left[\frac{\cosh(\theta + px)}{\cosh(\theta + pl)}\right]$$

At the sending end, putting $x = l$,

$$Z_{in} = Z_c\coth(\theta + pl)$$
$$= Z_c\coth[(\alpha l + \rho) + j(\beta l + \Phi)]$$

On comparing this last formula with the earlier formulae for Z_{in} it is seen that some simplification has been introduced, but at the expense of expressing Z_t/Z_c as a complex hyperbolic function.

Putting $A = \alpha l + \rho$ for the overall attenuation and $F = \beta l + \Phi$ for the overall phase shift,

$$Z_{in} = Z_c\coth(A + jF)$$

$$= Z_c\left[\frac{\cosh(A + jF)\sinh(A - jF)}{\sinh(A + jF)\sinh(A - jF)}\right]$$

$$= Z_c\left[\frac{\sinh 2A}{\cosh 2A - \cos 2F} - j\frac{\sin 2F}{\cosh 2A - \cos 2F}\right]$$

Putting $Z_c = \sqrt{(Z/Y)} = R_c(1 - j\phi)$ where R_c is the resistive component of Z_c, this may be written $Z_{in} = R_{in} + jX_{in}$ where

$$R_{in} = R_c\left[\frac{\sinh 2A - \phi\sin 2F}{\cosh 2A - \cos 2F}\right]$$

and $$X_{in} = -R_c\left[\frac{\sin 2F + \phi\sinh 2A}{\cosh 2A - \cos 2F}\right]$$

In the paper referred to, a number of curves are plotted showing the results obtained by means of these formulae applied to some actual lines. In most cases the terms involving ϕ are negligible.

To calculate A and F in terms of R, X, and ϕ the formulae may be written

$$A = \tfrac{1}{2}\tanh^{-1}\left[\frac{2R_c(R_{in} - \phi X_{in})}{(R_{in}^2 + X_{in}^2) + R_c^2(1 + \phi^2)}\right]$$

$$F = \tfrac{1}{2}\tan^{-1}\left[\frac{-2R_c(X_{in} + \phi R_{in})}{(R_{in}^2 + X_{in}^2) - R_c^2(1 + \phi^2)}\right]$$

Another line of approach is to put $Z_{in}/Z_c = r_{in} + jx_{in}$ in which r_{in} and x_{in} are dimensionless ratios. From the above formulae

$$r_{in} = \frac{\sinh 2A}{\cosh 2A - \cos 2F} = \frac{R_{in} - \phi X_{in}}{R_c(1 + \phi^2)}$$

and $$x_{in} = \frac{-\sin 2F}{\cosh 2A - \cos 2F} = \frac{X_{in} + \phi R_{in}}{R_c(1 + \phi^2)}$$

If one neglects ϕ, $r_{in} = R_{in}/R_c$ and $x_{in} = X_{in}/R_c$, but for greater accuracy

$R_{in} = R_c(r_{in} + \phi x_{in})$ and $X_{in} = R_c(x_{in} - \phi r_{in})$

By substituting r_{in} and x_{in} in the formulae for A and F one obtains

$$A = \tfrac{1}{2}\tanh^{-1}\left[\frac{2r_{in}}{r_{in}^2 + x_{in}^2 + 1}\right]$$

$$F = \tfrac{1}{2}\tan^{-1}\left[\frac{-2x_{in}}{r_{in}^2 + x_{in}^2 - 1}\right]$$

From these formulae it can be shown that the curves of constant A and those of constant F, when plotted to rectangular co-ordinates r_{in} and x_{in}, are families of circles from which one can read off the values of A and F corresponding to any given values of r_{in} and x_{in}. In the paper referred to such a circle diagram is plotted. If instead of impedance, resistance, and reactance, the problem is solved in terms of admittance, conductance, and susceptance, it is shown that the same circle diagram can be used, r and x being replaced by g and $-b$. This is more convenient when dealing with terminations in parallel.

Although we have put $A = \alpha l + \rho$ and $F = \beta l + \Phi$ and thus obtained the conditions at the sending end, the conditions at any point of the line are obtained by substituting the distance x from the receiving end for l.

Since writing the above we have found that in the recently published book "Radio and Radar Technique" by A. T. Starr, the subject is discussed very fully, and circle diagrams, both cartesian and polar, reproduced from H. P. Williams' "Antenna Theory and Design."

G. W. O. H.

IONOSPHERIC STORM-WARNING SERVICES

Assessment of Their Value

By C. M. Minnis, M.Sc., F.Inst.P.

(*Radio Research Station, Slough.*)

SUMMARY.—The comparison between forecast and actual ionospheric storminess over a period of time is usually presented in the form of a table containing one row and one column for each category into which days are divided. Even in the simplest case where only quiet and storm days are recognized, there is no agreed method of assessing the accuracy of a set of forecasts. Numerous empirical methods are in use which are intended to express the accuracy numerically, but these do not give consistent results.

An attempt is made to overcome these difficulties by assessing the accuracy of a set of forecasts in terms of their economic value within a communication system. Although the analysis is based on the assumption that only quiet and storm days exist, it could be extended to include more complicated subdivisions provided the principles involved are considered sound.

Introduction

THE extension of the network of ionospheric observatories during and since the war has resulted in a marked improvement in the accuracy with which ionospheric parameters can be forecast. Such forecasts refer only to normal undisturbed conditions, but attempts have also been made to forecast the onset of the abnormal conditions which frequently cause serious interruptions on radio-communication circuits. This is usually referred to as ionospheric-storm forecasting, and although it has been attempted in several countries the present state of knowledge of solar-terrestrial relations is not sufficiently advanced to ensure any great success.

The storm forecaster aims at giving a correct forecast for every day, but it is found in practice that the maximum possible accuracy over a period of a few weeks or more is never achieved. The fact that a particular set of forecasts falls short of complete accuracy is of course obvious, but there is at present no accepted way in which this deficiency can be measured. Until this becomes possible, forecasters will have no means of assessing the effect on their accuracy of changes in forecasting technique; nor will commercial and other organizations responsible for operating communication services be able to compare the relative merits of forecasts made by different methods.

The sole purpose of these notes is to discuss the value, in economic terms, of a storm-warning service to a radio-communication organization. The scientific basis on which forecasts of ionospheric storms are made is outside the scope of this discussion.

1. Terminology

The term 'ionospheric storm' has no precise meaning and it will be assumed here merely to denote any abnormal condition in the ionosphere which gives rise to the conditions known as 'disturbed', 'poor', or 'stormy' on those radio circuits which depend on ionospheric propagation. The organization responsible for the day-to-day operation of such a circuit will be referred to briefly as the 'user'.

'Storm days' and 'quiet days' will be defined as those on which the user experiences 'disturbed' and 'normal' conditions respectively on a particular set of circuits. It is assumed, for simplicity, that the user can classify each day as being either a storm day or a quiet day, and that the 'forecaster', who represents the storm-warning service, issues a forecast for the following day only in terms of one or other of these two classes.

It follows that each operating day for which a forecast is issued must fall into one of four categories; viz., quiet and storm days, each of which may be either correctly or incorrectly forecast. These categories can be conveniently represented by pairs of letters, the first of which denotes the type of forecast issued, and the second whether the day was in fact a quiet day or a storm day:—

QQ — Quiet day correctly forecast,
QS — Storm day forecast as quiet day,
SS — Storm day correctly forecast,
SQ — Quiet day forecast as storm day.

It will be convenient later to arrange these four categories in the form of a 2 × 2 table, the days in each cell of which can then be referred to by the appropriate pair of letters.

It is necessary to assume that the user, when he receives the forecast for the following day, makes appropriate technical and administrative arrangements, the nature of which will depend on whether a Q or an S forecast has been issued. These arrangements, which will be described as 'normal working' and 'storm working' respectively, would be designed to make the best use of normal

MS accepted by the Editor, July 1952.

conditions or to minimize the bad effects of a storm day as required. Unless a user is able to take some action appropriate to the forecast received, a storm-warning service cannot be of any use to him because his operations will be unaffected by the forecasts he receives.

TABLE 1

Forecast issued →		Quiet	Storm
Actual conditions	Quiet	QQ	SQ
	Storm	QS	SS

2. The 'Value' of a Communication System

In general, the maintenance of a storm-warning service entails considerable effort on the part of the forecasting staff. Also it is evident that action taken by the user on receiving incorrect forecasts will degrade the efficiency of his circuits. It is important, therefore, to devise some means of measuring the 'value' of the forecasts to the user and then to decide whether the value obtained is commensurate with the effort expended in operating the storm-warning service.

Before trying to assess the value of a set of forecasts to a user, it is necessary to enquire how the user measures the value of his operations. This is necessarily a matter of costing and economics which need not be discussed in detail, but it is reasonable to assume that a unit of value could be devised to suit each type of organization. (The word value will be spelt with a capital V when it is used to represent such units of Value.)

A broadcasting system might, for example, express the Value for a particular day in terms of hours of satisfactory reception multiplied by the area over which reception was satisfactory. On the other hand the Value of a high-speed telegraphy point-to-point system could probably be represented by the number of groups, excluding repetitions, actually received on a given day.

Once such a unit has been chosen, it should be possible to estimate the Value of a QQ day for a given circuit, the relatively smaller Value of a storm day even if it has been correctly forecast (SS day), and the even smaller Value of a storm day which was forecast as quiet (QS day). In the same way the reduction in the Value of a quiet day resulting from the unnecessary initiation of storm-working (SQ day) could be estimated.

The Valu s in absolute units of the four types of day need not be discussed any further. From now on, the Value of each type of day will be expressed as the ratio of its Value to that of a QQ day as in Table 2.

TABLE 2

Category of day	Value coefficient
QQ	1
SQ	α
SS	β
QS	γ

When the Value of a QQ day is taken as the standard, α, β, and γ must be less than unity. Their actual values for a particular organization will depend on how its operations are affected by ionospheric disturbances and they will therefore differ from one organization to another.

Consider now a period containing $(a+b+c+d)$ days during which a forecast was available for each day. The results of the forecasts are assumed to be as shown in Table 3 in which the number of days falling into each category is shown, together with the appropriate Value coefficient (in parenthesis).

TABLE 3

Forecast issued →		Quiet	Storm
Actual conditions	Quiet	a (1)	b (α)
	Storm	c (γ)	d (β)

The total Value (V) for the whole period may now be expressed as the sum of the number of days in each category multiplied by the appropriate Value coefficient. We have then:—

$$V = a + \alpha b + \beta d + \gamma c \quad (1)$$

Assuming that the values of α, β, γ are known, it is now possible to write down corresponding expressions for any other set of forecasts for the same period and thereby to compare the relative merits of competing forecasting services.

3. Operational Procedure when No Forecasts are Available

When a user does not receive ionospheric-storm forecasts, he is forced to decide for himself each day whether to arrange for storm working or normal working on the following day. Assuming that he does not attempt to make logical forecasts himself, he may adopt one of three rules, each of which is based on a simple assumption:

Rule A. The following day will always be quiet.

Rule B. The following day will always be stormy.

Rule C. The following day will always be the same as the preceding day.

If we now consider a period of N days containing S storm days, P periods of one or more consecutive storm days, and P periods of one or more consecutive quiet days, then the adoption of the three rules in turn will give respectively the results shown in Tables 4, 5, 6. The result of applying the rule is assumed to be the equivalent of issuing a forecast.

TABLE 4

RULE A

Forecast issued →		Quiet	Storm	Total
Actual conditions	Quiet	$N-S$	0	$N-S$
	Storm	S	0	S
	Total	N	0	N

TABLE 5

RULE B

Forecast issued →		Quiet	Storm	Total
Actual conditions	Quiet	0	$N-S$	$N-S$
	Storm	0	S	S
	Total	0	N	N

TABLE 6

RULE C

Forecast issued →		Quiet	Storm	Total
Actual conditions	Quiet	$N-S-P$	P	$N-S$
	Storm	P	$S-P$	S
	Total	$N-S$	S	N

The Values V_A, V_B, V_C corresponding to the adoption of the three rules may then be written down by inserting the appropriate values of a, b, c, d (Table 3) in equation (1). We have then:—

$$V_A = N - S(1-\gamma) \quad \ldots \quad (2)$$

$$V_B = N - S(\alpha - \beta) \quad \ldots \quad (3)$$

$$V_C = N - S(1-\beta) - P(1 - \alpha + \beta - \gamma) \quad (4)$$

If a user, who has been using Rule C, for example, receives storm forecasts and acts accordingly over a reasonable period, he will be in a position to compute the Value (V_X) of his operations during the period and also the Value (V_C) which would have obtained had no forecasts been available. The difference ($V_X - V_C$) is then a measure of the increase or decrease in Value of the operations which has accrued as a result of taking appropriate action on the receipt of the forecasts.

Before proceeding further, it is worth inquiring which of the rules is the best one to use when no storm forecasts are available; i.e., which rule gives the greatest value for V. It is easily shown that:—

$$V_A > V_B \text{ when } S/N < K/(1+K) \quad \ldots \quad (5)$$

$$V_C > V_A \text{ when } S/P > (1+K) \quad \ldots \quad (6)$$

$$V_C > V_B \text{ when } Q/P > (1+K)/K \quad \ldots \quad (7)$$

$$\text{where } K = (1-\alpha)/(\beta-\gamma)$$

$$Q = (N-S)$$

The parameter K reflects the changes in efficiency of a communication circuit resulting from the effects of ionospheric disturbances and of going over from normal to storm working. It must be emphasized that, within a given organization, K will not necessarily have the same value for all circuits. Its magnitude will depend not only on the type of service operated but also on the locality of the terminal points.

Although numerical values cannot at present be assigned to α, β, γ, it is obvious that K must lie between 0 and 1. Once the value of K has been determined, the three inequalities can be used to find the magnitudes of V_A, V_B, V_C for typical values of S/N, S/P, Q/P and hence to show which rule is best under the condition represented by these values.

A graphical method of finding the best rule to adopt is described in the Appendix.

4. Figures of Merit for a Set of Forecasts

We shall now return to the period of N days of which S were storm days, and which contained P storm periods and P quiet periods. If a perfect set of forecasts had been available, the days would have been distributed among the various categories as shown in Table 7.

TABLE 7

Forecast issued →		Quiet	Storm	Total
Actual conditions	Quiet	$N-S$	0	$N-S$
	Storm	0	S	S
	Total	$N-S$	S	N

Let us suppose that in an actual set of forecasts for this period, only x of the S storm days were correctly forecast while y days, forecast as storm days, were in fact quiet (Table 8).

TABLE 8

Forecast issued →		Quiet	Storm	Total
Actual conditions	Quiet	$N-S-y$	y	$N-S$
	Storm	$S-x$	x	S
	Total	$N-x-y$	$x+y$	N

It is now desired to derive some figure of merit which expresses the value of this set of forecasts to a user. Numerous indices of this type have been used, all of which have the desirable common property of being equal to unity when applied to the perfect set of forecasts of Table 7. Those most commonly used have been:—

$$I_1 = x/S \qquad I_2 = 1 - [y/(N-S)]$$

$$I_4 = x/S - y/(N-S) \qquad I_3 = (N-S-y+x)/N$$

$$I_5 = x/S - y/S$$

I_1 and I_2 merely represent respectively the fractions of storm days and quiet days correctly forecast. While for a perfect set of forecasts I_1 and I_2 both equal unity, I_1 also equals unity if a storm forecast is issued for every day. Similarly, if a quiet forecast is issued every day I_2 attains its maximum value of 1.

The Index I_3 is intended to overcome this defect since it takes into account both x and y. In practice, however, $(N - S - y)$ is usually much greater than x, and I_3 is not sufficiently sensitive to changes in x to be a reliable index.

The empirical expressions I_4, I_5 have been designed to strike a balance between the desirability of having a large value for x and the undesirability of large values of y. Both appear to give roughly equal numerical values for conditions in W. Europe, except when $(x - y)$ is small: I_5 then approaches zero at a rate which is obviously too great and it may even become negative.

So long as figures of merit are expressed in terms of empirical expressions of this kind, it will be impossible to obtain agreement on their relative merits. For this reason it is suggested that they should be derived, not empirically, but in terms of the units of Value discussed earlier.

Let us consider a period during which storm forecasts were issued which resulted in the operations of a communications organization having Value $= V_X$. If no forecasts had been available, the user would have used one of the three rules and this would have resulted in Value $= V_M$ for the period. The difference $(V_X - V_M)$ represents the increase or decrease in Value resulting from making use of the forecasts.

If for this same period a perfect set of forecasts had been available, a Value V_P would have been attained and the difference $(V_P - V_M)$ represents the maximum possible increase in Value which the user could expect. It seems logical, therefore, to use the ratio:—

$$M = (V_X - V_M)/(V_P - V_M)$$

as the figure of merit for a set of forecasts. This parameter has the following advantages:—

(*a*) $M = 1$ for a perfect set of forecasts.

(*b*) $M = 0$ if the forecasts actually received do not result in any increase in Value as compared with the adoption of the appropriate rule.

(*c*) M is negative when the actual forecasts lead to a fall in Value as compared to the use of the rule.

(*d*) Changes in M are proportional to changes in Value, in economic terms, of the forecasts to the user.

An important consequence of (*d*) is that the forecaster can measure, in terms of M, the effect of changing his forecasting methods. He might find, for example, that certain improvements in his technique involving considerable effort on his part resulted in such a small increase in M that the additional effort was not justified. It might also be found that with present-day forecasting methods M is so nearly equal to zero that the effort spent in attempting to forecast ionospheric storms is not worth while commercially.

Fisher's χ^2 test can, of course, be used to find the probability of the actual forecast results having arisen by chance. However, neither χ^2 nor the probability are satisfactory measures of the value of the forecasts to a user because they change rapidly even when x (Table 8) changes by such a small amount that the value of the forecasts is unlikely to have been materially altered.

5. Full Expressions for M

The form of the full expression for M depends on which rule would have been used had no forecasts been available; i.e., on whether $V_M = V_A$, V_B or V_C. The expressions for these quantities have been given earlier [equations (2), (3), (4)]. The corresponding expressions for V_X and V_P are:—

$$V_P = N - S(1 - \beta)$$

$$V_X = N + x(\beta - \gamma) - y(1 - \alpha) - S(1 - \gamma)$$

Substituting these values in the expression for M we find:—

Rule A

$$M_A = x/S - Ky/S$$

Rule B

$$M_B = 1 - [(1/K)\{1-(x/S)\} + (y/S)]/[(N/S)-1]$$

Rule C

$$M_C = 1 - [\{(S-x)/P\} + (Ky/P)]/(1+K)$$

There is a striking similarity between the expression for M_A and the empirical figure of merit, I_5, mentioned earlier. In fact when $K = 1$, $I_5 \equiv M_A$, but such a high value for K would represent very unrealistic conditions. If, as seems likely, $K = 0{\cdot}5$ approximately, the numerical values of I_5 and M_A will be quite different.

6. Conclusions

The so-called 'accuracy' of a set of ionospheric-storm forecasts is sometimes expressed as the percentage of storm days for which correct forecasts were issued. This simple figure is unreliable because it fails to discount the number of quiet days for which a storm warning was issued. To overcome such disadvantages, various empirical expressions have been devised which are intended to give a truer picture of the value of the forecasts, but no agreement has been reached on their relative merits.

A more logical approach to the problem is required and it is suggested that the usefulness of a set of forecasts might be measured in terms of units describing the economic value of a communication system. Using such units, a figure of merit is derived which measures the increase in economic value resulting from the use of a set of storm forecasts and which has a value of unity for a perfect set.

The figure of merit includes a constant which describes the effects of ionospheric disturbances on a communication system. This constant also depends on the type of system operated and on the geographical location of the circuit; its numerical value can best be determined by those responsible for the operation of the circuits in question.

Acknowledgments

The author is indebted to Mr. K. S. W. Maunder, of the Joint Radio Propagation Bureau, for valuable discussion and criticism.

The work described above was carried out as part of the programme of the Radio Research Board. This paper is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

APPENDIX

1. *The Best Rule to Use*

In Section 3 three rules were defined, one of which would be used if no storm forecasts were available. The Values V_A, V_B and V_C which result respectively from the use of these rules are given by equations (2), (3) and (4). Under a particular set of actual conditions, the rule giving the greatest value for V is the best one to use. This can be determined by making use of the three inequalities [equations (5), (6) and (7)]; viz.,

$$V_A > V_B \text{ when } S/N < K/(1+K) \quad .. \quad .. \quad (5)$$

$$V_C > V_A \text{ when } S/P > (1+K) \quad .. \quad .. \quad (6)$$

$$V_C > V_B \text{ when } Q/P > (1+K)/K \quad .. \quad .. \quad (7)$$

where

S = number of storm days in the period
$Q = (N - S)$ = number of quiet days in the period
N = total number of days in the period
P = number of storm periods or quiet periods of one or more consecutive days
$K = (1 - \alpha)/(\beta - \gamma)$

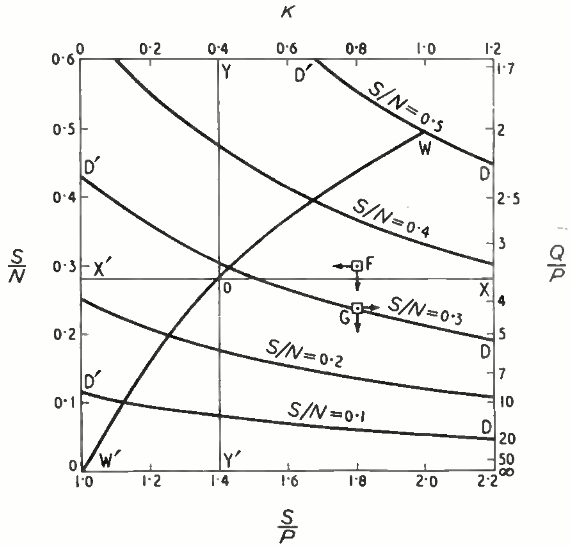


Fig. 1.—*Diagram for finding the best rule to use when no storm forecasts are available. Equation of WW′:* $\dfrac{S}{N} = \dfrac{K}{1+K}$ *; equation of DD′ :* $\dfrac{Q}{P} = \dfrac{S/N}{(1 - S/N)S/P}$.

2. *Construction of Diagram (General Case)*

The relative magnitude of V_A, V_B, V_C for a given set of values of S, N, P, K can be found by using the diagram (Fig. 1) which has been constructed in the following way:—

A. The S/P and K scales are such that $S/P = (1 + K)$ [equation (6)].

B. The Q/P and S/N scales are such that $Q/P = N/S$ [equations (5) and (7)].

C. The curve WW′ expresses the relation $S/N = K/(1+K)$ [equation (5)].

D. The family of curves DD′ express the relation $Q/P = (S/P)\ [1 - (S/N)\ ]/(S/N)$ [equations (5), (6) and (7)].

3. *Construction of Diagram (Particular Case)*

The preceding construction is quite general, but what follows depends on the particular value of K appropriate to the circuits under consideration. The procedure will be illustrated by assuming that $K = 0{\cdot}4$, but a similar construction would be used for any other value of K.

E. Draw the ordinate YY′ through $K = 0{\cdot}4$. On account of Construction A and equation (6), YY′ must represent the condition $V_C = V_A$. The areas on the right and left of YY′ will then represent $V_C \neq V_A$.

F. Draw the abscissa XOX′ passing through the intersection (O) of YY′ and WW′. XX′ represents the condition $V_A = V_B$ on account of Construction C and equation (5), and the areas above and below it the condition $V_A \neq V_B$. Construction B and equations (5) and (7) imply that XX′ also represents the condition $V_B = V_C$.

4. *Procedure for Using Diagram*

Let us suppose that during a period of 60 days there were 18 storm days and 10 storm periods; i.e., $N = 60$, $S = 18$, $P = 10$. Hence $S/P = 1{\cdot}8$, $S/N = 0{\cdot}3$. The value of Q/P corresponding to these values of S/P and S/N can be read off the curve DD′ marked $S/N = 0{\cdot}3$ and is found to be $4{\cdot}2$.

Plot the point F (S/P, S/N) and the point G (S/P, Q/P) using the appropriate scales and note into which of the quadrants formed by XX′ and YY′ the points fall. For the numerical values given above, it is found that F lies in the 1st and G in the 4th quadrant, assuming that the quadrants are numbered in the conventional manner with 0 as origin.

The diagram has been constructed in such a way that the relative magnitudes of V_A, V_B and V_C can be deduced from the quadrants into which F and G fall. When F falls in the 2nd or 4th quadrants the relation can be deduced immediately. If it falls in the 1st or 3rd quadrants, there is an ambiguity which cannot be resolved unless G is also taken into account.

TABLE 9

Quadrant containing		Order of Merit of Rules		
F	G	1	2	3
1st	1st	B	C	A
1st	4th	C	B	A
2nd	2nd, 3rd	B	A	C
3rd	2nd	A	B	C
3rd	3rd	A	C	B
4th	1st, 4th	C	A	B

Point F is (S/P, S/N)
Point G is (S/P, Q/P)

Table 9 gives the order of merit of the three rules as determined by the positions of the points F and G. For the particular case just quoted it will be seen that, since F and G fell into the 1st and 4th quadrants respectively, the best rule to use would be Rule C and, the worst, Rule A.

POWER GAIN OF CURTAIN ARRAYS OF AERIALS

By P. Hammond, M.A., A.M.I.E.E.

University of Cambridge, Department of Engineering.)

By a curtain array of aerials is meant a flat grating of similar, parallel and equally-spaced wires. Its purpose is to restrict the radiation into a comparatively narrow beam centred on the normal to the curtain. This results in a considerable saving of power compared with the use of an omnidirectional aerial and it is common to use the term 'power gain' in connection with this saving.

Provided the beam is to be centred on the normal to the curtain then every effort is made to feed its members with currents which are all co-phased with one another. The process of calculating the polar diagram (or diffraction pattern) for any set of co-phased currents is well known. It is common practice, though not invariable, to arrange that all members of the curtain array carry equal currents. We shall restrict our attention here to this uniform loading and, initially, to the diffraction pattern in the equatorial plane.

Our initial problem is to examine how this diffraction pattern changes with the spacing between the members of a curtain having a given total number of aerials and to discover the optimum spacing from the point of view of power gain, in so far as this can be inferred from the equatorial pattern.

MS accepted by the Editor, October 1952

First consider the problem in very general terms. Let Fig. 1 typify a curtain array and consider the field on bearing θ from the normal. The path difference between the component fields due to two successive members is CE = CD $\sin\theta$. If CE is a whole number of wavelengths then these two components will be co-phased, and in such circumstances the field of the whole curtain on bearing θ will be equal to the field on bearing zero. Then the polar diagram of a four-member curtain will have at least six beams of equal intensity. But the purpose of the curtain is to produce only two beams of equal intensity.

Now CE cannot equal a whole number of wavelengths unless CD exceeds one wavelength. If CD = λ the polar diagram will consist of four beams of equal intensity and will resemble a cross. It now follows that the optimum value of CD is less than λ. A common value is $\frac{1}{2}\lambda$ and we wish to discover whether there is an optimum spacing somewhere between $\frac{1}{2}\lambda$ and λ.

One method of procedure would be to plot a succession of diffraction patterns for various values of CD for curtains having different numbers of members. These families of curves could then be

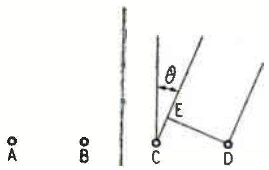


Fig. 1. *General form of curtain array.*

replotted to show the square of the relative field strength, in the equatorial plane, as a function of bearing angle and we could then evaluate $\int_0^{\frac{\pi}{2}} E_\theta^2 \, d\theta$ by graphical integration. The power gain, in respect of the equatorial pattern, could then be defined as the ratio $E_0^2 \frac{\pi}{2} \Big/ \int_0^{\frac{\pi}{2}} E_\theta^2 d\theta$.

But this ratio can be arrived at by a shorter, simpler and more elegant method and, moreover, one which discloses the fraction of the total output contributed by each member of the curtain. The method proposed is that of working out the radiation resistance of each of the aerials of the curtain array and thus arriving at the total radiated power output of the curtain.

Power Gain of Curtains of very Long Filaments

Brief consideration will show that the pattern in the equatorial plane is independent of the height of the curtain. This pattern will be the same whether the curtain consists of a row of doublets or of members many wavelengths high. A very convenient method of attack will therefore be to consider first the field due to an infinitely long filament carrying a current $I \sin pt$. By symmetry the magnetic field will be arranged in circles centred on the filament and the electric field will everywhere be parallel to the wire. Applying Maxwell's equations we find that the electric force E is given by the equation

$$\frac{d^2E}{dr^2} + \frac{1}{r}\frac{dE}{dr} + a^2E = 0, \text{ where } a = \frac{2\pi}{\lambda}$$

It can be shown[1] that the solution of this equation for the case of the filament is given by

$$\frac{cE}{a\pi I} = - J_0(ar) + j\, Y_0(ar)$$

where $J_0(ar)$ and $Y_0(ar)$ are Bessel functions of zero order and of the first and second kinds respectively.

The real term of this expression gives the in-phase component of electric force. In the case of a curtain of infinite filaments this in-phase component can therefore be found anywhere by a summation of the terms involving $J_0(ar)$. In particular it is possible to find the in-phase component of electric force at the surface of a filament and thus the output of work per unit length of any filament can be calculated. If it is preferred this output can then be expressed in terms of radiation resistance per unit length of aerial.

The simple example of the case of two similar filaments separated by a distance R will illustrate the method. The in-phase component of force at either filament is given by

$$\frac{cE}{a\pi I} = - [J_0(0) + J_0(aR)] = - [1 + J_0(aR)]$$

The rate of working per unit length is therefore:

$$EI = \frac{a\pi}{c}[1 + J_0(aR)]\, I^2$$

Since I is the maximum current, the radiation resistance per unit length is given by

$$2\frac{a\pi}{c}[1 + J_0(aR)].$$

$J_0(aR)$ is an oscillatory function and therefore its

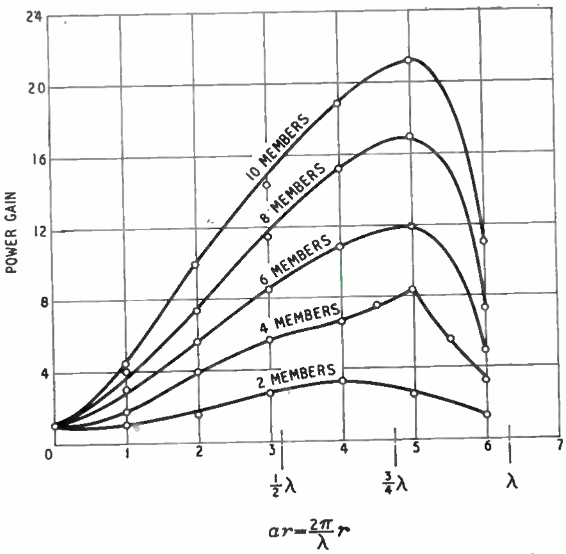


Fig. 2. *Power gain of curtain of long filaments relative to single filament.*

value can be positive or negative according to the magnitude of aR. Hence the power radiated from either filament can be more or less than the power radiated from a single isolated filament. It will be seen that the power gain of such a pair of filaments is given by the formula P.G. $= \dfrac{4}{2[1 + J_0(aR)]}$. This is a maximum whenever $J_0(aR)$ is a minimum. The same result would be obtained by plotting the diffraction pattern for various distances between the filaments and evaluating its mean-square ordinate. But it is much simpler to obtain the result by means of the formula involving $J_0(aR)$. It is the extension of this method that we shall use here.

[1] E. B. Moullin, "Radio Aerials", Section 1.7. (*Oxford University Press*).

Fig. 2 shows the power gain of curtain arrays of equally-spaced very long current filaments carrying co-phased current plotted against the distance between individual members. (To simplify calculation the power gain is worked out for integral values of ar where r is the distance between the members and $a = 2\pi/\lambda$, thus when $ar = \pi$, $r = \lambda/2$). It will be seen that the power gain reaches a blunt maximum when the spacing is about $\frac{3}{4}\lambda$ and that it is then almost 50% larger than at the usually employed spacing of $\frac{1}{2}\lambda$. Above the $\frac{3}{4}\lambda$ spacing the power gain falls fairly rapidly and this is of course to be expected because, as mentioned above, the polar diagram will become cruciform with λ spacing.

Fig. 3 shows various diffraction patterns in the equatorial plane for a 4-member curtain array.

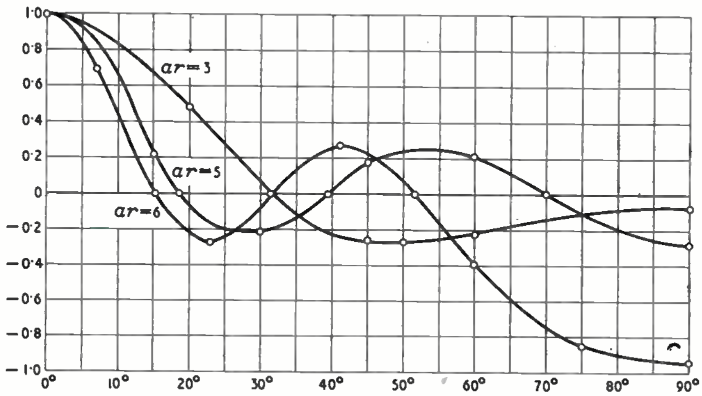


Fig. 3. *Diffraction pattern on equatorial plane of 4-member array with various spacings.*

If it is remembered that the power gain depends on the area under a curve obtained by squaring the ordinates of the diffraction pattern, then the reason for the shape of the power gain curve is evident. In the region between $ar = 3$ and $ar = 5$ $\left(\frac{\lambda}{2} \text{ to } \frac{3\lambda}{4} \text{ approx.}\right)$ the gain is increased by the narrowing of the main beam. In this range the side lobes do not dissipate much power, but as the spacing is still further increased and approaches λ the side lobes are increased enormously, and the gain is consequently reduced. Fig. 4 shows the further narrowing of the beam as the number of members in the curtain is increased.

It is important to realise that the output per unit length is not the same in all members. Tables 1 and 2 show the radiation resistance per unit length, relative to an isolated filament, for the various members of a 4- and of a 10-member curtain respectively at a spacing of $ar = 5$.

TABLE 1

Number of member	1	2	3	4
Relative resistance	0·56	0·4	0·4	0·56

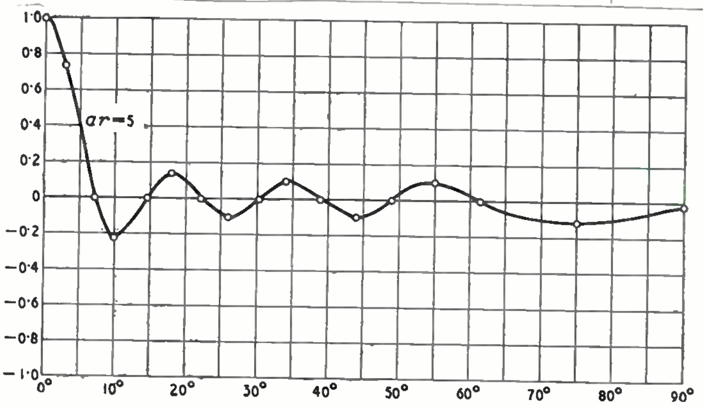


Fig. 4. *Diffraction pattern of 10-member curtain array on equatorial plane; spacing* $r = 5\lambda/2\pi$.

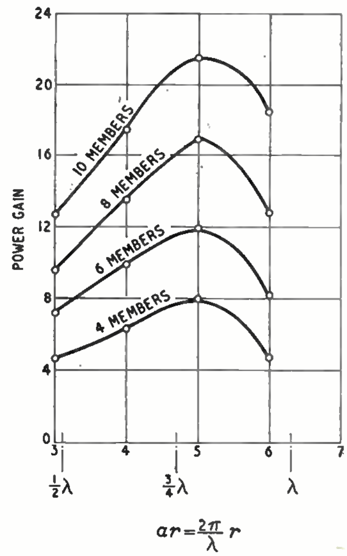


Fig. 5. *Power gain of curtain of half-wave aerials relative to single half-wave aerial.*

TABLE 2

Number of member	1	2	3	4	5
Relative resistance	0·8	0·51	0·19	0·3	0·55
Number of member	6	7	8	9	10
Relative resistance	0·55	0·3	0·19	0·51	0·8

Power Gain of Curtains of Finite Height

So far we have concerned ourselves only with the power gain in so far as it is disclosed by the equatorial pattern. The question naturally arises as to how far the advantage of a spacing of about $\frac{3}{4}\lambda$ applies to curtains of finite height when the basis of comparison is the true gain of power reckoned with respect to a single isolated half-wave aerial.

Fig. 5 shows the power gain[2] for curtains of half-wave aerials for spacings of approximately $\lambda/2$ to λ. It is seen that the curves of Fig. 2 and Fig. 5 agree closely. Since the diffraction patterns in the equatorial plane must be the same for all curtains regardless of the length of the aerial members, any disagreements must be due to the difference between diffraction patterns in other planes. Thus at a spacing of λ it is clear that at an elevation of 60° the path difference in the plane of the curtain will be $\lambda/2$ for the half-wave aerials and there will be no radiation on this bearing. The power gain will therefore tend to be larger than that for infinite filaments spaced at λ. That this is indeed the case will be seen by comparing Fig. 2 with Fig. 5.

But these disagreements are slight and it is clear that the adoption of $\frac{3}{4}\lambda$ spacing would also increase the power gain of half-wave aerials by a very appreciable amount (about 50%).

We must now consider the effect of construc ing the aerial curtain of several half-wave members in line as well as side by side. Clearly we shall expect the lobes at different elevations from the equatorial plane to be considerably reduced. Fig. 6 shows diffraction patterns of 4 high by 6 wide curtains at various angles of elevation. These curves should be compared with Fig. 7 which shows patterns at the same angles for a curtain of single half-wave aerials.

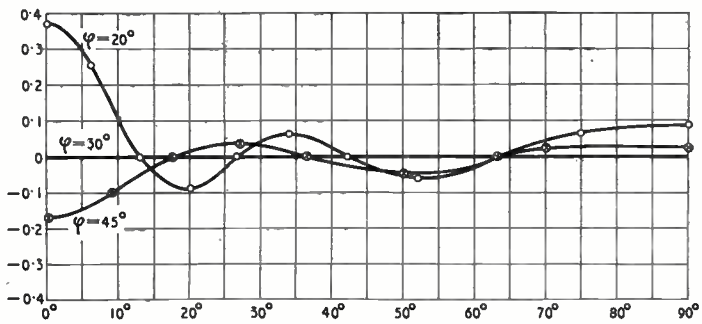


Fig. 6. *Diffraction pattern of 4-high 6-wide array at different elevations; spacing* $= 5\lambda/2\pi$.

It would be very tedious to obtain the power gain from an integration over a 'Poynting' sphere. It is again far more convenient to consider the radiation resistances of the individual members. It can be shown (Section 2.19 of Ref. 1.) that the average radiation resistance of an in-line succession of half-wave aerials approaches very rapidly to the radiation resistance per half-wave-length of an infinite filament of the same average current loading. This is true within 10% even for as few as 3 half-wave aerials in line. The problem of the high and wide curtain can then be treated as the problem of a grating of infinite filaments (loc. cit., Section 1.19). The radiation resistances and hence the power gain can then be calculated. As would be expected it is found that the gain with a spacing of $\frac{3}{4}\lambda$ is of the order of $1\frac{1}{2}$ times that with a spacing of $\frac{1}{2}\lambda$.

Our method has therefore disclosed the considerable saving that is possible (wherever practical considerations such as methods of feeding permit) by a wider spacing than that normally adopted. It has also shown that, while the diffraction patterns of aerial arrays give a useful general indication of the power gain to be expected, a more direct approach can be made by using the concept of radiation resistance.

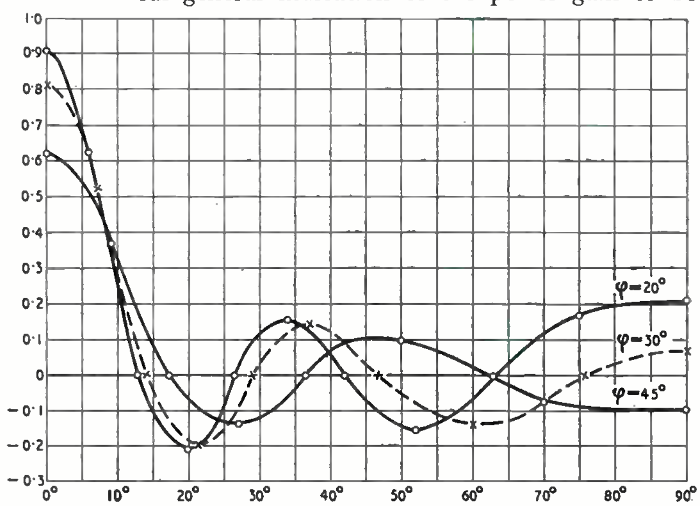


Fig. 7. *Diffraction pattern of 1-high 6-wide array at different elevations; spacing* $r = 5\lambda/2\pi$.

The calculations have been made by the method used in Sections 2.11–2.16 of Ref. 1.

Acknowledgment

Acknowledgment is due to Professor E. B. Moullin for his advice and encouragement.

SPECTRUM EQUALIZATION

Use of Differentiating and Integrating Circuits

By G. G. Gouriet, A.M.I.E.E.

(Engineering Research Department, B.B.C.)

SUMMARY.—It is shown that the transfer characteristics of nearly all forms of linear four-terminal network may be equalized by adding to the response successive derivatives or integrals with respect to time. The method offers considerable flexibility in that amplitude and phase are both equalized by a characteristic which is continuously variable. It is shown that the method may be applied to transmission systems which are linear, but for which the equivalent four-terminal passive network is non-realizable; for example, a scanning aperture. The application of the method to servo-control and television is discussed.

1. Introduction

THE attenuation and phase characteristics of all electrical transmission circuits are inevitably functions of frequency, since stray reactive elements are present in even the simplest of circuits. The distortion which results from this cause is normally referred to as 'frequency distortion' as distinct from 'amplitude distortion,' which exists when non-linear elements are present.

In telephony and sound broadcasting a transmission circuit is usually considered to be equalized if correction is introduced to render the attenuation constant over the transmission band; the phase characteristic is not considered to be of great importance. In some forms of communication, however, dispersion (i.e., variation of group-delay) must be avoided and the meaning of equalization must be broadened to include correction of the phase characteristic. The term 'spectrum equalization' has been chosen because it is the complex spectrum which must be equalized and not merely its modulus.

In this article we are concerned with the general case of any linear system for which an *excitation* gives rise to a *response*. The steady-state behaviour of such a system is described by the transfer characteristic which will, in general, be a complex function of frequency, and not necessarily dimensionless. For example, the transfer characteristic of a photo-electric cell may be expressed in amps/lumen, while the characteristic of an electro-mechanical system may have such dimensions as radians/volt. Whatever the dimensions, the transfer characteristic may, however, always be normalized to give a dimensionless function of frequency, which we shall refer to here as the transfer function, and this will have the form,

$$\phi(\omega) = P(\omega) + j\,Q(\omega)$$

It is obvious that an ideal equalizer would have the reciprocal characteristic,

MS accepted by the Editor, February 1953

$$\frac{1}{\phi(\omega)} = \frac{1}{P(\omega) + j\,Q(\omega)}$$

which would produce an overall transfer factor of unity, or some other real number.

In practice, time-delay, which is inherent in the process of transmission, will make it impossible to achieve such ideal equalization, even within a restricted bandwidth. This is unimportant, however, except for closed-loop systems, and for normal communication purposes it is sufficient if the excitation and response are of similar form. By 'similar form' is meant that for an excitation $f(t)$ we may at best expect a response $K\,f(t-\tau)$ where K is a real constant and $f(t-\tau)$ is understood to exist for $t \geqslant \tau$. The question of time delay will be discussed in more detail later, but neglecting this for the present, it is nevertheless true that to produce the reciprocal function $1/\phi(\omega)$ with passive elements may prove extremely difficult and even impossible.

This article describes a means of producing the desired equalizing characteristic by adding to the response function its successive derivatives or integrals with respect to time, with appropriate adjustment of the amplitudes and signs. The method may be regarded as making use of *time* operators rather than the *frequency* operators which are involved in the more conventional approach, and has the advantage of considerable flexibility in that the characteristics of non-realizable as well as realizable passive networks may be produced. In a recent paper by Linke[1], a variable time-equalizer is described which operates by introducing into the response function 'echoes' at prescribed time intervals. This procedure would appear to be eminently suitable for equalizing wideband links. The method proposed here is probably most suitable for equalizing the transfer characteristics of terminal equipment rather than the characteristic of actual cable circuits. Further experience will, however, be required before definite conclusions can be reached.

2. Theory of Method

2.1. *Theorems*

We shall commence by stating two theorems which are implicit in the operational calculus of Heaviside, although hitherto they do not appear to have been stated explicitly.

(a) If the normalized transfer function of any linear system, expressed in terms of the variable $p = j\omega$, can be expanded as

$$\phi_L(p) = \frac{1}{a_0 + a_1 p + a_2 p^2 + \ldots . a_n p^n} \quad \ldots \quad (1)$$

where the coefficients $a_1, a_2 \ldots a_n$ are real, and $f(t)$ is the response of the system to an excitation $F(t)$, then:—

$$\left[a_0 + a_1 \frac{d}{dt} + a_2 \frac{d^2}{dt^2} + \ldots . a_n \frac{d^n}{dt^n}\right] f(t) = F(t) \quad (2)$$

(b) If the transfer function as above is such as to permit of the expansion

$$\phi_H(p) = \frac{1}{b_0 + \frac{b_1}{p} + \frac{b^2}{p^2} + \ldots . \frac{b_n}{p^n}} \quad \ldots \quad \ldots \quad (3)$$

then:—

$$\left[b_0 + b_1 \int^{(1)} dt + b_2 \int^{(2)} dt^2 + \ldots . b^n \int^{(n)} dt^n\right] f(t)$$

$$= F(t) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

where $\int^{(r)} dt^r = \int_0^t \int_0^t \ldots . \int_0^t dt^r$

The implications are apparent; the transfer function $\phi_L(p)$ in (1) has the general form of a low-pass characteristic and (2) shows that this may be equalized by adding to the response its successive derivatives with respect to time using the coefficients of p in (1).

Similarly, $\phi_H(p)$ in (3) is a high-pass characteristic, which, according to (4) may be equalized by adding to the response the successive time-integrals with the appropriate coefficients. The significance of the inferior limit of integration in (4) is simply that in equalizing a high-pass system we cannot hope to reinstate the constant, which would correspond with the d.c. term of an electrical waveform. Without the inferior limit this would appear as an unknown constant of integration.

Band-pass and band-stop characteristics will obviously be dealt with by combinations of both operations, but these are less likely to be of interest in practice.

The formal proof of these two theorems may be given as follows:

If 'unit impulse' defined as

$$\delta(t) = \frac{1}{2\pi j} \int_{c - j\infty}^{c + j\infty} e^{pt}\, dp \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

is applied to any linear system which has a transfer function $\phi(p)$ we may write for the excitation and response respectively

$$F(t) = \delta(t) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

and $$f(t) = \frac{1}{2\pi j} \int_{c - j\infty}^{c + j\infty} e^{pt} \phi(p)\, dp \quad \ldots \quad \ldots \quad (7)$$

Since for any practical system this integral will converge, we may differentiate under the integral sign with respect to time, and write

$$a_1 \frac{df(t)}{dt} = \frac{a_1}{2\pi j} \int_{c - j\infty}^{c + j\infty} p\, e^{pt} \phi(p)\, dp \quad \ldots \quad (8)$$

$$a_2 \frac{d^2 f(t)}{dt^2} = \frac{a_2}{2\pi j} \int_{c - j\infty}^{c + j\infty} p^2 e^{pt} \phi(p)\, dp \quad \ldots \quad (9)$$

$$a_n \frac{d^n f(t)}{dt^n} = \frac{a_n}{2\pi j} \int_{c - j\infty}^{c + j\infty} p^n e^{pt} \phi(p)\, dp \quad \ldots \quad (10)$$

Adding the derivatives to the response $f(t)$ multiplied by a constant, a_0, gives

$$\left[a_0 f(t) + a_1 \frac{df(t)}{dt} + a_2 \frac{d^2 f(t)}{dt^2} \ldots a_n \frac{d^n f(t)}{dt^n}\right]$$

$$= \frac{1}{2\pi j} \int_{c - j\infty}^{c + j\infty} e^{pt} \phi(p) \left[a_0 + a_1 p + a_2 p^2 + \ldots a_n p^n\right] dp$$

$$\ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

If $$\phi(p) = \frac{1}{a_0 + a_1 p + a_2 p^2 + \ldots a_n p^n} \quad (12)$$

then $$\left[a_0 f(t) + a_1 \frac{df(t)}{dt} + a_2 \frac{d^2 f(t)}{dt^2} \ldots a_n \frac{d^n f(t)}{dt^n}\right]$$

$$= \frac{1}{2\pi j} \int_{c - j\infty}^{c + j\infty} e^{pt} dp = F(t) \quad \ldots \quad \ldots \quad (13)$$

and the modified response is thus identical to the excitation. This is true for unit-impulse excitation and must also be true for any other excitation since the overall system is linear.

The proof of the second theorem is furnished by a similar procedure, except that integration of $f(t)$ is performed in place of differentiation.

2.2 *Real and Imaginary Parts of $\phi(p)$*

It has been shown that all transfer functions which permit of the finite expansions given in (1) and (3) may be equalized by adding to the response function time-derivatives or time-integrals respectively.

For the present we shall be concerned with the equalization of the low-pass characteristic expressed in (1) since in practice this is more likely to be of interest. For the equalizing characteristic we have,

$$\Psi(p) = a_0 + a_1 p + a_2 p^2 + \ldots a_n p^n \ldots \quad (14)$$

Substituting $j\omega$ for p and expressing (14) in the form

$$\Psi(\omega) = P(\omega) + j\,Q(\omega) \quad \ldots \quad (15)$$

we see that

$$P(\omega) = 1 - a_2\,\omega^2 + a_4\,\omega^4 \text{ etc.} \quad \ldots \quad (16)$$

$$Q(\omega) = a_1\,\omega - a_3\,\omega^3 + a_5\,\omega^5 \text{ etc.} \quad \ldots \quad (17)$$

Now the signs of the coefficients a_1, a_2, etc., may be chosen at will (i.e., the time derivatives may either be added to, or subtracted from, the response, as shown in Section 4, and it is, therefore, possible to produce any characteristics $P(\omega)$ and $Q(\omega)$ which can be expanded in powers of ω, with the proviso that $P(\omega)$ and $Q(\omega)$ are *even* and *odd* functions respectively. It is clearly not possible to generate a characteristic $P(\omega)$ which contains odd powers of ω, or $Q(\omega)$ containing even powers. This is, however, no restriction in practice, since the real and imaginary parts of all physical linear transfer characteristics are necessarily even and odd functions respectively. The proof of this is given in Appendix 1.

It will be appreciated that this method of equalization offers a much greater degree of flexibility than can be obtained with conventional equalizing sections. For example, consider any scanning process which involves the concept of a scanning aperture; such an aperture will exist due to the finite size of a scanning beam in television, or to an optical slit in sound recording, etc. If the density distribution of the aperture is symmetrical about a centre axis, it follows that its transfer function will be an even function of frequency and will thus have the form:—

$$\phi(p) = \frac{1}{1 + a_2\,p^2 + a_4\,p^4 \ldots \text{etc.}} \quad \ldots \quad (18)$$

for which the imaginary part is zero*.

Any attempt to equalize such a characteristic with a passive network will of necessity introduce undesired dispersion, since a passive network which causes attenuation as a function of frequency must inevitably introduce a phase term which is also a function of frequency. The best that can be done is to choose a network for which the modulus transfer characteristic approximates to $1/\phi(p)$ and then to correct the unwanted dispersion with a phase-equalizing network. This procedure is very unwieldy and can only provide equalization at the expense of a time delay. Needless to say, a continuously variable aperture correction is almost impossible to achieve by this means.

Using the 'time operator' approach it is only necessary to add to the response function even-order time derivatives, say D_2, D_4, D_6, etc., with coefficients a_2, a_4, a_6, etc., respectively and equalization may be achieved with any desired accuracy, and in theory without time delay. The equalizing characteristic is, of course, continuously variable by adjustment of the signs and magnitudes of the coefficients. (See Section 4.)

2.3. *Time-Delay*

In discussing time-delay it is important to distinguish between two types of delay which will be referred to here as 'real' delay and 'virtual' delay.[3,4] Basically, the distinction lies in the fact that the former is due to transmission with a finite velocity of propagation, and cannot be recovered, while the latter is due to dispersion and can be recovered.

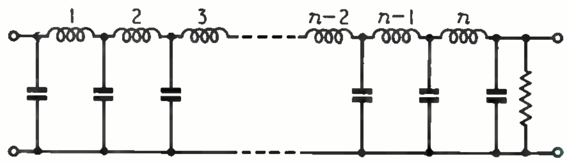


Fig. 1. *Artificial delay line comprising 'n' lumped-element sections.*

To illustrate this point, consider a transmission line of length l, for which the velocity of propagation is c; a signal entering the line will take l/c seconds to reach the distant end and will thus be delayed by this time. Obviously this delay will not be recoverable, since it will be impossible to deduce anything about the signal at the receiving end until it has arrived. On the other hand, consider an artificial delay line which comprises a number of lumped elements arranged as a ladder network terminated with a resistance, as in Fig. 1; provided that the number of elements is finite, the transfer function will be of the form

$$\phi(p) = \frac{1}{1 + a_1\,p + a_2\,p^2 \ldots a_n\,p^n} \quad \ldots \quad (19)$$

The order, n, of the polynomial which forms the denominator is in fact equal to the number of lumped reactive elements. It is thus possible to recover the 'virtual' delay completely by multiplying the transfer function $\phi(p)$ by a reciprocal function. In terms of the time function this means adding to the response its successive derivatives with respect to time with coefficients $a_1, a_2 \ldots a_n$ as previously discussed.

It is, of course, true that the behaviour of the artificial line approaches asymptotically that of the continuous line as the number of elements is increased and their magnitude is reduced; in the limit, however, the denominator of (19) will become an infinite series, divergent as $p \to \infty$. This is easily seen from the fact that an ideal continuous line of delay τ, if correctly terminated, has a transfer function $e^{-p\tau}$ which may be readily

* For any practical aperture the expansion of $\phi(p)$ in (18) will be convergent but for certain theoretical apertures zeros will exist on the imaginary axis and the denominator of (18) will thus be infinite; e.g., an ideal slit gives[2] $\phi(p) = \dfrac{\sinh a\,p}{a\,p}$. This is an example of a non-minimum phase system which cannot be equalized, as is shown to be the case in Section 2.4.

expanded in the form of (19). Thus, in the limit, equalization would require the addition of an infinite number of derivatives, and also infinite gain.

The same argument applies to any linear system which comprises only lumped elements, and which has only a single path of transmission. (Systems which have more than one transmission path are dealt with in the next section.) Any practical system of lumped elements will, of course, occupy space and will, therefore, introduce 'real' delay, since *distance* will be involved in the transmission process: this is usually negligible, however, compared with the 'virtual' delay caused by dispersion. The reason why the 'virtual' delay in almost all lumped systems is recoverable is that the signal as a whole is not in fact delayed, but merely *dispersed*; a component of response exists at the instant the excitation is applied. For a network which comprises a large number of elements, for example, an artificial delay line, the undelayed component of the response may be of exceedingly small amplitude, but such a component is nevertheless present. It is the signal/noise ratio of the system which will in fact determine the extent to which the 'virtual' delay may be recovered, since in the absence of noise the undelayed component could be amplified, no matter how small.

This aspect of equalization has an important bearing on the design of servo-control systems (Section 3.1) where loop delay is normally the factor which limits the ultimate performance.

2.4. *Linear Networks—General*

The most general form of transfer function, which will apply to all four-terminal linear networks comprising lumped elements, is

$$\phi(p) = \frac{a_0 + a_1 p + a_2 p^2 \ldots + a_n p^n}{b_0 + b_1 p + b_2 p^2 \ldots + b_m p^m} \qquad (20)$$

For the moment we shall restrict our attention to minimum-phase systems for which $\phi(p)$ will be free of zeros or poles in the right half of the complex plane.[5] In these circumstances it will always be possible to cancel the denominator of (20) by adding to the output time function, its successive time-derivatives with the appropriate coefficients. Thus, if $f(t)$ is the output time function due to any arbitrary excitation, then the time function

$$g(t) = \left(b_0 + b_1 \frac{d}{dt} + b_2 \frac{d^2}{dt^2} + \ldots b_m \frac{d^m}{dt^m}\right) f(t) \qquad (21)$$

is that which would have resulted from the numerator of (20) alone. For a finite number of lumped elements, this will be achieved with a finite number of operations on the time function since m will be finite. It will not, however, be possible to cancel the numerator with any finite number of operations, either of integration or of differentiation, since for this purpose we require to produce the reciprocal function:—

$$\frac{1}{a_0 + a_1 p + a_2 p^2 \ldots a_n p^n}$$

It is, however, possible in many cases to expand (20) in terms of the reciprocal of an infinite series in ascending powers of p or $1/p$, corresponding respectively to the low-pass or high-pass cases. The degree of convergence of the infinite series will determine whether it is practicable to attain a sufficient approximation to this series by taking the first n terms. Treated in this way it will be seen that equalization to any degree of approximation may be effected over a given band of frequencies by adding to the time function a sufficient number of time derivatives or time integrals, as described in Section 2.1.

Non-minimum phase systems having poles in the right half of the complex plane (i.e., the denominator of (20) zero for p complex with a positive real part), cannot exist in a physically stable condition, and are, therefore, of little interest here. Systems for which the denominator of (20) becomes zero for a value of p with a real part zero (i.e., a pole on the imaginary axis) are also included in the non-minimum phase category; a simple example is a tuned circuit with zero resistance. Such systems sustain continuous oscillation and may be produced by applying feedback to active networks; e.g., oscillators and servo-control systems. In practice, a stable condition is only possible by virtue of non-linearity, but analysis using linear theory is often permissible.[6]

In either of the above cases, if the denominator of (20) is factorized, terms of the form $(a - p)$ or $(a - bp + p^2)$ will be found present. While in theory such terms could be removed by introducing similar terms into the numerator, this cannot be achieved in practice, because of the presence of noise, which inevitably excites the system into a state of oscillation. Such transfer functions can, therefore, only exist during a transient condition, after which the system becomes non-linear. The poles may, however, be removed by modifying conditions within the feedback loop and a general procedure for stabilizing servo-control systems is discussed in the following section.

The passive forms of non-minimum phase systems exhibit zeros in the right half of the complex plane; i.e., the numerator of (20) becomes zero. This can occur only when the signal arrives at the output terminals via two or more paths, as with lattice, or the equivalent bridged-T sections. As a simple example, consider two paths with transfer functions $a/(a + p)$ and $p/(a + p)$ respectively; subtraction of the output signals will give $(a - p)/(a + p)$ which is the simplest form of all-pass characteristics; i.e., constant modulus and variable phase. More complicated all-pass structures have the general form

$$\phi(p) = \frac{a_0 - a_1 p + a_2 p^2 - a_3 p^3 \ldots \text{etc.}}{a_0 + a_1 p + a_2 p^2 + a_3 p^3 \ldots \text{etc.}} \quad (22)$$

the numerator and denominator being conjugate functions. Such networks cannot be equalized, for the obvious reason that the transfer function of the 'equalizing' network would need to have poles to off-set the zeros and would, therefore, be unstable.

It is, however, worth noting that a ladder network, giving

$$\phi(p) = \frac{1}{a_0 + a_1 p + a_2 p^2 + a_3 p^3 \ldots \text{etc.}} \quad (23)$$

will be converted to an all-pass system if the even-order derivatives are added, as for equalization, but the odd-order derivatives are subtracted, thus producing the conjugate of the denominator. It will be seen that if the transfer function of the ladder, expressed in polar co-ordinates is

$$\phi\ (\omega) = H\ (\omega)\underline{/\theta(\omega)} \quad \ldots \quad \ldots \quad \ldots \quad (24)$$

the resulting all-pass characteristic will be

$$\phi_A(\omega) = 1\underline{/2\theta(\omega)} \quad \ldots \quad \ldots \quad \ldots \quad (25)$$

The same result will be obtained with any network over a finite frequency band, if the sign of each odd-order derivative or integral is adjusted to be the reverse of that required for equalization.

3. Practical Applications

3.1. *Servo-Control Systems*

The principle of servo-control is being applied ever increasingly to the physical problems which arise in our present-day civilization. Wiener[7] has indicated that the unsurpassed excellence of the human machine as a control mechanism is due to the extensive use of the principle of error-reduction by means of feedback. While prediction of the future, other than on a statistical basis, is not physically possible, servo-control does enable accurate action to be taken immediately a change of circumstance *occurs*. As opposed to direct control, the basic merit of the servo is that it establishes a correspondence between excitation and response which is virtually independent of the system parameters.

It is suggested that, using derivative equalization, the ultimate performance of any linear servo-control system is fundamentally limited only by 'real' time-delay (Section 2.3) and noise. Provided that the control signal is of sufficient amplitude, noise fluctuations arising in the loop need not be a limiting factor. Thus, for a practical electro-mechanical system, the maximum rate of response, for a given maximum error, will depend upon instrumental rather than fundamental issues; i.e., the amount of power available and the strength of materials.

As a simple example, consider an electro-mechanical system in which the output of an electrical amplifier is used to displace a large mass. If the mass is to be displaced and brought to rest in, say, a small fraction of a second, large forces will need to be applied, first in a positive sense to bring about the required acceleration and later in a negative sense to arrest the motion. More elaborate systems involving a plurality of masses and compliances will require a more complicated 'ensemble' of forces to be applied in order to absorb the stored energy, which will normally result in overshoots. Examination of the differential equation of such a system reveals that the additional forces may all be expressed as derivatives of the response and the 'equalization' process described in Section 2 is, therefore, the natural way in which they may be produced. In this instance the equalization would be carried out electrically before the distortion had occurred, but in a linear system this is equivalid. For a sudden change in excitation approximating to unit step, the added derivatives will comprise a rapid succession of impulses with various amplitudes and signs. Thus, for such systems speed of response can be obtained only provided that sufficient power is available to supply the necessary peaks of force, and the materials are strong enough to withstand them. No fundamental limit exists, however, if the system can be represented, by analogy, by means of a lumped electrical network.

The above discussion will serve to show that it is possible to cause a mechanical system possessing considerable inertia and stiffness to respond faithfully to rapid changes in excitation whether or not feedback is applied. In the absence of feedback, conventional amplitude and phase equalizers might be used as an alternative means of obtaining approximate correction, but this can be achieved only at the cost of time-delay. For a closed-loop system, however, the equalizing process must necessarily be effected without time-delay, and the time-derivative method is in most cases the only way in which this can be accomplished.

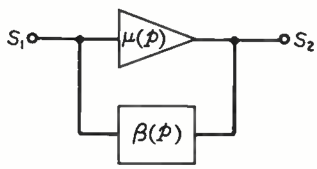


Fig. 2. *Single-loop servo-control system.*

As an example, the essential elements of a linear single-loop servo-control system,[8] which are shown in Fig. 2, may be considered. The transfer function, S_2/S_1, is given by

$$\frac{S_2}{S_1} = \phi(p) = \frac{\mu(p)}{1 + \mu(p) \cdot \beta(p)} \quad \cdots \quad (26)$$

in which negative feedback has been assumed and μ and β have both been written as functions of p, in order to generalize. Except in the case of wide-band feedback amplifiers, the velocity of propagation around the loop is seldom a limiting factor, and a lumped system can normally be assumed.

In the theoretically ideal case in which μ and β are numerics over an infinite frequency band, assuming that the product $\mu\beta \gg 1$,

$$\frac{S_2}{S_1} \approx \frac{1}{\beta}.$$

Thus, $S_2 \propto S_1$ which is, of course, the ultimate aim of servo-control. In practice, μ and β are invariably low-pass systems having the general form,

$$\mu = \frac{\mu_0}{1 + \sum_{n=1}^{\infty} a_n p^n} \quad \cdots \quad \cdots \quad \cdots \quad (27)$$

$$\beta = \frac{\beta_0}{1 + \sum_{n=1}^{\infty} b_n p^n} \quad \cdots \quad \cdots \quad \cdots \quad (28)$$

where μ_0 and β_0 are the respective values of μ and β at zero frequency.

A limit to the maximum value of μ_0 is thus imposed by the condition for stability, namely that $\phi(p)$ must have no poles in the right half of the complex plane. It follows, of course, that this also imposes a limit to the maximum rate at which S_2 can be made to follow S_1 with a given error. In order to extend the range of stable operation, equalization may be effected by the addition of time derivatives, in the following manner.

Considering first the β path, the denominator of (28) may be effectively cancelled over a frequency band, f_c, which is large compared with the desired working band, f_w, by adding the necessary derivatives to the β output signal as shown schematically in Fig. 3(a). The maximum value of f_c will depend only upon the 'noise' level and the real time-delay in the loop. For the equalized conditions we may write:—

$$\beta(p)\,|_{p < p_c} \approx \beta_0 \quad \cdots \quad \cdots \quad \cdots \quad (29)$$

In the same manner, μ may be equalized over the band f_c as illustrated in Fig. 3(b), giving:—

$$\mu(p)\,|_{p < p_c} \approx \mu_0 \quad \cdots \quad \cdots \quad \cdots \quad (30)$$

Using these values in (29) gives

$$\phi(p)\,|_{p < p_c} \approx \frac{\mu_0}{1 + \mu_0 \beta_0} \quad \cdots \quad \cdots \quad (31)$$

Beyond the limit $p = p_c$ equalization will fail and for a large value of μ_0, poles will still exist in the right half of the complex plane.

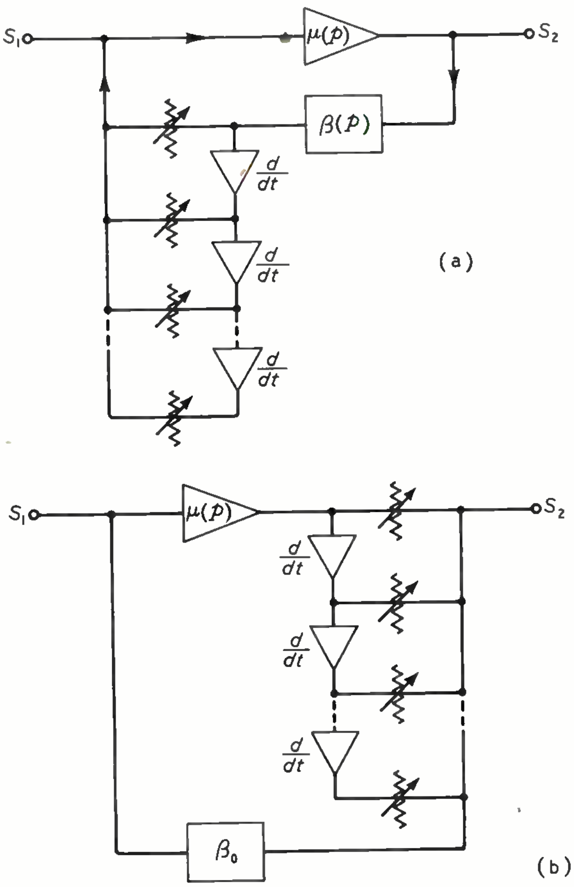


Fig. 3. *Equalization of (a) β path and (b) μ path.*

We now introduce into the μ path a filter for which the denominator of the transfer function is quadratic; i.e.,

$$h(p) = \frac{1}{1 + k\left(\frac{p}{\omega_s}\right) + \left(\frac{p}{\omega_s}\right)^2} \quad \cdots \quad (32)$$

where $\omega_s = 2\pi f_s \ll 2\pi f_c$.

This transfer function may be obtained with a simple low-pass circuit, which, together with the indicial response for various values of k, is shown in Fig. 4.

With the filter included, the overall transfer function in (26) becomes:—

$$\phi(p) = \frac{\mu_0}{1 + \mu_0\beta_0} \cdot \frac{1}{1 + \frac{k}{\sqrt{1 + \mu_0\beta_0}}\left(\frac{p}{\Omega}\right) + \left(\frac{p}{\Omega}\right)^2} \quad \cdots \quad \cdots \quad \cdots \quad (33)$$

where $\Omega = \omega_S\sqrt{1 + \mu_0\beta_0}$

(See Appendix 2.)

The limit p_c has been dropped from $\phi(p)$ since with the filter included it is assumed that the loop gain is reduced sufficiently at frequencies above f_c to be negligible. It will be noted that the actual cut-off frequency, $\omega_S/2\pi$, of the filter is substantially lower than $\Omega/2\pi$ which by design will be made equal to the desired upper working frequency f_w. Considerable attenuation will thus be introduced by the filter at frequencies above f_c to which μ and β are equalized.

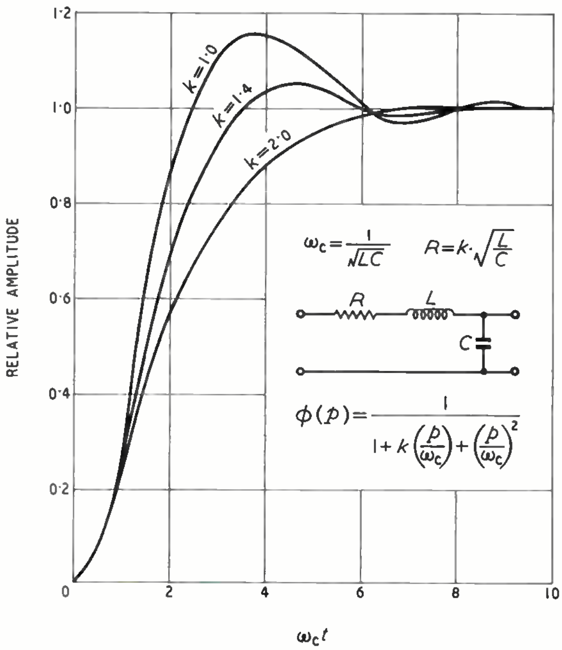


Fig. 4. *Indicial response of simple low-pass filter.*

The overall transfer characteristic given in (33) will be seen to be of identical form to (32), but the cut-off frequency has been raised by the factor

$$\sqrt{1 + \mu_0\beta_0}$$

and the coefficient, k, has been reduced by the same factor. The appropriate values for the components of a practical filter to give a desired overall response may be deduced readily by reference to Fig. 4.

As an alternative to equalizing the loop transfer characteristic and adding a filter, it would be possible to remove only the undesired poles from (26) over a finite frequency band (Section 2.4.). However, the method proposed has the merit that the final transfer characteristic is, for practical purposes, determined entirely by the known constants of the filter and the most suitable compromise between rate of response and overshoot may therefore be chosen at will. Since the denominator of the filter characteristic is quadratic, the system will be essentially stable.

3.2. *Television*

In television the *shape* of the time-function representing the scene intensities, as scanned, is all-important, and it is not surprising, therefore, that the time-derivative approach to equalization has considerable application. It is true that equalization applied to the electrical signal can only result in an improvement in definition along the scanning lines, but subjectively an improvement in horizontal definition is well worth while.[9]

It has already been pointed out in Section 2.2 that aperture loss introduced by a finite scanning spot may be compensated by the method, and this is also true for loss introduced by an optical lens with the proviso that the circle of confusion remains approximately constant over the image field. It must be emphasized again that correction applied to the electrical signal will only be effective in the line direction.

A most important feature of the method in its application to television is its flexibility; it is a relatively simple matter to obtain accurate compensation for the overall loss due to most causes, on a trial and error basis by looking at the reproduced picture. When second- or higher-order derivatives are involved, the correct adjustments may be arrived at quickly if note is taken of the fact that even-order derivatives modify the time function symmetrically, while odd orders introduce skew symmetry. Thus, an overshoot, or a loss of definition on one side only of a transition may be compensated using odd-order derivatives, and remaining symmetrical defects may then be removed with even orders.

In particular, the method has already been applied successfully to correcting overall losses occurring in such complicated processes as those involved in standards conversion (Paris-London Relay,[10] July 1952) and television recording. It has been found that, in practice, the loss of horizontal definition, due to the shortcomings of the various optical, electron-optical, and electrical elements involved in such processes, may be substantially reduced by means of a derivative equalizer of relatively simple design. It is seldom necessary to use derivatives of order higher than the fourth, and indeed a poor signal/noise ratio will often exclude the use of derivatives of order higher than third. In practice it is desirable to include in the circuit to be equalized, a phase-equalized low-pass filter in order to remove noise components which are present outside the working band of frequencies, and which would be amplified considerably by an unrestricted equalizing characteristic.

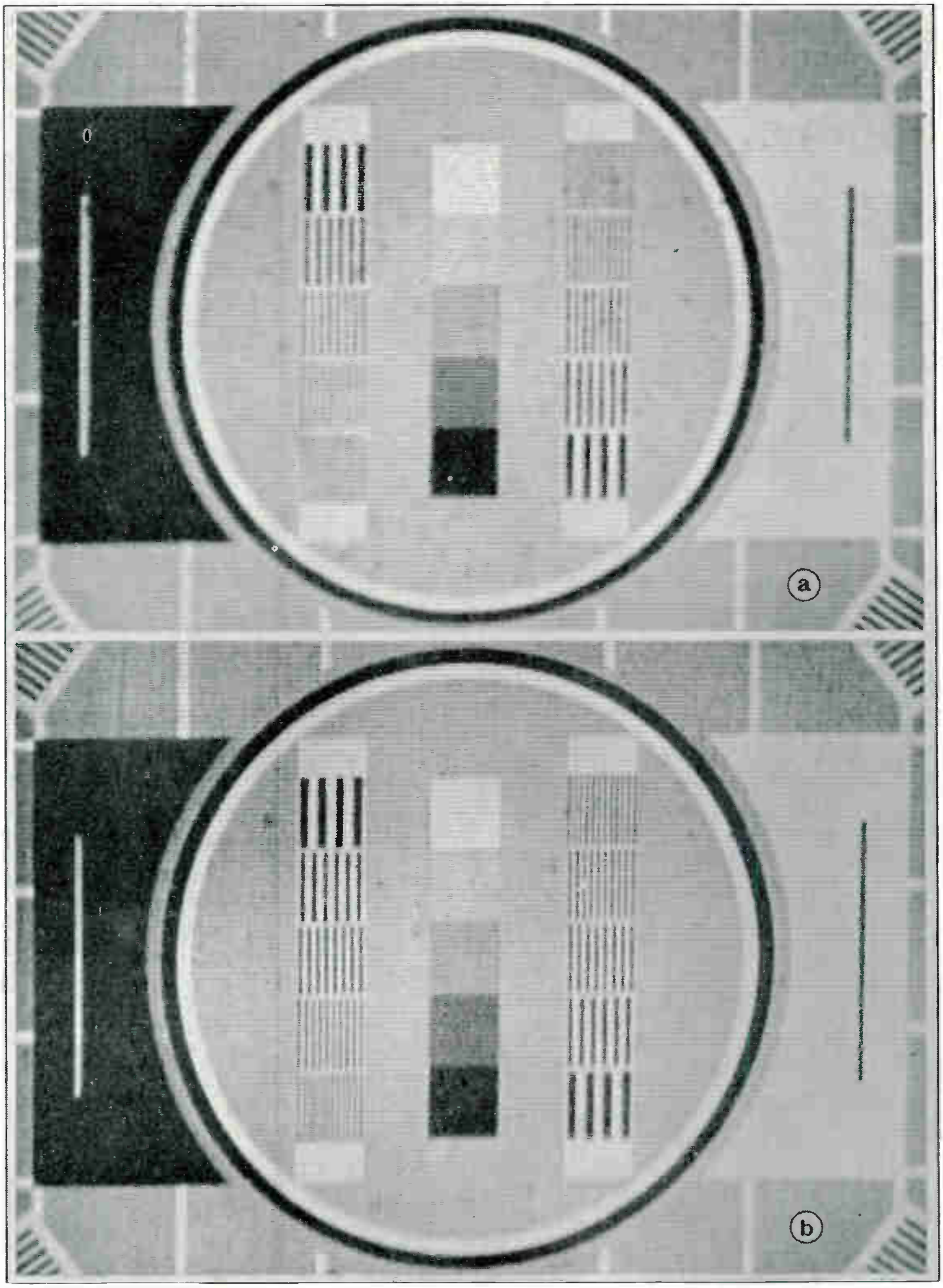


Fig. 5. *These photographs show part of a television picture of Test Card C. The signal has been degraded by passing it through a 2-Mc/s π-section low-pass filter with the result depicted at (a). The use of 1st-, 2nd- and 3rd-order derivative correction is illustrated at (b).*

Figs. 5(a) and (b) show the results of adding first-, second- and third-order derivatives to a degraded television picture requiring a bandwidth of 3 Mc/s. The impulsive response of the system with and without correction is shown in Figs. 6(a), (b) and (c). The test pulse shown in Fig. 6(a) was obtained by restricting the bandwidth of a signal approximating to an impulse function to 3 Mc/s by means of a phase-equalized low-pass filter.

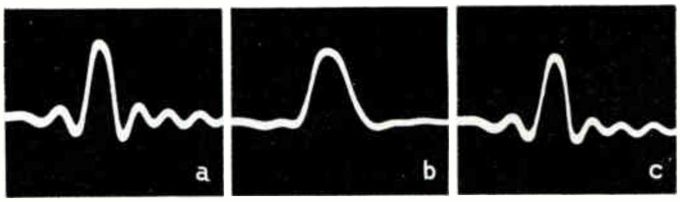


Fig. 6. *Impulse response of system with and without equalization; (a) test pulse out of 3-Mc/s phase-corrected filter, (b) response of system degraded with 2-Mc/s π-section low-pass filter and (c) response of system after equalization using 1st-, 2nd- and 3rd-order derivatives.*

3.3 *The Integral Equalizer*

In Section 2 reference was made to the 'integral' type of equalizer which produces a transfer function of the form

$$\psi(p) = \beta_0 + \frac{\beta_1}{p} + \frac{\beta_2}{p^2} + \ldots . \frac{\beta_n}{p^n} \quad .. \quad (34)$$

This was included for the sake of completeness rather than because of the practical value of the method. The equalization of high-pass characteristics is seldom of interest, although on occasion it is useful to equalize simple transfer functions, or parts of transfer functions, by this method. For example, a term

$$\frac{p}{a+p}$$

may be written:—

$$\frac{1}{1 + a/p}$$

and this will be equalized by adding to the response a signal which is the time integral of the response.

It is of interest to note that terms of the form

$$\phi(p) = \frac{p}{a_0 + a_1 p + a_2 p^2} \quad .. \quad .. \quad (35)$$

may be equalized in two ways. One method is to integrate the response, which gives

$$\frac{\phi(p)}{p} = \frac{1}{a_0 + a_1 p + a_2 p^2} \quad .. \quad .. \quad (36)$$

after which the addition of first and second derivatives will effect equalization. Alternatively, the response may first be differentiated, giving

$$p.\phi(p) = \frac{p^2}{a_0 + a_1 p + a_2 p^2} = \frac{1}{\frac{a_0}{p^2} + \frac{a_1}{p} + a_2} \quad .. \quad .. \quad .. \quad (37)$$

which may be equalized by adding first and second integrals.

Electrical integrating circuits naturally fail at low frequencies, approaching zero frequency, since in the limit, an infinite time-constant would be required. For most practical purposes, however, this is not important, and a time constant of a few seconds is usually sufficiently large to be regarded as infinite.

4. Instrumentation

It is not proposed to discuss the practical design of a complete equalizer in any detail, since this will be governed by actual performance requirements. By way of illustration, however, some of the more general aspects of design are given below.

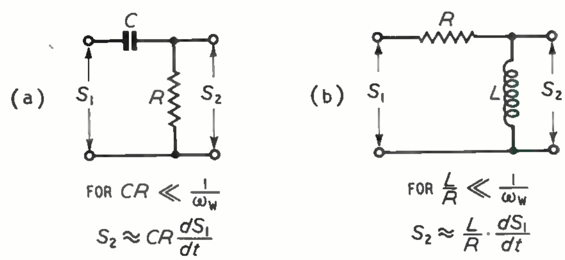


Fig. 7. *Basic differentiating circuits.*

4.1 *Electrical Differentiation*

The approximate differentiation of an electrical signal may be accomplished by using either of the basic circuits shown in Fig. 7. In both cases the transfer function is

$$\phi(p) = \frac{p}{p+a} \quad .. \quad .. \quad .. \quad .. \quad (38)$$

where a is the reciprocal of the time constant CR or L/R. Thus, if $a \gg p$ over the working range, say 0—p_w, then

$$\phi(p)\Big|_{p < p_w} \approx \frac{p}{a} \quad .. \quad .. \quad .. \quad .. \quad (39)$$

and for an input S_1 we have for the output:—

$$S_2 = \tau \frac{d S_1}{dt} \quad \text{where } \tau \text{ is the time constant.}$$

For accurate differentiation it is necessary that a should equal or exceed about $5\omega_w$ where $\omega_w/2\pi$ is the higher working frequency. Even for this condition the error becomes appreciable when a number of stages are connected in cascade. The accuracy of differentiation may, however, be increased without a reduction of output signal amplitude, by introducing a factor $(p + a)$ either before or after differentiation, thus effectively cancelling the denominator of (38). At frequencies up to hundreds of kilocycles the circuit of Fig. 7(a) may be used; at higher frequencies the value of capacitance required for

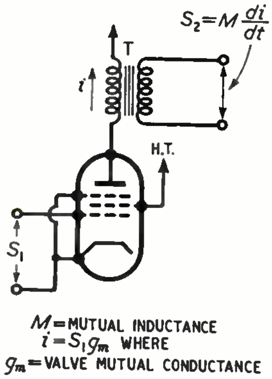


Fig. 8. *Practical circuit suitable for differentiating a wide-band signal.*

the high series reactance becomes so small as to be comparable with stray capacitance, and the circuit of Fig. 7(b) is then more practicable. The high value of series resistance required for the latter circuit is conveniently provided by a pentode valve, in the anode circuit of which is connected the inductance *L*.

The frequency at which the inductance resonates with stray shunt capacitance must of course be arranged to fall well outside the working frequency band, and this sets the limit to the maximum value of inductance which may be

4.2 *Frequency Range*

A block schematic of a complete equalizer is shown in Fig. 9, in which each differentiating stage is preceded by an amplifying stage with a gain μ_0.

It will be seen that the overall transfer function, with the potentiometer P_0 adjusted to maximum to give $a_0 = 1$, may be written

$$\phi(p) = 1 \pm a_1 \frac{p}{\omega_0} \pm a_2 \left(\frac{p}{\omega_0}\right)^2 \pm \dots a_n \left(\frac{p}{\omega_0}\right)^n \quad \dots \quad (40)$$

where $\omega_0 = 1/\mu_0\tau$ (τ = differentiating time constant)

and the a terms are the fractional outputs of the potentiometers, P_1, P_2, P_3, etc., respectively.

The normalized transfer characteristic is thus expressed directly in terms of the variable p/ω_0 and for given potentiometer settings the characteristic is independent of the product $\mu_0\tau$ which affects only the absolute frequency scale. If τ is chosen to equal $1/5\omega_w$, as previously suggested, then for $\mu_0 = 10$, we have:—

$$\omega_0 = \omega_w/2$$

and the equalizer may therefore be used over the range for which p/ω_0 varies from 0 to 2, which will be found adequate for many purposes.

It will be noted that the relative value of all the coefficients in (40) will be increased by the same factor if a_0 is made fractional by adjusting the potentiometer P_0, which controls the undifferentiated component of the output signal.

If the potentiometers are calibrated, the

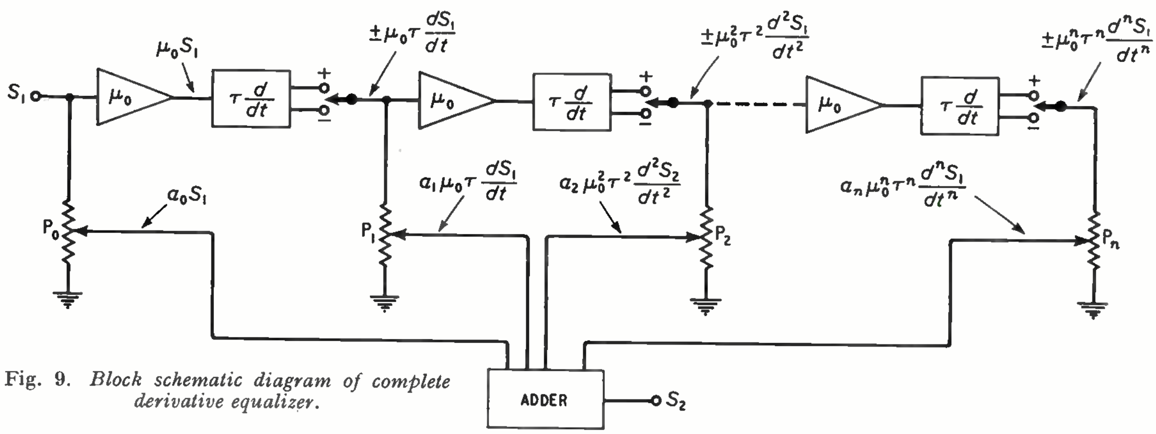


Fig. 9. *Block schematic diagram of complete derivative equalizer.*

used. An arrangement which has been used successfully for a frequency band of several megacycles is shown in Fig. 8. A pentode is used as a constant-current generator, differentiation being performed by the mutual inductance of the transformer T. With this arrangement, the sign of the coefficient may be changed simply by reversing the transformer connections.

equalizing characteristics may be written down immediately by inserting the values of a_0, a_1, a_2, etc., in (40). This affords a rapid means of measuring an unknown transfer characteristic, which is of course the reciprocal of its equalizing characteristic. The latter may be determined rapidly by correcting the transient response on a trial-and-error basis.

A simplified circuit diagram of a practical wideband equalizer is shown in Fig. 10.

5. Conclusion

It has been shown that the transfer characteristic of all linear four-terminal minimum-phase systems comprising lumped elements may in theory be equalized by adding to the response successive time-derivatives and/or integrals. In practice, the method is particularly applicable to low-pass systems, in which case derivatives only are required to be added.

The most noteworthy features of the method are enumerated below:—

(1) The phase and amplitude characteristics may be 'equalized' simultaneously.

(2) The 'virtual' delay caused by dispersion in lumped minimum-phase systems is corrected; this is of considerable importance in the application to servo-control systems.

(3) Equalizing characteristics of non-realizable as well as realizable networks can be produced; e.g., an amplitude characteristic caused by a scanning aperture may be corrected without affecting phase or introducing delay.

(4) The characteristic is continuously variable by means of gain adjustments only.

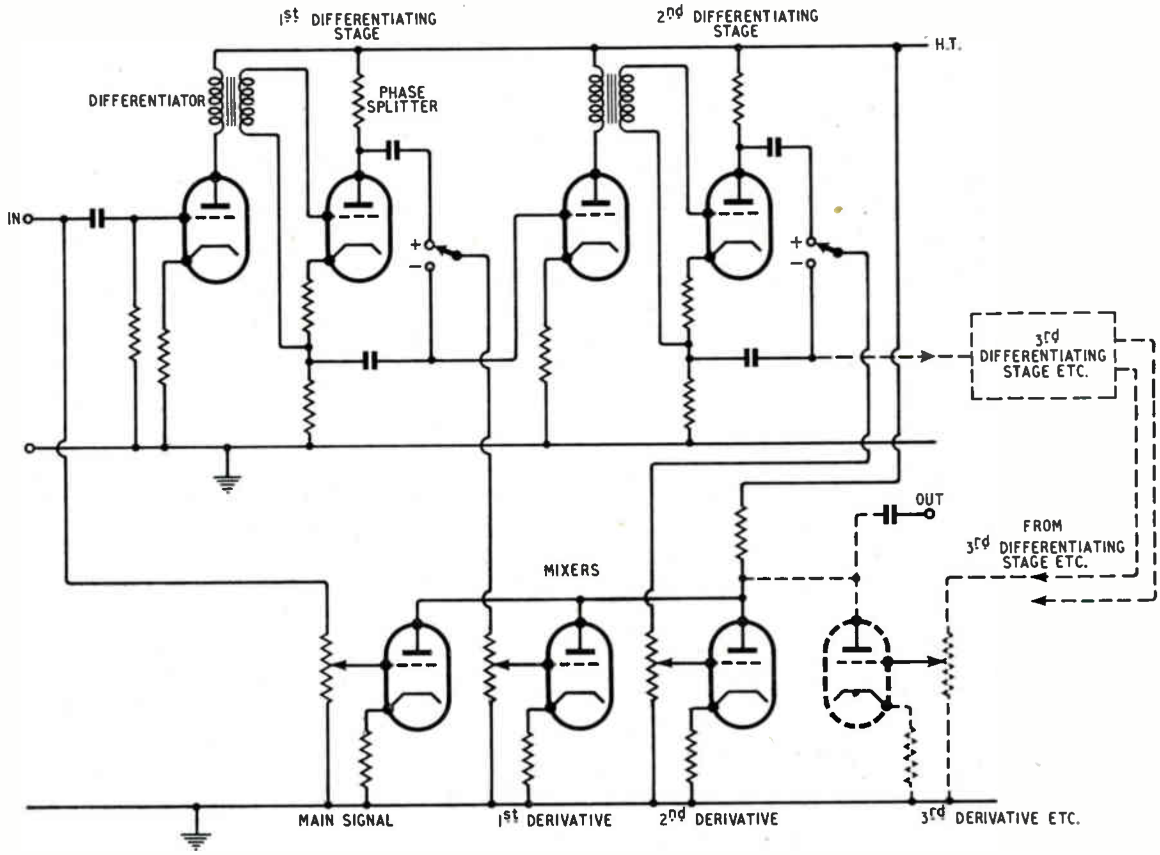


Fig. 10. *Simplified circuit diagram of 2-stage wideband equalizer showing method of adding further stages as required.*

6. Acknowledgements

The author wishes to thank the Chief Engineer of the B.B.C. for granting permission to publish this article, also Mr. W. Proctor Wilson, C.B.E., Head of the Research Department, and a number of colleagues—in particular Mr. C. G. Mayo, Dr. R. D. A. Maurice, and Mr. J. W. Head—for helpful discussions.

APPENDIX 1 (Section 2.2.)

Symmetry of Real and Imaginary Parts of $\phi(\omega)$

It is proposed to show that the transfer characteristics of any practical linear system will have a real part which is an *even* function of frequency and an imaginary part which is an *odd* function.

Using the appropriate Fourier transform to express the transfer function $\phi(\omega)$ in terms of the response,

$f(t)$, to unit impulse, we have

$$\phi(\omega) = \frac{1}{2\pi}\int_{-\infty}^{\infty} f(t)\, e^{-j\omega t}\, dt \quad \ldots \quad 1(a)$$

Substituting ($\cos \omega t - j \sin \omega t$) for $e^{-j\omega t}$ we obtain

$$\phi(\omega) = \frac{1}{2\pi}\int_{-\infty}^{\infty} f(t) \cos \omega t\, dt - \frac{j}{2\pi}\int_{-\infty}^{\infty} f(t) \sin \omega t\, dt \quad 2(a)$$

Whatever the form of $f(t)$ it is always possible to express it as the sum of two functions $f_e(t)$ and $f_o(t)$, which are even and odd, respectively.

We may thus write:—

$$\phi(\omega) = \frac{j}{2\pi}\int_{-\infty}^{\infty} f_e(t) \cos \omega t\, dt + \frac{1}{2\pi}\int_{-\infty}^{\infty} f_o(t) \cos \omega t\, dt$$

$$- \frac{j}{2\pi}\int_{-\infty}^{\infty} f_e(t) \sin \omega t\, dt - \frac{j}{2\pi}\int_{-\infty}^{\infty} f_o(t) \sin \omega t\, dt \quad 3(a)$$

Since $\cos \omega t$ is an even function and $\sin \omega t$ is an odd function, the second and third integrals vanish. The first integral, which is the real part of $\phi(\omega)$, is an even function of frequency and the fourth integral, which is the imaginary part, is an odd function of frequency. This will always apply provided that $f(t)$ is such that the integral in 1(a) converges, which must be true of any practical linear system.

APPENDIX 2 (Section 3)

The Effect of a Filter in the μ-Path of the Servo Loop

After equalization over a band f_e, $\mu(p)$ is given as:—

$$\mu(p)\Big|_{p < p_e} \approx \mu_0 \quad \ldots \quad (30)$$

Inserting the filter characteristic [see Equ. (32)] gives

$$\mu(p)\Big|_{p < p_e} = \frac{\mu_o}{1 + k\left(\frac{p}{\omega_s}\right) + \left(\frac{p}{\omega_s}\right)^2} \quad \ldots \quad 4(a)$$

and for the overall transfer function, (26) we have

$$\phi(p)\Big|_{p < p_e} = \frac{\mu_o}{1 + k\left(\frac{p}{\omega_s}\right) + \left(\frac{p}{\omega_s}\right)^2 + \mu_o \beta_o} \quad \ldots \quad (5a)$$

It will be seen from inspection of 5(a) that if ω_s is sufficiently small compared with ω_e the modulus of $\phi(p)$ will tend to zero as $p \rightarrow p_e$; i.e., the loop gain characteristic will be controlled by the additional filter, and 5(a) will hold approximately over an infinite frequency band. This being the case we may drop the limit p_e and by rearranging 5(a) write:—

$$\phi(p) = \frac{\mu_o}{1 + \mu_o \beta_o} \cdot \frac{1}{1 + \frac{k}{1 + \mu_o \beta_o}\left(\frac{p}{\omega_s}\right) + \frac{1}{1 + \mu_o \beta_o}\left(\frac{p}{\omega_s}\right)^2} \quad \ldots \quad 6(a)$$

Making the substitution $\Omega = \omega_s\sqrt{1 + \mu_o \beta_o}$ we obtain

$$\phi(p) = \frac{\mu_o}{1 + \mu_o \beta_o} \cdot \frac{1}{1 + \frac{k}{\sqrt{1 + \mu_o \beta_o}}\left(\frac{p}{\Omega}\right) + \left(\frac{p}{\Omega}\right)^2} \quad (7a)$$

REFERENCES

[1] J. M. Linke. "A Variable Time-Equaliser for Video-Frequency Waveform Correction", *Proc. Instn elect. Engrs*, 1952, Vol. 99, Part IIIA, No. 18.

[2] B. Van der Pol and H. Bremmer. "Operational Calculus based on the Two-Sided Laplace Integral", Cambridge University Press, 1950, pp. 293-294.

[3] J. R. Carson. "Electric Circuit Theory and the Operational Calcuits", McGraw-Hill, 1926, pp. 127-128.

[4] Colin E. Cherry. "Pulses and Transients in Communication Circuits", Chapman & Hall, Ltd., 1949, pp. 200-202.

[5] J. A. Tanner. "Minimum-Phase Networks", *Electronic Engineering*, November 1951.

[6] G. G. Gouriet. "High-Stability Oscillator", *Wireless Engineer*, April 1950, Vol. 27, p. 105.

[7] N. Wiener. "Cybernetics", John Wiley & Sons, New York, 1948.

[8] H. M. James, N. B. Nichols and R. S. Phillips. "Theory of Servo-Mechanisms", McGraw-Hill, 1947.

[9] M. W. Baldwin. "The Subjective Sharpness of Simulated Television Images", *Bell Syst. tech. J.*, October 1940, Vol. 19, pp. 563-587.

[10] T. H. Bridgewater. "Paris-London Television", *Electronic Engineering*, September 1952, pp. 410-412.

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.

Anode Follower

SIR,—In your February 1953 issue, Mr. M. G. Scroggie criticises the use of the term 'anode fcllower.' He suggests that it should "be condemned as expressing an entirely false analogy."

This, in fact, has already been done—as regards the Services and Government Departments at any rate. According to the "Inter-Services Glossary of Terms Used in Telecommunications and Electronic Engineering (1950)," the term 'anode follower' is to be deprecated. The accepted alternatives are 'see-saw' or 'floating paraphase.'

It can, of course, be argued that these leave much to be desired. The term 'see-saw'—on the basis that as the input voltage falls, the potential of the anode rises—can surely be applied to most amplifying stages. The term is really only justified when input and anode potential changes are equal; i.e., when input and feed-back resistors are equal. The "Inter-Services Glossary" restricts its use to circuits having " . . . two impedances of the same order . . .," but does not stipulate equality.

The name 'anode follower' may have been introduced because of the similarity of the circuit to the *cathode* follower as regards output impedance.

GEO. L. CONNON.

Weymouth,
Dorset.
13th March 1953.

Formulae for Ladder Filters

SIR, In amplification of A. T. Starr's letter, in your March issue, on the history of ladder filters, it may be noted that E. L. Norton gave the solution for the maximally-flat filter, loaded at one end only, in U.S. Patent No. 1,788,538. (13th Jan., 1931) which precedes W. R. Bennett's Patent by a year.

A general solution for either Tchebyshev, Butterworth, or the under-coupled type of response, for any distribution of terminal loading, was given in the *Marconi Review* No. 108, Vol. XVI, 1st. Quarter, 1953, p. 25.

E. GREEN

Writtle Mead,
Writtle, Essex.
7th April 1953

PHYSICAL SOCIETY'S EXHIBITION

THE 37th annual exhibition of scientific instruments and apparatus was held by the Physical Society from April 13th to 17th at Imperial College, London. As usual, the bulk of the exhibits were in some way connected with electrical matters, and those of a purely optical, chemical or mechanical nature were few. The connection with electricity varies a good deal in both kind and extent, however and, in some cases, it is almost incidental.

Anything but the very broadest classification of the exhibits is impracticable for they varied from the standard resistor to the digital computer and few intermediate steps were absent. In a limited space, therefore, it is impossible to do more than refer rather briefly to some of the more interesting things which were shown. Of these, the research items usually have pride of place and, although there is now no official research section to the exhibition, a number of the exhibits do fall conveniently under this heading and were, in fact, grouped together by the organizers.

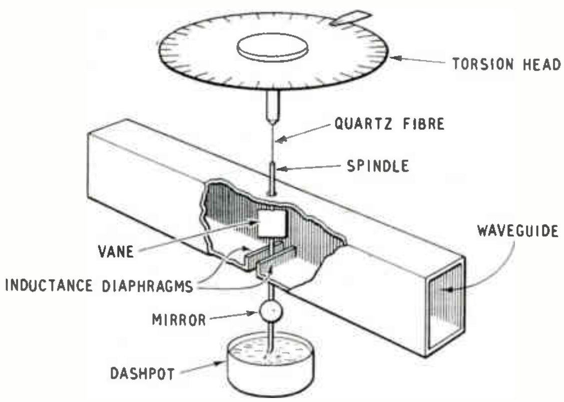


Fig. 1. *Elliott waveguide power-measuring device.*

Research

The use of germanium as an infra-red modulator was demonstrated by the Telecommunications Research Establishment. A beam of infra-red radiation of 2 microns wavelength (150 MMc/s) passes through a germanium crystal which is carrying a biasing current. The absorption depends on the magnitude of the current and this is varied at audio frequency (derived from a gramophone pick-up for the demonstration) to modulate the beam. The infra-red transmission actually depends on the number of free-current carriers, and it is this number which is varied by the current in the crystal.

Transistors were not any great feature of this year's exhibition, but Standard Telephones & Cables showed their Type LS737, for which a gain of 20 db with a 20-kΩ load is claimed. Marconi's Wireless Telegraph Company demonstrated a cathode-ray transistor-characteristics display in which the whole family of curves is shown on a c.r. tube.

Magnetron mode-plotting apparatus was demonstrated by the Services Electronics Research Laboratory. A cavity anode is excited by a tunable oscillator and the magnitude of the field in the anode-cathode space is determined with the aid of a probe attached to the cathode. The probe is rotated and its output is applied as a radial deflection to a c.r. tube, the trace rotating synchronously with the probe. The field pattern is thus drawn out on the tube and the various modes are clearly evident. A merit of the method is that it permits the characteristics of the anode to be investigated without having to build the complete valve.

A new method[1] of measuring power in waveguides was shown by Elliott. A small vane is suspended by a quartz thread in a section of guide. The wave exerts a mechanical couple on it, which tends to rotate it; the rotation is resisted by a torsion head which is adjusted so that the position of the vane remains unchanged. From the reading of the scale on the torsion head the power passing along the guide can be determined. The position of the vane is made evident by the reflection of a beam of light from a mirror attached to it, as shown in Fig. 1.

The design exhibited is for a wavelength of 3·2cm and for a mean power of 10W upward, with an accuracy of ± 1·6%. The minimum detectable signal is about 100 mW and the peak power limitation 100kW.

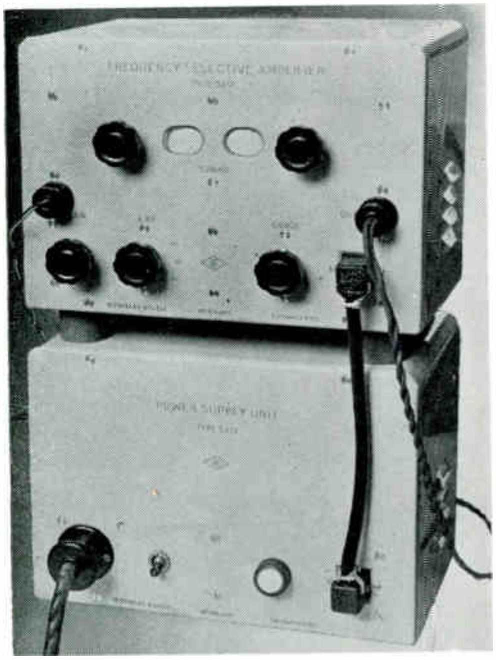
Another method of measuring power was shown by Mullard. In principle, this is similar to the usual water load. It takes the form of a short coaxial line, of which the inner conductor is a glass rod coated with a very thin gold film. In order to secure uniformity of power dissipation the film is graded. The line is filled with carbon tetrachloride, which is circulated to act as the cooling agent, the rate of circulation being regulated by a flowmeter. The temperature difference between the inlet and the outlet is a measure of the power dissipation. Carbon tetrachloride has been employed largely because its dielectric properties are similar to those of polyethylene, so enabling a mixture of solid and liquid

Philips FM-AM generator, type GM 2889, covering 5-225 Mc/s. On f.m. a deviation up to 10 Mc/s is obtainable. A marker oscillator is included and the apparatus is suitable for use with an oscilloscope to depict the bandpass curve of a television receiver.

[1] Cullen, A. L., *Proc. Instn elect. Engrs*, 1952, Vol. 99, Pt. IV, Monograph 23, 24, 42.

dielectrics to be used without introducing discontinuities. The dummy load will handle up to 600 W and power can be measured to ± 2% or ± 1·5 W, whichever is the greater. The impedance is 75 Ω and it is for frequencies of 100 Mc/s upwards.

At the other end of the frequency scale lies the speech synthesizer demonstrated by the Signals Research and Development Establishment. Speech is produced artificially under the control of slowly-varying parameters which specify the frequencies of the vocal-cavity system and the excitation applied to it. The bandwidth required is of the order of one-fiftieth of the initial speech.



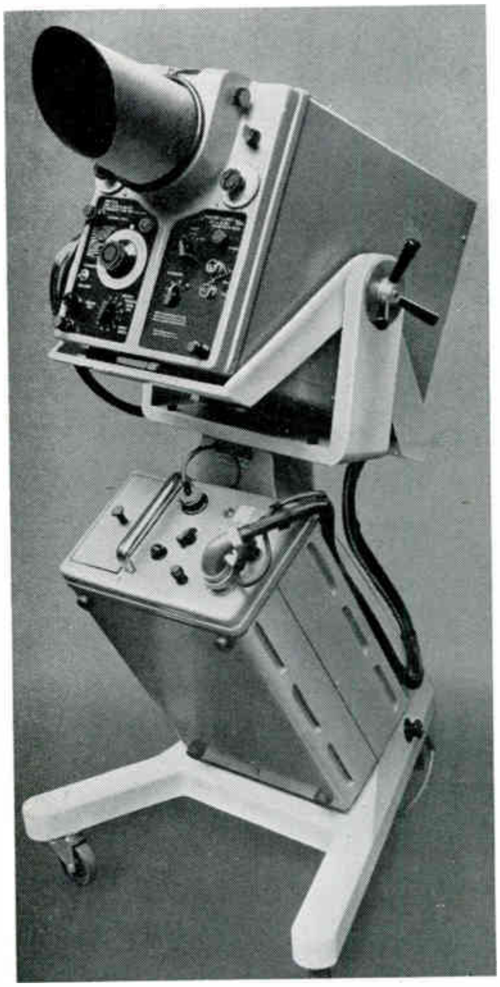
Tinsley frequency-selective amplifier and power unit, type 5212, *covering* 10-10,000 *c/s with a Q of* 32-35 *and* 80-100-*db gain.*

Laboratory Standards

To turn from research to Wheatstone bridges and the like may seem peculiar, for the one represents something close to the limits of knowledge, whereas the other is so old and well known that one might well think that the last word had been said. However, all practical aspects of electricity and magnetism, electronics and electronic devices, rest upon measurement of the fundamental electrical quantities and quite an important section of the exhibition was devoted to apparatus for the precision measurement of resistance, capacitance, inductance, current and voltage. No startling changes were evident here and the old methods are still the usual, alterations being generally confined to refinements. Precision standards were shown by many firms and Wheatstone bridges in a surprisingly large number of forms. The potentiometer, too, was unusually prominent and ranged from large laboratory models to small types for field use (e.g., Pye). The word is, of course, used here in its proper sense for a potential meter and not in the common one of a potential divider.

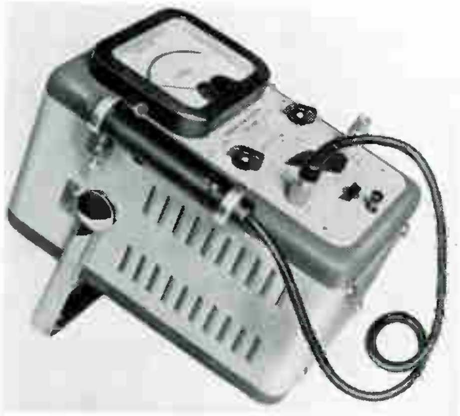
Sullivan showed their well-known range of temperature-compensated inductance standards and also a new variable-inductance standard with temperature-compensated windings. It covers 10-160 μH in two ranges and is direct-reading. This firm also showed a decade air-dielectric capacitor having silica insulation. No switching is used, the decades being obtained by the stepped movement of a variable capacitor having segmented vanes. A parallel variable capacitor gives a continuous change to fill in the gap between the decades.

In its constructional form, the precision equipment tends to remain in its old style; the mahogany case, the ebonite panel, and the brass terminal are still the normal. In the apparatus for more general laboratory use, however, this has given place to modern 'styling' and metal cases of attractive finish are more usual. Simple RC and RCL bridges abound with an accuracy of the order of 1% only and are of great practical utility, for they meet most everyday requirements.



Nagard oscilloscope, type L 103, *on adjustable stand with its power-supply unit.*

For current and voltage measurement, the moving-coil pointer instrument is still supreme. Most changes of recent years have come about through improvements in magnetic materials and have resulted, through the years, in a steady increase in the sensitivity obtainable for a given degree of robustness. Panel-mounting meters of 5 μA f.s.d. are now obtainable and a range of miniature meters with movements upwards from 50 μA f.s.d. was shown by Pullin. These are of only 1½ in. diameter and yet have built-in dial lamps for illuminating the scales.



Furzehill sensitive valve voltmeter covering 1 mV to 100 V in five ranges; the frequency range is 10 c/s to 500 kc/s and the meter scale is logarithmic.

Although not new this year, the Pye 'Scalamp' galvanometer is worthy of note, for it is a self-contained mirror galvonometer with a 14-cm scale, and it has a case of very modern style. This instrument is also the basis of a new instrument, the 'Scalamp' fluxmeter, which can be used with a high resistance, and so a small, search coil. The full-scale reading is 700,000 lines, and readings can be estimated to 1,000 lines. The galvanometer is available for independent use with a current sensitivity of 1,000 mm/μA and a period of 15-20 sec.

This firm is also making an instrument of similar external appearance but quite different inside. This is an electrostatic voltmeter of unconventional type. A light vane is mounted on a taut suspension of galvanometer type and near a fixed electrode. When a voltage is applied between the two, the vane rotates and deflects a beam of light to provide the indication on the scale.

Pye d.c. microvoltmeter.

Valve-Assisted Meters

Electronically-assisted meters are now used a good deal. This term is used in a broader sense than the valve voltmeter, for there are cases where meter and valves are combined in quite different ways. An example is the Pye D.C. Microvoltmeter. The meter movement has two coils on the same axis, one of which is in an a.c. field. Its pick-up is zero when it lies in the plane of the field, but when the coil moves either way an e.m.f. is induced in it. This is amplified and converted to d.c. in a phase-sensitive detector. The direct voltage to be measured is applied to the first coil, the resulting movement of both coils produces an alternating e.m.f. in the second, and the output of the detector is used to operate a micro-ammeter as an indicator. The sensitivity is 10 μV and the impedance 50 Ω.

Electronic Instruments model 26 valve voltmeter.

As an example of the valve voltmeter, the Electronic Instruments Model 26 may be mentioned. This covers the large range of 0·2-250 V a.c. or d.c., with an upper frequency limit of 200 Mc/s. A meter movement with a 6-in. scale is used, and there are two d.c. amplifiers each of two stages back-to-back in bridge formation. On d.c., an accuracy of better than ± 1·2% is claimed and a drift not exceeding ± 0·7% over 24 hours; the input resistance is 50 MΩ. On a.c., a diode probe is used for frequencies above 10 kc/s, but without the probe the range extends down to 30 c/s. In addition to the balanced amplifier, the power supply is stabilized.

This, incidentally, is a most marked trend, and voltage-stabilization is now by no means confined to special pieces of apparatus. It is hardly yet a matter of course in all measuring apparatus, but there are signs that it is becoming so. There are, too, many examples of stabilized power units for general laboratory work. The Advance voltage-regulating transformers are well known; they are now extended by the Volstat which is the combination of such a transformer with a variable auto-transformer, the combination providing an output variable from 0-260 V with a regulation of ± 1%. The output is 170 W with a total harmonic content of less than 5%.

However, a voltage-stabilized supply commonly means not stabilization of the a.c. but a d.c. stabilized supply. The Ediswan R 1095 unit supplies an output adjustable between 120 V and 250 V for a load of up to 50 mA. The output voltage changes by less than 0·15 V for a 10-V change of input or a 50-mA change of output current. The output resistance is 2 Ω only and the ripple 2 mV. Another unit is the EP 254, shown by Boulton Paul Aircraft. The output in this is 200-400 V at 0-80 mA. At a higher voltage, 300-1,100 V, the Ediswan R1184 is interesting in that it includes a corona-tube stabilizer. It gives a stability of 0·05% for 10% mains-voltage change, and a long-term stability of 0·25% over 1,000 hours.

Oscilloscopes

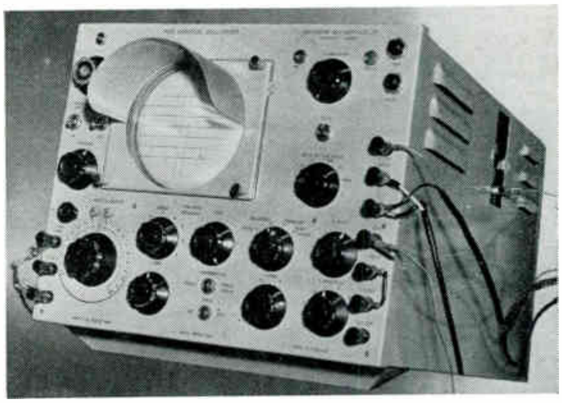
Perhaps the most generally useful laboratory tool, especially to those working with non-sinusoidal waveforms, is the cathode-ray oscilloscope. Except for the smaller models, there is a tendency for them to become more and more complex devices. As an example, the Philips high-speed oscilloscope includes a Y-amplifier with a 3-db response of 15 c/s to 10 Mc/s with a gain of 100 times. The rise time is stated to be 40 mμsec, with little overshoot. A frequency-compensated stepped attenuator is included, and there is a built-in voltage calibrator. The X-deflection velocity is variable continuously and in steps, and can be synchronized externally, internally from the signal, or from a built-in pulse generator. A 1-Mc/s generator is included to provide a time-base calibration to 2%.

The Southern Instruments Type 950 has a d.c. Y-amplifier with a response up to 250 kc/s within ± 0·5 db at the full gain of 1,200 times. A 5-in. tube is used, normally operating at 2 kV; it is of the post-acceleration type and an additional 3 kV can be switched on to the accelerator when required. The time-base can be operated triggered or single-stroke and has a frequency range of 0·5 c/s to 100 kc/s.

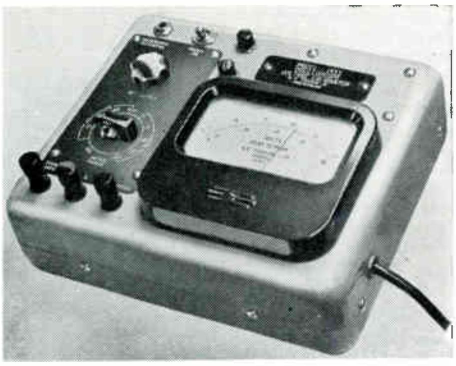
Furzehill Instruments also have a d.c. Y-amplifier. In the 1684D/2, the amplifier can be used to provide a sensitivity of 0·15 cm/mV up to 1 Mc/s or of 0·05 cm/mV up to 3 Mc/s, the change being effected by altering an internal link. An X-amplifier is included and permits sweep expansion up to five diameters, and the time-base is synchronized through a limiting amplifier.

Airmec adopt an unusual arrangement in the 723 oscilloscope, for the 4-in. flat-screen tube is mounted with its screen horizontal and viewed through a surface-aluminized mirror. This is done so that a recording camera can be permanently mounted above the tube. The time-base operates at speeds up to 1 μsec for full deflection and the Y frequency response is within ± 2 db from zero to 5 Mc/s.

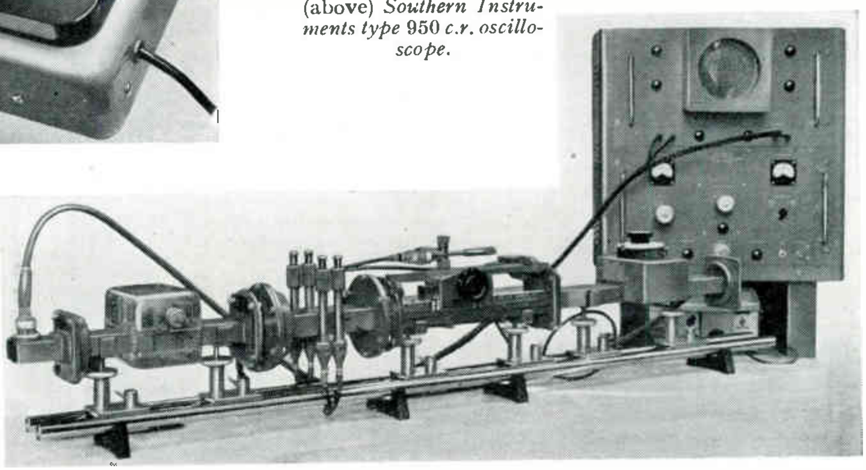
An adjunct to the oscilloscope is a pre-amplifier shown



(above) *Southern Instruments type* 950 *c.r. oscilloscope.*

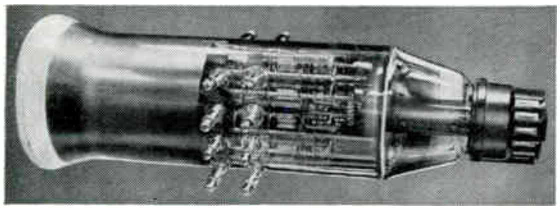


(above) *Cossor model* 1433 *voltage calibrator for oscilloscopes.*



(right) *Decca microwave test bench with oscilloscope display on Smith chart.*

by Cossor. This is the model 1430 and covers zero to 30 kc/s with a gain of 50 and a maximum output of 3 V p-p. Provision is made for a calibration signal of 1 mV. There are two stages of balanced amplification with cathode followers at input and output. The amplifier is battery-operated.



20th Century Electronics four-gun c.r. tube.

Another accessory which is becoming more generally available is the oscilloscope calibrator which basically comprises a source of alternating voltage of known peak-to-peak amplitude and an attenuator. One example is the Cossor Model 1433, which provides an output of 3 mV to 100 V; the accuracy claimed is $\pm$ 3%.

Forms of oscilloscope are, of course, widely used for display purposes in other apparatus. An unusual kind of display is that used with the Decca microwave test bench, for the tube gives a direct reading on a Smith chart. The guide has two pairs of probes spaced by $\lambda/4$, staggered by $\lambda/8$, and the outputs from their detectors provide the X and Y deflections. The Smith

Mullard GD 16-21 radar c.r. tube.

chart provides the graticule. The guide is fed from a swept-frequency oscillator.

A new tendency in waveform display is to use numbers of miniature c.r. tubes built in to apparatus to show the waveforms at strategic points. Several pieces of apparatus, including banks of six or more such c.r. tubes, were shown. This has come about through the introduction of the Emitron 1CP1 tube with a screen diameter of 25 mm. It is designed for operation at 500 V to 800 V, and has a deflection sensitivity of about 100 V_{a3} mm/V. The tube is self-focused and needs no external focus control. In addition to its monitor application, it lends itself well to use in a miniature oscilloscope.

At the other end of the scale in oscilloscope tubes are the 20th Century Electronics types for precision work. They have flat screens, ground and polished on both sides, and have been made for some years in single- and double-gun types. This year, a four-gun tube was shown; it provides four independent electron beams, and the four sets of Y-plates are brought out to horns on the neck of the tube.

A development in radar tubes is the Mullard GD 16-21. It is intended for use with an A-display and has a rectangular face of normal width, but of greatly-reduced height, so considerably reducing the space required. It is for electrostatic deflection. Mullard also showed a development in cathode construction which is being

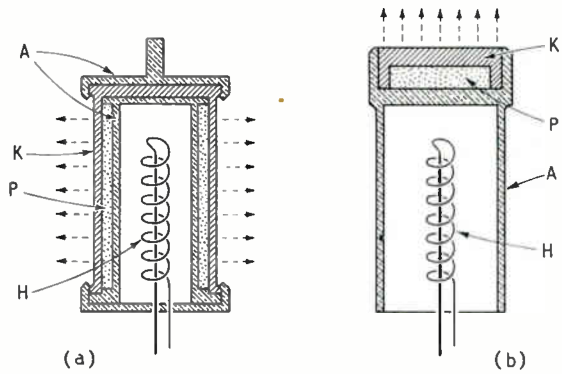
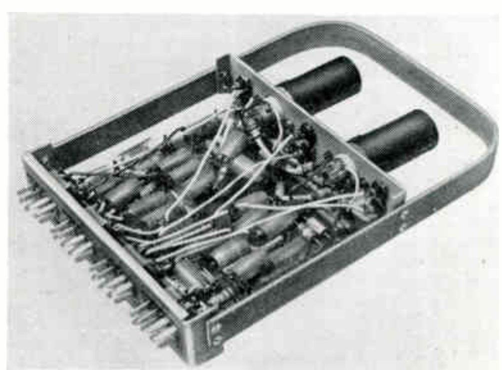


Fig. 2. *Mullard L cathode.*

used in some cathode-ray tubes and special valves. The cathode itself (K, Fig. 2) is of sintered tungsten and is porous. It is held in a molybdenum case A, enclosing the heater H. Beneath the cathode proper is a pellet P of the oxide material. This permeates the cathode to form a molecular layer on its outer surface. The two forms shown in Fig. 2 are for a valve and a cathode-ray tube.

Of recent years, new fields of application for valve circuits have opened up in atomic research and in computing. Different as the two things are, they both depend very much upon similar forms of basic circuit. However, for counters and scalers, the gas tubes of the Dekatron and Nomotron types are becoming widely used since they give decade counts more simply



Plug-in unit of Elliott computer.

than the multivibrator. Among the very many units of this type exhibited, the Ekco N530 Autoscaler is of interest, for it includes a stabilized high-voltage supply for a G.M. tube, an input amplifier and a pulse-height discriminator. It has an input resolution of 5 μsec and only counts pulses exceeding the preset level of 5-50 V.

The computer 401 shown by Elliott has been developed for the National Research Development Corporation. It measures 13 ft $\times$ 2 ft $\times$ 7 ft 6 in., requires a 5-kVA 3-phase power supply and includes about 500 valves. A feature of the machine is the way in which most of the valve circuits are divided into individually small and simple plug-in units of quite a few types. The main 'store' is a rotating magnetic disc having eight tracks, each carrying 128 'words' of 32 binary digits. The disc rotates at 4,600 r.p.m., giving a digit rate of 333,000 per second. Three further tracks on the disc are provided for 'address' information and timing signals. One-word length magnetostriction delay lines are used as storage loops for the arithmetic registers. The input is by punched tape and the output is obtained from an electrically-operated typewriter at 10 characters per second.

The application of television technique to microscopy continues. In the Pye-Cathodeon apparatus a standard microscope is used, and the optical image is projected on to a photo-sensitive surface which converts it into an electrical signal. It is then amplified and displayed on a c.r. tube.

In the Cinema-Television system scanning is used. The specimen is viewed by a photo-cell and illuminated by the raster produced on the end of a flying-spot scanner tube. The raster is, of course, reduced optically to suit the size of the specimen.

NEW BOOKS

Filter Design Data for Communication Engineers

By J. H. Mole, Ph.D., A.C.G.I., D.I.C., A.M.I.E.E. Pp. 252 + xvi with 127 figures and charts and 56 tables. E. & F. N. Spon, Ltd., 22 Henrietta Street, London, W.C.2. Price 63s.

This is not another text-book on filters, but—as stated in its title—a collection of filter-design data. With one small exception, it is concerned only with image parameter (Zobel) filters. It is intended for readers with an "elementary knowledge of the principles of line transmission and of filters such as is usually given in University Courses in Electronics or Telecommunications." The purpose of the book is stated as follows:—"Existing text-books on filters concentrate on theoretical principles and give comparatively little attention to the needs of the practical designer; the present work is an attempt to supplement them by providing in a convenient form charts, tables and formulae which have been selected or constructed so as to lighten the labour of calculation as much as possible."

The outcome of this 'attempt' is an extremely useful—and rather unusual—book which fills a definite gap in the present literature on filters (this remains true even if one does not completely agree with the remarks, quoted above, on existing text-books). The formulae and tables, and particularly the charts—many already known but some published here for the first time by Dr. Mole—are most impressive; their practical value is further increased by their appearing together in a single volume. In most cases only results but no derivations are given. Where the formulae and methods recommended are only of approximate validity, limitations and maximum errors are stated. The chapter headings are:—1. Introduction (terms and symbols, the design process, computation, bibliography); 2. Low-pass, high-pass, symmetrical band-pass and band-stop sections; 3. Dissymmetrical band-pass filters; 4. Impedance transformation; 5. Junction losses; 6. Calculation of effective loss; 7. Design of terminal sections; 8. Tchebycheff behaviour of stop-band attenuation; 9. The effects of dissipation; 10. Tolerances on element values (effect of a small change in the value of a component, statistical addition of effects); 11. Tables of useful functions; 12. Simpler filters with Tchebycheff behaviour of pass-band loss.

One may regret that in a modern book on filter design the concepts and methods of the insertion parameter method—which also lead to a deeper understanding of some image parameter problems—have been excluded (Chapter 12 in which half and full sections and coupled circuits are discussed, is very useful but not representative of modern insertion parameter methods). However, by deliberately restricting himself to image parameter problems Dr. Mole has produced a book much more uniform in conception and style than would otherwise have been possible, as "to understand these (insertion parameter) methods, a greater knowledge of mathematics than is possessed by the majority of design and development engineers is needed." More regrettable is the exclusion, without any references, of important image parameter techniques like the template method of adding attenuation-frequency curves due to Laurent and Rumpelt and described by Scowen and the methods due to Payne and Bode (1930) and Bode (1941) for connecting filters in parallel (only x-terminations, with susceptance annulling, are described in Chapter 7). On the other hand, the discussion, in the same chapter, of the loop loss of filters connected in parallel is very useful indeed.

Some of the most interesting novel charts (in Chapters 1, 8 and 9) are used to determine the best value of the nominal cut-off frequency f_1 in a low-pass filter design problem (the book makes full use of frequency transformations for converting low-pass filter solutions into solutions for any other type of filter). No analytic method for finding f_1 in terms of specified loss-frequency requirements has so far been found and f_1 has ordinarily to be obtained by trial-and-error. Dr. Mole attacks this important practical problem in a novel and ingenious way. By comparing a number of calculated attenuation-frequency curves he obtains *empirical* relations which not only give the best value of f_1 but also lead directly to the m-values of a suitable filter.

It is impossible to mention all other points of particular interest, but one more example will be given: the study of tolerance effects and their statistical addition seems to be entirely new and may attain great practical importance. One wonders, however, whether readers with limited mathematical knowledge will always be able to apply correctly the very compressed statistical information given in Chapter 10.

Utmost compression—the omission of proofs, and only very brief comments and captions—is a characteristic of the book as a whole, which makes it necessary to study it with great care. Its usefulness could be very much increased by providing a more detailed bibliography and by a relaxation of the 'austerity' standards applied to some of the explanatory material. This would also enable the reader to correct various printing errors and ambiguities—which in a chart collection of this magnitude are probably unavoidable—with much more confidence than if he is given bare instructions only. Thus, in the case of Figs. 2, 3, 4 and 71, which give the 'basic' number n of elements necessary to meet a minimum image attenuation A_2 in the stop band and a maximum attenuation A_1 in the pass band, it would seem desirable to state more clearly that a consideration of insertion loss rather than image attenuation in the pass band would in many cases lead to more than n elements. In the case of the explanation, on p. 19, of Fig. 11 the apparently arbitrary change from $\tanh a = m/m_1$ to m_1/m; could be made much clearer by a reference to Table 1 which shows that $\tanh a = T^{\pm 1}$ for $m >< m_1$ where $T = m_1/m$; in the caption to this figure a statement that a is the image attenuation of a *half*-section would be of help ('m_2' should presumably read 'm').

These are mostly minor points—which could be corrected in later editions—in a very valuable addition to the literature on filters. "Filter Design Data" will be of great help to the designer and also a challenge to the reader to supply the missing derivations.

W. S.

Mikrowellenbandfilter im Hohlleiter

By Dr. F. S. Atiya. Pp. 99 with 70 illustrations. Verlag Leemann, Zürich. Price 12.50 Fr. (Swiss).

This book on Microwave Band-Pass Filters in Waveguides is the thesis written by the author for the D.Sc. degree of the Zürich Technische Hochschule, based on research work carried out at that institution. At very high frequencies very efficient band-pass filters can be made up of a chain of waveguide resonators coupled either directly or by quarter-wave sections. The experiments were made at a wavelength of 15 cm but similar filters would be very suitable for wavelengths of 1 to 10 cm. Beginning with a low-pass ladder, the theory of waveguide resonators, methods of coupling them, the losses and consequent damping, and the synthesis of a filter to meet given conditions are all developed very fully. Numerical examples are worked out, experiments made on filters of from two to six resonators are described and discussed. The author classifies the filters according to the shape of the response curve as (a) maximally flat, (b) quasi-Tschebyscheff, and (c) Tschebyscheff. He says that he calls class (b) quasi-Tschebyscheff because under certain conditions they show "Tschebyscheffsches" behaviour. We may mention, as a matter of general interest, that in the original Russian this man's name contains only seven letters, and the leading authorities in this country and in America, including the British Academy and the Russian Union Catalogue, spell the name Chebyshev.

The author claims that the synthesis of a class (b) filter with n resonators is new and that this type needs a much smaller number of resonators than the class (a) type; in one case only six instead of fifteen. Many sets of curves are given to enable filters to be designed with a minimum of calculation.

This book can be unreservedly recommended to anyone interested in the subject.

G. W. O. H.

INSTITUTION OF ELECTRONICS

The eighth annual Electronics Exhibition organized by the North-Western Branch of the Institution of Electronics will be held at the College of Technology, Sackville Street, Manchester from 15th-21st July 1953.

It will be open from 12 noon until 10 p.m. on the 15th; 10 a.m. until 10 p.m. on the 16th, 17th and 20th; 10 a.m. to 7 p.m. on Saturday the 18th and 10 a.m. to 9 p.m. on the 21st.

Lecture tickets and programmes and exhibition tickets will be available (stamped addressed envelopes) after 1st June from the honorary exhibition organizing secretary, W. Birtwistle, 17 Blackwater Street, Rochdale, Lancs.

I.E.E. MEETINGS

13th May. "Recent Work in France on New Types of Valve for the Highest Radio Frequencies," Radio Section Annual Lecture by Dr. R. Warnecke and Monsieur P. Guenard.

19th May. "Measurement with the Flying-Spot Microscope," postponed Measurement Section Annual Lecture by Professor J. Z. Young, M.A., F.R.S.

These meetings will be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2 and will commence at 5.30.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for March 1953

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

The values are based on astronomical data available on 1st April 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.

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.

ACOUSTICS AND AUDIO FREQUENCIES

534 : 061.4 1218

The 1952 Audio Fair in Review.—H. K. Richardson. (*Audio Engng*, Dec. 1952, Vol. 36, No. 12, pp. 26–28 . . 60.) Alphabetical list of firms represented, with notes of their exhibits.

534.15 1219

Study and Representation of a Complex Musical Tone.—A. Moles. (*Ann. Télécommun.*, Nov. 1952, Vol. 7, No. 11, pp. 430–438.) Discussion of the representation of a complex tone by a 3-dimensional diagram involving the three parameters:—pitch, intensity or level above threshold of audibility, and duration. Analysis of the three projections of the 3-dimensional representation furnishes some rules for coding in the transmission of information representing any particular complex tone. An experimental method of determining the parameters of the 3-dimensional representation is outlined and the application of autocorrelation theory is briefly considered.

534.232 1220

The Absorption Surface of Acoustic Radiators and Radiator Arrays.—F. A. Fischer. (*Akust. Beihefte*, 1951, No. 1, pp. 7–8.) The absorption surface of an acoustic radiator of arbitrary size is calculated as a function of wavelength, and its relation to Stenzel's compression factor is demonstrated.

534.232 1221

The Relation between Directivity Characteristic and Amplitude Distribution for Linear and Plane Radiator Systems.—F. A. Fischer. (*Akust. Beihefte*, 1951, No. 1, pp. 9–11.) Analysis shows that a given characteristic can be produced by an infinite number of different amplitude distributions.

534.321.9 : 534.23 1222

Ultrasonic Absorption in Mixtures of Ethyl Alcohol and Water.—L. R. O. Storey. (*Proc. phys. Soc.*, 1st Dec. 1952, Vol. 65, No. 396B, pp. 943–950.) Report of measurements using a pulse method, with operating frequencies of 22·5, 37·5 and 52·5 Mc/s and temperatures of 0°, 10° and 25°C. Results are discussed in relation to the theory of the absorption mechanism.

534.321.9 : 534.6 1223

Interferometer Arrangements for the Detection of Ultrasonic Waves.—C. Rossetti. (*C. R. Acad. Sci., Paris*, 10th Dec. 1952, Vol. 235, No. 23, pp. 1484–1486.) Results of experiments are noted on the generation of standing waves by reflection in a gas column excited by a crystal X_1 oscillating at about 1 Mc/s. When the reflecting surface is a crystal X_2, similar to X_1 and coupled electrostatically to it, the distance between X_1 and X_2 for successive voltage minima across X_2 is a multiple of λ. In air, minima are sharply defined; in CO_2, which has high absorption, the response of X_2 as a function of displacement is roughly sinusoidal.

534.321.9 : 534.614 1224

Measurement of the Temperature Dependence of the Velocity of Sound in Water and Heavy Water and in Mixtures of Water and Ethyl Alcohol.—P. P. Heusinger. (*Akust. Beihefte*, 1951, No. 1, pp. 3–6.) A modification of the fixed-path ultrasonic interferometer method of Bender (443 of 1941) is used in which no thermostat is required. Results are shown in graphs.

534.321.9 : 534.614 1225

A Method for Determining the Velocity of Ultrasonic Waves in Solids.—N. F. Otpushchennikov. (*Zh. eksp. teor. Fiz.*, April 1952, Vol. 22, No. 4, pp. 436–439.) A method is proposed based on Rayleigh's law for determining the coefficient of reflection of a sound wave incident normally on a nonabsorbing plate. Using this method, the velocity of ultrasonic waves of frequency 3·3 Mc/s was determined for Al, Mg, glass, methyl methacrylate and ebonite.

534.41 1226

A Development of the Tone-Pitch Recorder having Applications to Phonetics Research.—W. Kallenbach. (*Akust. Beihefte*, 1951, No. 1, pp. 37–42.) A modification of the arrangement described by Grützmacher & Lottermoser (590 of 1938) enables vowels and consonants to be distinguished by their effect on the intensity of the beam in the c.r. tube.

534.442.2 1227

Frequency Analyser with Mechanical High-Frequency Filter.—K. Tamm & I. Pritsching. (*Akust. Beihefte*, 1951, No. 1, pp. 42–48.) A heterodyne analyser is described incorporating a filter consisting of two coupled steel resonators giving a pass band of width 15 c/s at 40 kc/s and capable of discriminating between frequency components separated by as little as 25 c/s and differing in level by 40 db. Analysis over the frequency range 0–20 kc/s can be effected in 150 sec by use of the automatic drive.

534.61 **1228**
Multiple-Rayleigh-Disk Mesh Arrangement for increasing Measurement Sensitivity.—L. Keidel. (*Akust. Beihefte*, 1951, No. 1, pp. 34–36.)

534.75 **1229**
Contribution to a Scientific Theory of Single-Channel Transmission of Sound.—P. Burkowitz. (*Funk u. Ton*, Nov. 1952, Vol. 6, No. 11, pp. 561–580.) Relations between the physical, physiological and psychological aspects of the problem are investigated. See also 2419 of 1952.

621.395.616 **1230**
New High-Grade Condenser Microphones.—F. W. O. Bauch. (*Wireless World*, Feb. & March 1953, Vol. 59, Nos. 2 & 3, pp. 50–54 & 111–114.) Description of the Type-M49 and Type-M50 microphones [see also 893 of 1952 (Grosskopf)] and of the Type-U47, a gradient microphone offering the choice of cardioid or omnidirectional characteristics.

AERIALS AND TRANSMISSION LINES

621.392.26 **1231**
The Visual Observation and Photographing of the Radiation from Waveguides.—D. I. Penner. (*C. R. Acad. Sci. U.R.S.S.*, 11th Dec. 1951, Vol. 81, No. 5, pp. 819–820. In Russian.) The waveguide is excited by means of a vibrator with spark-discharge gap, and the field pattern is made visible by use of metal powders.

621.392.26 : 538.614 **1232**
Faraday Rotation of Guided Waves.—H. Suhl & L. R. Walker. (*Phys. Rev.*, 15th Dec. 1952, Vol. 88, No. 6, p. 1435.) Correction to paper noted in 2710 of 1952.

621.396.6 : 621.392.21.029.64 **1233**
Manufacture of Microstrip.—(See 1269.)

621.396.67 **1234**
Folded Dipoles of Two or More Elements.—R. Guertler. (*Proc. Instn Radio Engrs, Aust.*, Nov. 1952, Vol. 13, No. 11, pp. 389–392.) Formulae previously derived (556 of 1950) are developed to give the impedance transformation of folded dipoles having two, three or four elements. Design charts based on the formulae are presented.

621.396.67 **1235**
The Input Impedance of Thick Cylindrical Aerials.—H. W. Ehrenspeck. (*Fernmeldetech. Z.*, Nov. 1952, Vol. 5, No. 11, pp. 497–501.) The results of measurements of the complex input impedance of thick vertical aerials are presented in curves, and a general diagram is deduced which gives the complex input impedance for any length of aerial, the reduction factor for $\lambda/4$ and $\lambda/2$ resonance, the mean characteristic impedance and the wide-band properties of cylindrical aerials of diameter from $0{\cdot}01\lambda$ to $0{\cdot}17\lambda$. Numerical values are determined for a $\lambda/2$ aerial of diameter 2 cm for $\lambda = 40$ cm.

621.396.67 : 621.397.6 **1236**
High-Gain Loop Antenna for Television Broadcasting.—A. G. Kandoian, R. A. Felsenheld & W. Sichak. (*Elect. Commun.*, Dec. 1952, Vol. 29, No. 4, pp. 268–277; *Tele-Tech*, Nov. 1952, Vol. 11, No. 11, pp. 42–44 . . 132.) An extension of a previous design (1209 of 1952) for the 174–216-Mc/s band whereby 16 elements, each comprising three folded dipoles, are stacked one above another on an 80-ft lattice structure. 'Isolation' rings around the mast reduce the coupling effect between adjacent pairs of elements. A diplexing unit is described and performance characteristics are discussed. Power gain relative to a $\lambda/2$ dipole is 17.

621.396.67 : 621.397.62 **1237**
Receiving Aerials for British Television.—F. R. W. Strafford. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 631–642. Discussion, pp. 645–650.) Six different methods of analysis are considered; the proximity of an aerial to the earth and the presence of the necessary feeder render agreement between experimental measurements and calculations based on any of the theories rather fortuitous. The properties of 2-element and 4-element arrays are discussed and also indoor aerials. The problem of ghost images due to multipath propagation, and difficulties of reception in hilly country, where the image due to reflection may be stronger than the direct-transmission image, are briefly considered. Mechanical design is also treated.

621.396.67.001.11 **1238**
On the Calculation of Some Definite Integrals in Antenna Theory.—H. L. Knudsen. (*Appl. sci. Res.*, 1952, Vol. B3, No. 1, pp. 51–68.) If the expression for the mutual radiation resistance obtained by the Poynting vector method (32 of January) for two identical linear aerials is equated to that obtained by the e.m.f. method, a useful formula may be obtained which expresses a definite integral in terms of known functions. An outline of this procedure is given for the simple cases of two parallel and two collinear identical aerials.

621.396.67.018.424 **1239**
Experimentally Determined Radiation Characteristics of Conical and Triangular Antennas.—G. H. Brown & O. M. Woodward, Jr. (*RCA Rev.*, Dec. 1952, Vol. 13, No. 4, pp. 425–452.) Impedance and radiation measurements, mostly at 500 Mc/s, were made on conical and triangular aerials constructed of copper-plated sheet steel. For various flare angles and aerial lengths, graphs of resistance, reactance and relative field strength are given, and the power gain relative to a $\lambda/2$ dipole is calculated. Measurement results agree reasonably well with values calculated by Papas & King (1307 of 1951).

621.396.677 + 621.385.029.6 **1240**
Attenuation of Wire Helices in Dielectric Supports.—Peter, Ruetz & Olson. (See 1523.)

621.396.677 **1241**
Factors affecting the Performance of Linear Arrays.—L. L. Bailin & M. J. Ehrlich. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 235–241.) Discussion mainly of the deterioration of side-lobe level due to variations in the excitation of the individual elements of an array arising from manufacturing inaccuracies. Analysis is presented for three 24-element linear shunt-slot arrays using a Dolph-Tchebycheff distribution for the element excitations [2487 of 1946 (Dolph)], the arrays being designed for the X band, with side lobes 20, 30 and 40 db down respectively.

621.396.677 **1242**
Electromagnetic Horn Radiators with Phase-Correcting Microwave Lenses.—K. Hurrle. (*Arch. elekt. Übertragung*, Dec. 1952, Vol. 6, No. 12, pp. 502–506.) Experiments are reported on a pyramidal horn having a flare

angle of 32° and a mouth 64 cm × 64 cm with a circular opening of diameter 55 cm. Measurements were made on a wavelength of 6·1 cm, (*a*) without phase correction, (*b*) with a delay lens made of metal louvres in the opening, (*c*) with a paraffin lens. The radiation patterns obtained clearly show the improvements in gain and directivity due to the phase correction.

621.396.677 **1243**
A Theoretical Study of an Antenna-Reflector Problem.—W. C. Jakes, Jr. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 272–274.) Discussion of systems used at microwave relay stations in which an aerial with circular aperture, facing upwards, receives incoming energy from a plane reflector immediately above it and inclined at 45°. Analysis shows that for certain values of λ, distance between aerial and reflector, aerial aperture and size of reflector, the received power is greater than when the aerial is used alone in the position of the reflector. See also 936 of April (Unger).

621.396.677 : 537.226 **1244**
Longitudinal Radiation of Dielectric Aerials.—J. C. Simon & G. Weill. (*C. R. Acad. Sci., Paris*, 1st Dec. 1952, Vol. 235, No. 22, pp. 1379–1381.) A calculation is made of the field at infinity and the total radiated power for the simple case of a plane wave crossing a boundary between media of different refractive indices. The results are applied to determine the radiation from a dielectric-rod aerial as a function of the phase velocity of the field along the aerial. The calculated results have been verified experimentally.

621.396.677 : 621.396.9 **1245**
Parabolic Aerial with Rotating Beam.—G. von Trentini. (*Rev. telegr. Electronica, Buenos Aires*, Sept. 1952, Vol. 41, No. 480, pp. 579–581.) A radar aerial system for operation at a wavelength of 3·21 cm comprises a parabolic Al reflector of diameter 40 cm and focal length 17·8 cm with a brass disk of 9 cm diameter arranged 18·1 cm in front of the vertex of the parabola. Energy is fed through a rotating circular waveguide projecting through the parabola and inclined at a small angle to the axis. Measurements on the system are reported.

621.396.677.029.64 **1246**
An Experiment on a Plane Microwave Diffraction Grating.—L. Grillini. (*Nuovo Cim.*, 1st Dec. 1951, Vol. 8, No. 12, pp. 952–959.) Observations of the Fraunhofer pattern are reported for a metal-strip grating, using a wavelength of 3·2 cm. Results are substantially different for the cases of electric vector respectively parallel to or perpendicular to the strips.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.015.3 **1247**
Initial Conditions in Transient Analysis.—L. Tasny-Tschiassny. (*Wireless Engr*, Feb. 1953, Vol. 30, No. 2, pp. 28–31.) In a paper on network theory (37 of 1946) Lee & MacDonald indicated the equivalence of a charged capacitor and the series combination of an uncharged capacitor and a battery; extension of this idea to consideration of inductors leads to a simple method of analysing initial conditions. The method is elucidated by two theorems and examples; the Laplace-transform treatment is used.

621.3.015.3 : 621.392 **1248**
Transient Conditions.—P. Poincelot. (*C. R. Acad. Sci., Paris*, 10th Dec. 1952, Vol. 235, No. 23, pp. 1492–1494.) By transformation of the Fourier integrals to obtain a series development of Bessel functions, expressions have been derived for certain transient-response characteristics. These include the response of a low-pass and a high-pass *LC* ladder filter, and of a homogeneous transmission line, to unit-step and sinusoidal voltage input, when the system is terminated by its image impedance.

621.3.018.78 **1249**
Reduction of Carrier-Frequency Build-Up Process to a Complex Low-Frequency Process.—J. Peters. (*Arch. elekt. Übertragung*, Dec. 1952, Vol. 6, No. 12, pp. 513–514.) The Laplace-transform method is used. By applying the displacement law, the distortion of a carrier envelope due to a linear transmission element can be calculated directly. Vestigial as well as symmetrical sideband systems can be dealt with in this way.

621.314.22.015.7 **1250**
A Turns Index for Pulse-Transformer Design.—H. W. Lord. (*Elect. Engng, N.Y.*, Nov. 1952, Vol. 71, No. 11, p. 978.) Summary only. By assuming certain ratios between core and coil dimensions which represent average values of normal practical designs, it is found possible to generalize design relations so that coil and core dimensions are eliminated from first-design considerations, the only parameter remaining being that of the turns of the windings. For a step-up pulse transformer of ratio $> 3 : 1$, a formula is given for the number of turns on the secondary in terms of performance requirements and properties of the dielectric and magnetic materials used. The formula was checked against actual values for existing transformers covering a range of pulse widths from 0·05 to 10 μs and secondary voltages from 15 to 100 kV.

621.314.3† **1251**
A Mathematical Analysis of an Inductively Loaded Parallel-Connected Magnetic Amplifier.—L. A. Pipes. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1358–1361.)

621.316.543.2 : 621.392.26 **1252**
A Multichannel Switch for Operation in a Microwave Circuit.—H. M. Barlow & H. G. Effemey. (*J. sci. Instrum.*, Nov. 1952, Vol. 29, No. 11, pp. 378–379.) Description of a rotating-disk type of switch for c.r.o. display of a rapid succession of pulses picked up by a number of probes arranged at different points along a waveguide passing 3-kMc/s signals.

621.316.8 **1253**
E-C Glass Resistors.—J. K. Davis. (*Tele-Tech*, Nov. 1952, Vol. 11, No. 11, pp. 55, 120.) Discussion of performance characteristics of highly stable resistors consisting of a thin conductive coating on heat-resistant glass. Ratings range from ½ W to 45 W. Resistance change is $< 0{\cdot}2\%$ for temperature cycles between $-55°$ and $+200°$C.

621.318.435.3 **1254**
The Design of Single-Phase Transductors.—H. A. Ross. (*Aust. J. appl. Sci.*, Dec. 1952, Vol. 3, No. 4, pp. 277–292.)

621.318.57 **1255**
A Ferromagnetic Scaling Circuit.—C. H. Hertz. (*Ark. Fys.*, 23rd Aug. 1952, Vol. 5, Parts 1/2, pp. 141–161.) Each incoming pulse triggers the discharge of a capacitor through the primary coil on an iron-wire core. The maximum voltage of the pulse induced in the secondary depends on the core magnetization, and thus on the number of incoming pulses. On reaching a preselected level, a thyratron is fired and operates a mechanical

counter, the core being restored to its initial state of magnetization. Scales of up to 10 : 1 are stable in operation. Design details and theory are discussed.

621.318.572 **1256**

Gated Decade Counter requires No Feedback.—E. L. Kemp. (*Electronics*, Feb. 1953, Vol. 26, No. 2, pp. 145–147.) Decade counting is achieved in a system using binary-type counting circuits by arranging that eight pulses are directed into one storage circuit and the next two pulses into a second storage circuit, after which the system resets itself.

621.318.572 : 621.3.015.7 **1257**

Counting Pulses of Various Forms and Occurrence Intervals by Electronic Counters.—N. F. Roberts & L. T. Wilson. (*Aust. J. appl. Sci.*, Dec. 1952, Vol. 3, No. 4, pp. 263–276.) Modifications to univibrator circuits are described which prevent retriggering during the recovery period, or provide a retriggering characteristic permitting the recording of overlapping pulses, or both.

621.392.4/.5 **1258**

Maximum Power in Termination Impedors.—M. Skalicky. (*Elektrotech. u. Maschinenb.*, 1st Nov. 1952, Vol. 69, No. 21, pp. 479–480.) An analytical proof that power is a maximum when the resistive component of the load is equal to the internal resistance of the source, and the reactive components cancel out. The principle can be extended to the case of a quadripole by reformulating the Helmholtz equations.

621.392.41 **1259**

The Power of Nonsinusoidal Systems.—E. Astuni. (*Ricerca sci.*, Nov. 1952, Vol. 22, No. 11, pp. 2139–2147.) A calculation is made of the instantaneous power absorbed by a series LRC circuit with a nonsinusoidal periodic applied voltage. The square of the apparent power is the sum of the squares of all the component powers for all the harmonics, including so-called 'mutual' terms involving harmonics of different order.

621.392.43 : 621.392.26 : 621.315.212 **1260**

The Optimum Piston Position for Wide-Band Coaxial-to-Waveguide Transducers.—W. W. Mumford. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 256–261.) Matching of a coaxial line to a waveguide can be effected by means of a probe located ahead of a short-circuiting piston in the waveguide. Matching can usually be achieved by varying any two of the following dimensions: (*a*) off-centre distance of the probe, (*b*) probe length, (*c*) distance from piston to probe. As there is, theoretically, an optimum piston position giving greatest bandwidth, it is convenient to vary dimensions (*a*) and (*b*). Experimental results are quoted which corroborate the theory. Bandwidths $> \pm 10\%$ to the 1 db s.w.r. points were obtained.

621.392.5 **1261**

A Highly Stable Variable Time-Delay System.—Y. P. Yu. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 228–235.) Description, with detailed circuit diagrams, of delay systems in which distributed amplification is used to compensate the losses in the linear delay elements. Time jitter is extremely low. Two practical circuits have maximum delays of 12 μs (1 μs per step) and 88 μs (4 μs per step) respectively.

621.392.5 **1262**

Theory of the Compensated Delay Line.—R. Ascoli. (*Nuovo Cim.*, 1st Dec. 1951, Vol. 8, No. 12, pp. 914–927.) Analysis based on an equivalent ladder network indicates that for a certain compensating capacitance a constant delay can be obtained over a predetermined frequency range. Calculations are made for compensating rectangular-plate capacitors; results are presented in a graph useful for design. The results are in good agreement with those of Kallmann (41 of 1947) and others.

621.392.5 **1263**

Synthesis of 2-Terminal-Pair Networks.—R. Kahal. (*Elect. Engng, N.Y.*, Nov. 1952, Vol. 71, No. 11, p. 1014.) Summary only. To realize a quadripole ladder network comprising only reactive elements and with prescribed transfer function, five general conditions must be satisfied. These are discussed with particular reference to the synthesis of a ladder network consisting of a number of L sections in cascade, all the sections except one comprising only inductors and capacitors. A simple method of completely determining the transfer function of such a network is outlined.

621.392.5 **1264**

Four-Terminal Networks.—O. P. D. Cutteridge. (*Wireless Engr*, March 1953, Vol. 30, No. 3, pp. 61–69.) A rigorous theory of passive quadripoles in the steady state is presented. The general quadripole is regarded as consisting of n meshes, and the equations for the system as a whole are obtained by solving the equations for the meshes. Iterative and image impedances are obtained as properties of a single quadripole, and a suitable propagation function is associated with each pair of impedances. Conditions in quadripoles in two types of cascade arrangement can be deduced immediately from the equations for a single quadripole. Tables are included giving expressions for the image functions in terms of the iterative functions, and vice versa, and giving the equations of the quadripole in terms of the iterative and image functions.

621.392.5.029.64 : 538.614 **1265**

New Linear Passive Nonreciprocal Microwave Circuit Component.—L. Goldstein & M. A. Lampert. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 295–296.) A note calling attention to the fact that the magneto-optic element producing the Faraday rotations previously reported by Goldstein et al. (2911 of 1951 and 914 of 1952) constitutes a network element of the Tellegen 'gyrator' type. See also 1233 of 1952 (Hogan).

621.392.51 **1266**

A Theorem on Ideal Transformer Networks.—É. Achard. (*Ann. Radioélect.*, Oct. 1952, Vol. 7, No. 30, pp. 237–251.) By applying the principle of duality to an impedance-inversion network a general theorem on ideal transformation of voltage, current, and both voltage and current is derived. Provided the resistive components of reactors are sufficiently small, the theorem may be applied in designing networks which can be tuned by a single control (*a*) through a range of frequencies with fixed transformation ratio, (*b*) to give a variable transformation ratio at a fixed frequency.

621.392.52 **1267**

Exact Amplitude/Frequency Characteristics of Ladder Networks.—E. Green. (*Marconi Rev.*, 1st Quarter 1953, Vol. 16, No. 108, pp. 25–68.) A basic theory of the low-pass ladder network is developed on similar lines to Dishal's treatment (3369 of 1949). The theory can be applied by well-known analogies to the derived band-pass, high-pass and band-stop filters. Two types of desired frequency response curves are considered, the Butterworth and Tchebycheff types; general solutions are obtained for both. The results are applied to many practical problems, including the use of networks for coupling a valve to a resistive load or to another valve, power/bandwidth and gain/bandwidth curves being determined for particular cases. Impedance matching between a generator and its load is also considered and matching networks are designed. Examples are also given of the design of low-pass and band-pass filters with either the Butterworth or the Tchebycheff type of response, many useful design curves being given.

621.392.52.072.6 **1268**

Alignment and Adjustment of Synchronously Tuned Multiple-Resonant-Circuit Filters.—M. Dishal. (*Elect. Commun.*, Dec. 1952, Vol. 29, No. 4, p. 292.) Addendum to article noted in 3038 of 1952.

621.396.6 : 621.392.21.029.64 **1269**

Manufacture of Microstrip.—(*Elect. Commun.*, Dec. 1952, Vol. 29, No. 4, pp. 250–259.) Illustrated description of processes in the manufacture of microstrip components. See also 621 (Grieg & Engelmann), 622 (Assadourian & Rimai) and 623 (Kostriza) of March.

621.396.611.1 **1270**

Automodulation in Ferroresonance.—A. E. Salomonovich. (*Zh. tekh. Fiz.*, Feb. 1952, Vol. 22, No. 2, pp. 245–258.) Automodulation of forced oscillations in ferroresonant circuits, i.e., circuits containing nonlinear reactive elements, is considered. The following examples are examined: (*a*) circuit with a thermistor; (*b*) circuit with a capacitor whose value depends on the field and on temperature; (*c*) an e.s. voltmeter connected to a ferroresonant circuit. The stationary operating conditions and their stability in such circuits are discussed, and the depth and period of automodulation are determined. The discussion is limited to cases in which the circuit is nearly of the linear conservative type and the variations of amplitude and phase are slow in comparison with the period of the external force.

621.396.611.1 : 621.3.016.352 **1271**

A Criterion of Stability for Oscillations in *n*-Mesh Networks with Varying Parameters.—W. Haacke. (*Arch. elekt. Übertragung*, Dec. 1952, Vol. 6, No. 12, pp. 515–519.) Analysis given previously (2470 of 1952) is generalized to apply to any network in which some or all of the capacitances or inductances vary periodically. Conditions necessary for the growth of free oscillations having small initial amplitudes are investigated. The system is represented by a determinant equation from whose roots the stability conditions are derived.

621.396.611.1.029.62/.63] : 621.392.21 **1272**

Fixed-Length Transmission Lines as Circuit Elements.—A. A. Meyerhoff & R. Graham, Jr. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 262–268.) Resonant systems consisting of fixed-length transmission lines with a capacitor at each end have decided advantages, compared with short-circuited transmission-line sections, for use at frequencies of the order of 50–500 Mc/s. Analysis is presented which leads to simple graphical determination of the line and capacitor parameters. The analysis is extended to include interstage coupling circuits and wide-band coupling of an aerial to the output stage of a transmitter. Numerical examples are given.

621.396.611.21 **1273**

The Measure of Activity for Oscillating Quartz Crystals in Parallel-Resonance Circuits.—H. Awender & K. Sann. (*Telefunken Ztg*, Nov. 1952, Vol. 25, No. 97, pp. 269–274.) The concept of 'performance index' is explained. This is the effective parallel resistance R_{pq} of the resonant crystal shunted by a specified capacitance. A method of measurement of R_{pq} is described. Load-current density should be specified when quoting R_{pq}.

621.396.611.21 : 621.3.016.352 **1274**

The Stability of Quartz Oscillators.—E. Kettel. (*Telefunken Ztg*, Nov. 1952, Vol. 25, No. 97, pp. 246–256.) Supposing a series-connected crystal in a resonant LC circuit to be short-circuited, the relative detuning F due to the presence of the crystal is termed the stabilization factor. Different arrangements of Meissner, Hartley and Colpitts circuits are considered. The most stable circuit is one in which F is a maximum compatible with oscillation and is independent of (*a*) change in the valve interelectrode capacitance and (*b*) the load current through the crystal. The properties of a circuit in which the crystal acts as an inductance are similar in all respects to those of a circuit with the crystal operating at series resonance.

621.396.611.21 : 621.3.016.352 **1275**

Methods for Improving the Frequency Stability of Transmitters.—Herzog. (See 1513.)

621.396.611.3 **1276**

Equations for the Natural Frequencies of Coupled Circuits from the Quadripole Viewpoint: Part 2.—H. Rukop. (*Telefunken Ztg*, Nov. 1952, Vol. 25, No. 97, pp. 216–228.) Theory previously given (78 of 1952) is extended to the case of a six-terminal network with both series- and parallel-connected resistance. The biquadratic equation for a coupled system is expressed by two binomials, one referring to the circuits uncoupled, the other 'occupation' binomial taking account of the coupling data. Two schemes for formulating this 'occupation' factor and associated expressions probably cover all cases of coupling by a single resistor.

621.396.611.3 : 621.396.619.13 **1277**

Quartz-Crystal Circuit with Variable Coupling as Oscillator and Discriminator.—E. Kettel. (*Telefunken Ztg*, Nov. 1952, Vol. 25, No. 97, pp. 265–269.) The principle of the f.m. oscillator described is the use of two coupled tuned circuits, the second of which has a crystal connected in parallel. A reactance valve drives the oscillator valve, which has the first circuit connected between anode and a capacitor connected to the grid, with anode feed to the centre-tap on the inductor. The relative frequency swing attainable is from 1 to 10 parts in 10^4. Impedance diagrams for the circuit are shown. The principle is also applied in a discriminator in which the centre-tap of the second-circuit inductor is connected through a large-value capacitor to the anode side of the first circuit, the coupling between the inductors being variable. The centre frequency of this discriminator is largely independent of the characteristics of the rectifying diodes.

621.396.615 **1278**

Wien-Bridge Oscillator Design.—K. K. Clarke. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 246–249.) A set of curves is presented which allows direct determination of design parameters of Wien-bridge oscillators and selective amplifiers.

621.396.615 **1279**

Perturbations of Filtered Oscillators.—G. Cahen. (*C. R. Acad. Sci., Paris*, 22nd Dec. 1952, Vol. 235, No. 25, pp. 1614–1617.) The amplifier of an oscillator is assumed to be filtered to isolate the fundamental frequency, so that the oscillator responds to excitation by a synchronous sinusoidal oscillation. An equation for the oscillator perturbations is developed which involves the partial derivatives of the gain and phase. From this equation, the existence of a synchronization threshold can be demonstrated for the general case. When the perturbation is below this threshold, frequency pulling occurs.

621.396.615 : 621.316.726.078 **1280**

The Lock-In Performance of an A.F.C. Circuit.—G. W. Preston & J. C. Tellier. (*Proc. Inst. Radio Engrs*, Feb.

1953, Vol. 41, No. 2, pp. 249–251.) For the case of *RC* coupling between phase detector and reactance valve in an a.f.c. system, an explicit relation is derived which determines the lock-in condition in an a.f.c. system using a reactance-valve-controlled oscillator. The relation involves the filter time-constant, the initial frequency error, the phase-detector constant, and the sensitivity of the oscillator.

621.396.615.18 **1281**
Analysis and Performance of Locked-Oscillator Frequency Dividers employing Nonlinear Elements.—W. L. Hughes. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 241–245.) Locked-oscillator frequency dividers can be stabilized by inserting certain nonlinear elements in the oscillator circuits. These elements should have a characteristic such that the voltage is proportional to an integral root of the current through them. If this condition is satisfied, the locked-oscillator divider is almost completely insensitive to wide changes of anode voltage, driving-signal voltage, and driving frequency. The mathematical representation of the nonlinearity of the elements permits some analysis of the circuit nonlinear differential equations. Thyrite elements or varistors were used in experimental circuits for division by 3, 5, 7 or 9.

621.396.619.13(.14] : 621.3.018.78 **1282**
Calculation of the Harmonic Distortion in Sinusoidal Modulation of Frequency or Phase. Detailed Study of a Quadripole with Antiresonant Circuit.—L. Robin. (*Ann. Télécommun.*, Nov. 1952, Vol. 7, No. 11, pp. 459–465.) The f.m. voltage, applied to the input terminals of an arbitrary quadripole, is expressed by a convergent Fourier series. An expression is deduced for the tangent of the variable phase shift introduced by the quadripole, in the form of the quotient of two rapidly convergent series of Bessel functions which lend themselves well to numerical calculation. Three parameters are involved: the wavelength λ, the modulation index m, and the ratio μ of λ_0 to the Q factor of the parallel *RLC* circuit considered. Numerical calculations are made for eight cases of practical interest involving different values of λ, m and μ. The results given by the complete formulae for the harmonic distortion are compared with those obtained by application of the 'instantaneous frequency' rule.

621.396.64 : 621.315.612.4 **1283**
A Ferroelectric Amplifier.—H. Urkowitz. (*J. Franklin Inst.*, Dec. 1952, Vol. 254, No. 6, pp. 517–530.) A l.f. signal was applied to a capacitor with (Ba-Sr)TiO_3-ceramic dielectric, thereby causing its capacitance to vary. The capacitor formed part of a tuned circuit fed by a h.f. voltage. The resulting a.m. h.f. voltage was applied to a detector circuit to recover the signal. Analysis for this arrangement indicates the conditions for maximum amplification. With a signal frequency of 17·6 kc/s, h.f. of 2·06 Mc/s and load-resistance 20·8 kΩ, a power gain of 62 was obtained. With the signal source removed and the output fed back to the input terminals, sustained l.f. oscillations were obtained with only the h.f. voltage applied. The oscillation frequency could be varied continuously from 20·8 to 32 kc/s by varying the value of a r.f. choke in the input lead and of a capacitor in the detector circuit. See also 1561 of 1952 (Vincent).

621.396.645 **1284**
Distributed Amplifiers, Mutual-Inductance-Coupled Type.—B. Murphy. (*Wireless Engr*, Feb. 1953, Vol. 30, No. 2, pp. 39–47.) Design procedure is outlined, the problems of output voltage and output matching being considered in detail. A method involving over-running the valves is described for increasing gain and output, while maintaining the time delay constant, when amplifying random pulses. Details are given of the construction and performance of two amplifiers having a useful bandwidth of 100 Mc/s.

621.396.645 **1285**
Cathode-Follower Operation.—H. H. Adelaar. (*Wireless Engr*, Feb. 1953, Vol. 30, No. 2, p. 49.) Comment on 2481 of 1952 (Shimmins).

621.396.645 **1286**
***RC* or Direct-Coupled Power Stage.**—E. F. Good. (*Wireless Engr*, March 1953, Vol. 30, No. 3, pp. 54–57.) Analysis is performed for an *RC*- or direct-coupled output stage consisting of an ideal triode of resistance r_a, anode feed resistance R_D and load resistance R_L, to determine the relations between r_a, R_D and R_L for maximum efficiency. The formula derived is evaluated for some particular cases.

621.396.645 : 621.314.7 **1287**
Transistor Circuits.—W. Herzog. (*Arch. elekt. Übertrag-ung*, Dec. 1952, Vol. 6, No. 12, pp. 499–501.) By appropriate use of transformers, transistor circuits having characteristics similar to those of ordinary valves can be obtained. Calculations are given for several particular cases.

621.396.822 : 621.396.645 : 621.314.7 **1288**
Noise in Transistor Amplifiers.—E. Keonjian & J. S. Schaffner. (*Electronics*, Feb. 1953, Vol. 26, No. 2, pp. 104–107.) Conditions for obtaining optimum signal/noise ratio are indicated for amplifiers using point-contact and junction-type transistors. Graphs show the dependence of noise figure on operating point and, for a two-stage amplifier, on the source impedance of the second stage. See also 887 of March and 643 of March (Montgomery).

GENERAL PHYSICS

530.145 : 51 **1289**
Mathematical Aspects of the Quantum Theory of Fields: Part 3 — Boson Field in Interaction with a Given Source Distribution.—K. O. Friedrichs. (*Commun. pure appl. Math.*, Feb. 1952, Vol. 5, No. 1, pp. 1–56.) Parts 1 & 2: 644 of 1952.

530.145 : 51 **1290**
Mathematical Aspects of the Quantum Theory of Fields: Part 4 — Occupation Number Representation and Fields of Different Kinds.—K. O. Friedrichs. (*Commun. pure appl. Math.*, Nov. 1952, Vol. 5, No. 4, pp. 349–411.) Part 3: 1289 above.

531.51 : 537/538 **1291**
Gravitation and Electrodynamics.—B. Kursunoglu. (*Phys. Rev.*, 15th Dec. 1952, Vol. 88, No. 6, pp. 1369–1379.) A modification of Einstein's unified field theory is proposed and its physical implications are examined.

535.1 : 537.228 **1292**
Further Experimental Investigations on the Nature of Light.—J. Stark. (*Z. Phys.*, 4th Nov. 1952, Vol. 133, No. 4, pp. 504–512.) Experimental arrangements are described for obtaining (*a*) a photographic record of the effect of a strong nonuniform electric field on a light beam, (*b*) a photometric record of the variation in diffraction due to such a field. The deviation of the beam which occurs when the plane of polarization is perpendicular to the direction of the field is discussed in relation to the e.m. theory of light.

535.42 : 538.56 **1293**
Diffraction of Electromagnetic Waves by an Aperture in an Infinite Screen.—G. Bekefi. (*J. appl. Phys.*, Dec. 1952,

Vol. 23, No. 12, p. 1403.) An approximate solution is derived for conditions of normal incidence on a perfectly conducting screen. The method is applicable where the aperture is large compared with λ, and reduces the problem to one of scalar boundary values.

535.42 : 538.56 **1294**

Diffraction Field of a Circular Aperture.—G. A. Woonton. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1405–1406.) An equation expressing the diffracted field is derived for the case of a normally incident plane wave and a perfectly reflecting screen. The equation is of the form given by Stratton (1819 of 1941) but is modified to agree with certain theoretically and experimentally established conditions.

535.42 : 538.56 **1295**

A New Method of Solving Diffraction Problems.—H. E. J. Neugebauer. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, p. 1406.) A double-approximation method is indicated for dealing with various problems on the diffraction of e.m. waves.

535.42 : 538.566.029.64 **1296**

Application of the Methods of Optics to Calculations of Diffraction Phenomena in the Centimetre-Wave Range.—H. Severin. (*Tech. Mitt. schweiz. Telegr.-Teleph Verw.*, 1st Nov. 1952, Vol. 30, No. 11, pp. 347–356. In German.) Analysis and examples illustrating the use of Kirchhoff's theory for approximate calculation of diffraction effects, both for centimetre e.m. waves and for sound waves.

537.122 **1297**

Angular Momentum in Dirac's New Electrodynamics.—R. W. Iskraut. (*Nature, Lond.*, 27th Dec. 1952, Vol. 170, No. 4339, pp. 1125–1126.)

537.122 **1298**

The Energy Momentum Tensor in Dirac's New Electromagnetic Theory.—B. Hoffmann. (*Nature, Lond.*, 27th Dec. 1952, Vol. 170, No. 4339, p. 1126.)

537.291 **1299**

Diffraction by a Charged Filament.—S. M. Rytov. (*Zh. eksp. teor. Fiz.*, April 1952, Vol. 22, No. 4, pp. 510–511.) The deflection of an electron by a charged infinite filament is considered and an equation is derived determining its trajectory.

537.311.1 : 538.632 **1300**

Interpretation of the Electron-Inertia Experiment for Metals with Positive Hall Coefficients.—N. Rostoker. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 952–953.) A critical discussion of the measurements described by Brown & Barnett (700 of March).

537.311.1 : 538.632 **1301**

Interpretation of e/m Values for Electrons in Crystals.—W. Shockley. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, p. 953.) The e/m values obtained by Brown & Barnett (700 of March) are shown to be in agreement with established theory if the mass of the holes is considered to be negative.

537.311.3 **1302**

Mobility in High Electric Fields.—E. M. Conwell. (*Phys. Rev.*, 15th Dec. 1952, Vol. 88, No. 6, pp. 1379–1380.) Conductivity theory is extended to the case of strong e.s. fields, all electron collisions being assumed to be elastic. A relation is derived between mobility and relaxation time which is valid over a wide range of field strengths.

537.311.31.029.6 **1303**

The Anomalous Skin Effect.—R. G. Chambers. (*Proc. roy. Soc. A*, 22nd Dec. 1952, Vol. 215, No. 1123, pp. 481–497.) Measurements were made on a number of metals at frequencies of 1·2 and 3·6 kMc/s, at temperatures in the range 2°–90°K. The variation of r.f. surface conductance with d.c. conductivity (σ) agrees well with the theoretical predictions of Reuter & Sondheimer (1354 of 1949), assuming that the electrons are scattered diffusely when they hit the surface of the metal. The results are used to estimate the effective value of σ/l (l = mean free path of electrons); the estimate for Cu agrees well with that based on theory, but those for Ag and Au are rather lower than the theoretical values. The results are largely dependent on the surface condition of the metal; the use of the two different frequencies enables the influence of this factor to be assessed.

537.311.33 + 537.226 **1304**

The Influence of the Surface States of Electrons on the Optical Properties of Semiconductors and Dielectrics.—G. E. Pikus. (*Zh. eksp. teor. Fiz.*, March 1952, Vol. 22, No. 3, pp. 331–338.) The reflection of e.m. waves from a plane surface with electronic surface conduction is considered. For incidence angles close to 90°, reflection increases with the angle when the electric vector is parallel to the surface, but decreases when the electric vector is almost perpendicular to the surface.

537.311.33 **1305**

Experimental Verification of the Relationship between Diffusion Constant and Mobility of Electrons and Holes.—(*Phys. Rev.*, 15th Dec. 1952, Vol. 88, No. 6, pp. 1368–1369.) Short pulses of electrons or holes were injected into single-crystal rods of p- and n-type Ge. As the pulse travelled along the rod under the influence of an electric field, diffusion took place, resulting in broadening of the pulse. A large number of measurements of pulse widths and transit times for two positions of the emitter point were made, and the most probable value of the ratio of diffusion constant to mobility was derived by the method of least squares. This was found to verify the relation $eD = \mu kT$ [see 3402 of 1952 (Landsberg)].

537.523.3 + 537.527.3 **1306**

Corona-Suppression Methods.—A. H. Mankin. (*Elect. Mfg*, June 1951, Vol. 47, No. 6, pp. 125–127 . . 276.) Physical aspects of corona discharge are discussed, and its prevention by pressurization or evacuation of electrical equipment, by increasing the radii of curvature of conductors, and by coating with or immersion in materials of high dielectric strength, is described.

537.523.74 **1307**

The Single-Electrode Discharge at Pressures from a Few Millimetres of Mercury to Atmospheric Pressure at the Frequency of 31.7 Mc/s.—G. S. Solntsev, M. Z. Khokhlov & E. A. Rodina. (*Zh. eksp. teor. Fiz.*, April 1952, Vol. 22, No. 4, pp. 406–413.) Experiments were conducted with discharges in air, N and Ar to investigate the characteristics of the 'torch' discharge.

537.525.4 **1308**

Formative Time Lags of Uniform-Field Breakdown in N_2.—G. A. Kachickas & L. H. Fisher. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 878–883.)

537.562 **1309**

Dynamics of Plasma: Part 2—Plasma with Neutral Gas.—A. Schlüter. (*Z. Naturf.*, Feb. 1951, Vol. 6a, No. 2, pp. 73–78.) Continuation of work noted in 2150 of 1951. To illustrate the theory, it is applied to investigate the influence of self magnetic field on a glow discharge.

537.562 : 538.566 **1310**

Longitudinal Waves in an Ionized Medium (Plasma).—M. E. Gertsenshtein. (*Zh. eksp. teor. Fiz.*, March 1952, Vol. 22, No. 3, pp. 303–309.) The permittivity of an electronic plasma is calculated, taking account of electron motion; the value found depends on the spatial structure of the field. A concept of spatial dispersion is introduced. The properties of longitudinal waves and their relation to transverse waves are investigated.

538.22 + 548.0] : 549.517.2 **1311**

Crystal Structure and Antiferromagnetism in Haematite.—B. T. M. Willis & H. P. Rooksby. (*Proc. phys. Soc.*, 1st Dec. 1952, Vol. 65, No. 396B, pp. 950–954.)

538.221 **1312**

Ferromagnetism at Very High Frequencies: Part 4—Temperature Dependence of the Magnetic Spectrum of a Ferrite.—G. T. Rado, R. W. Wright, W. H. Emerson & A. Terris. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 909–915.) Continuation of work noted in 337 of 1951 (Rado et al.). Observations at 77°, 195° and 411°K are reported. By using single-domain particles embedded in wax, the rotational resonance was observed separately. The resonance frequencies decrease with increasing temperature; a theoretical interpretation is given. Auxiliary measurements of the spectroscopic splitting factor, saturation magnetization and coercive force are described.

538.3 **1313**

The Distribution of Currents in a Disk rotating in a Uniform Magnetic Field, and the Damping.—L. N. Deryugin. (*C. R. Acad. Sci. U.R.S.S.*, 1st Feb. 1952, Vol. 82, No. 4, pp. 581–584. In Russian.)

538.56 : 535.312 : 519.3 **1314**

Application of the Calculus of Variations to the Determination of Reflection Coefficients.—L. Ronchi & G. Toraldo di Francia. (*Rev. d'Optique*, Nov. 1952, Vol. 31, No. 11, pp. 481–484.) The method previously used to determine the reflection coefficient of a potential barrier [1894 of 1950 (Toraldo di Francia)] is here applied to the vector field of e.m. waves to determine the reflection coefficient of a stratified medium for TE and TM waves.

538.56 : 535.524 **1315**

The Complete System of Natural Electromagnetic Oscillations of a Biaxial Anisotropic Parallelepiped.—E. Hafner. (*Acta phys. austriaca*, Nov. 1952, Vol. 6, Nos. 2/3, pp. 209–218.) Analysis of the e.m. field inside a rectangular cavity resonator completely filled with an optically biaxial crystal.

538.566 : 537.53 **1316**

Propagation in Electron-Ion Streams.—R. Q. Twiss. (*Phys. Rev.*, 15th Dec. 1952, Vol. 88, No. 6, pp. 1392–1407.) Mathematical theory is developed for streams composed of N discrete beams. The solution of the propagation equations is obtained in vector form by an extension of Hansen's theory (*Phys. Rev.*, 1935, Vol. 47, p. 139) and takes explicit account of initial and boundary conditions. When certain restrictions are placed on the transverse boundary conditions, the general solution satisfying arbitrary initial conditions can be expanded in terms of a complete orthogonal set of elementary vector solutions. For this case the necessary and sufficient conditions are found for amplification and instability in the terminated and the unterminated stream. The analysis is extended to a continuous velocity distribution. See also 654 of 1952.

538.569.4 : 621.315.212.1 **1317**

A Broad-Band Coaxial Stark Cell for Microwave Spectroscopy.—L. J. Rueger & R. G. Nuckolls. (*Rev. sci. Instrum.*, Nov. 1952, Vol. 23, No. 11, p. 635.) The cell consists of a coaxial structure 10 ft long, the outer conductor being of 1½-in. brass tube and the inner of ⅝-in. brass rod; the ends are vacuum sealed. Only a single wave transmission mode is possible in the operation range 0·9–3·4 kMc/s. The application of a voltage between the conductors at some predetermined repetition rate modifies the variation of the absorption with the frequency of the r.f. wave field, thus facilitating detection of resonance. See also *Tech. News Bull. nat. Bur. Stand.*, Oct. 1952, Vol. 36, No. 10, pp. 150–151.

538.615 : 538.569.4.029.6 **1318**

Apparatus for Zeeman Effect Measurements on Microwave Spectra.—J. R. Eshbach & M. W. P. Strandberg. (*Rev. sci. Instrum.*, Nov. 1952, Vol. 23 No. 11, pp. 623–628.)

538.63 **1319**

The Connection between Transverse Magnetogalvanic Effects and Resistivity.—A. L. Perrier. (*Helv. phys. Acta*, 1st Nov. 1952, Vol. 25, No. 6, pp. 615–618. In French.) The 'magnetogalvanic rotation' due to the Hall effect in an isotropic conductor is expressed in terms of transverse magnetogalvanic conductivity. Its variation with temperature and field intensity is discussed briefly with reference to ferromagnetic and superconducting media.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.531 : 621.396.9 **1320**

A Radar Investigation of the Delta Aquarid Meteor Shower of 1950.—B. A. Lindblad. (*Chalmers tek. Högsk. Handl.*, 1952, No. 129, pp. 1–27.)

523.72 : 551.510.53 **1321**

Effects of Solar Radiation in the Upper Atmosphere.—M. Nicolet. (*Ann. Géophys.*, April/June 1952, Vol. 8, No. 2, pp. 141–193.) A survey paper. An account is given of the various radiations emitted by the sun and of the ionization and dissociation effects resulting from their absorption in the upper atmosphere.

523.72 : 621.396.822 : 538.561 : 537.56 **1322**

Solar 'Enhanced Radiation' and Plasma Oscillations.—H. K. Sen. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 816–822.) The dispersion formula for plasma oscillations in a static magnetic field is derived by the Laplace-transform method used by Landau (1346 of 1948); the oscillations are unstable in frequency bands around multiples of the gyrofrequency. Numerical calculations for sunspot magnetic fields in the corona indicate that random fluctuations may be amplified, and afford support for the explanation given by Wild (2170 of 1951) of 'enhanced radiation'.

523.74 : 551.543 : 550.386 **1323**

Solar Activity and the Atmosphere.—H. Koppe. (*Z. Met.*, Dec. 1952, Vol. 6, No. 12, pp. 369–378.) Statistical analysis of records confirms that correlation exists between geomagnetic disturbances and fluctuations of atmospheric pressure over Scandinavia. The hypothesis of planetary influence on solar activity is discussed. Assumptions regarding the mechanism of the sun's influence on the atmosphere are justified by measurements.

523.746 : [523.77 + 53 **1324**

The Physical Conditions in Large Sunspots, deduced from their Spectra.—R. Michard. (*C. R. Acad. Sci., Paris*, 22nd Dec. 1952, Vol. 235, No. 25, pp. 1608–1610.) The temperature, electronic pressure and gas pressure at the centre of a large sunspot are determined from published spectral data.

523.746"1952.07/.09" **1325**

Provisional Sunspot Numbers for July to September, 1952.—M. Waldmeier. (*J. geophys. Res.*, Dec. 1952, Vol. 57, No. 4, p. 534.)

523.755 : 550.38 **1326**

The Corona and Geomagnetism.—M. J. Smyth. (*Observatory*, Dec. 1952, Vol. 72, No. 871, pp. 236–239.) Discussion of available data for the present solar-activity minimum shows the existence of a tendency for the central meridian passages of moderately bright λ5303 regions to be followed by reduced geomagnetic activity for about three days.

523.78 : 551.510.535 **1327**

Effects of the Solar Eclipse of 25th February 1952 on the Ionospheric F_2 Region over Equatorial Africa.—S. Estrabaud. (*C. R. Acad. Sci., Paris*, 10th Dec. 1952, Vol. 235, No. 23, pp. 1521–1523.) Detailed note of effects observed in ionosphere soundings at Bangui. These are interpreted satisfactorily in terms of the existence of two interspersed layers X and G comprising the F_2 region. The lower X disappears as ionization decreases during occultation; during the reionization process, which occurs more rapidly at the base of the layer than at the top, the lower regions of X merge with the F_1 layer. The comparative insensitiveness of the upper layer G can be explained on the basis of corpuscular radiation.

523.8 : 621.396.822 **1328**

On Some Possible Mechanisms of Radio Stars: Part 1 — The Crab Nebula.—F. D. Kahn. (*Mon. Not. R. astr. Soc.*, 1952, Vol. 112, No. 5, pp. 514–517.) Neither the deflection of fast electrons nor transitions of thermally excited electrons can account for the observed intensity of radiation.

523.8 : 621.396.822 **1329**

The Determination of the Position of a Radio Star.—F. G. Smith. (*Mon. Not. R. astr. Soc.*, 1952, Vol. 112, No. 5, pp. 497–513.) Discussion of the accuracy of different methods.

523.8 : 621.396.822.029.64 **1330**

The Measurement of the Angular Diameter of Radio Stars.—F. G. Smith. (*Proc. phys. Soc.*, 1st Dec. 1952, Vol. 65, No. 396B, pp. 971–980.) The phase-switching interferometer method described by Ryle (2497 of 1952) is considered in detail, and measurements made by this method are reported.

523.854 : 621.396.822 **1331**

Electromagnetic Radiation from Cosmic Protons and the R.F. Radiation from the Galaxy.—A. A. Korchak & Ya. P. Terletski. (*Zh. eksp. teor. Fiz.*, April 1952, Vol. 22, No. 4, pp. 507–509.) Calculations indicate that galactic r.f. radiation may be originated by the proton component of cosmic rays when the latter pass through the galactic fields.

525.35 **1332**

A New Discussion of the Changes in the Earth's Rate of Rotation.—D. Brouwer. (*Proc. nat. Acad. Sci., Wash.*, Jan. 1952, Vol. 38, No. 1, pp. 1–12.) A detailed analysis of available information on changes in the rate of rotation of the earth since 1820.

538.12 : 525.35 **1333**

A Negative Experiment relating to Magnetism and the Earth's Rotation.—P. M. S. Blackett. (*Phil. Trans. A*, 16th Dec. 1952, Vol. 245, No. 897, pp. 309–370.) An experiment was made to determine whether a 10 cm × 10 cm gold cylinder rotating with the earth produced a weak magnetic field; no such field was observed. The magnetometer used is described in detail.

538.12 : 550.38 **1334**

The Electromagnetic Field of a Rotating Uniformly Magnetized Sphere.—A. Baños, Jr, & R. K. Golden. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1294–1299.)

550.38 : 523.746.5 **1335**

The Variation of the Geomagnetic-Activity Recurrence Interval with the Solar Cycle.—E. J. Chernosky. (*Trans. Amer. geophys. Union*, Dec. 1951, Vol. 32, No. 6, pp. 861–865.)

550.38"1952.07/.09" **1336**

Cheltenham [Maryland] Three-Hour-Range Indices *K* for July to September, 1952.—R. R. Bodle. (*J. geophys. Res.*, Dec. 1952, Vol. 57, No. 4, p. 534.)

550.384 **1337**

Isolation of the Eleven-Yearly Variation of the Horizontal Component of the Earth's Magnetic Field by Linear Combinations of Ordinates.—P. Bernard. (*Ann. Géophys.*, April/June 1952, Vol. 8, No. 2, pp. 248–252.) The eleven-yearly component is brought into evidence by using Labrouste's method of analysis. This component has in general a minimum value 1·1 years after the maximum of sunspot activity and a total amplitude of 20 gamma. Exceptional results observed for certain stations are discussed.

550.384 : 525.35 **1338**

On Variations of the Geomagnetic Field, Fluid Motions, and the Rate of the Earth's Rotation.—E. H. Vestine. (*Proc. nat. Acad. Sci., Wash.*, Dec. 1952, Vol. 38, No. 12, pp. 1030–1038.) Brouwer's results (1332 above) are compared with changes with time in the westward drift of fluid moving near the surface of the earth's central core, as inferred from the westward drift of the eccentric-dipole field of geomagnetism.

550.385"1952.03/.09" **1339**

Principal Magnetic Storms [March–Sept. 1952].—(*J. geophys. Res.*, Dec. 1952, Vol. 57, No. 4, pp. 535–536.)

550.386 **1340**

International Data on Magnetic Disturbances, Second Quarter, 1952.—J. Bartels & J. Veldkamp. (*J. geophys. Res.*, Dec. 1952, Vol. 57, No. 4, pp. 531–533.)

551.510.52 : 535.32 : 538.56.029.64 **1341**

Measurement of Tropospheric Index-of-Refraction Fluctuations and Profiles.—C. M. Crain, A. P. Deam & J. R. Gerhardt. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 284–290.) Results are presented of measurements made with a direct-reading microwave refractometer over the sea and coastal areas near Lakehurst, N.J., and over Southern Ohio, for heights up to 10 000 ft. The refractometer was essentially the same as that previously described by Crain (2565 of 1950).

551.510.53 **1342**

Some Reactions occurring in the Earth's Upper Atmosphere.—D. R. Bates. (*Ann. Géophys.*, April/

June 1952, Vol. 8, No. 2, pp. 194–204.) The photochemical reactions determining the equilibrium between N_2, N, NO and NO_2 are examined. The origin of the N_2O in the atmosphere is discussed; a considerable yield is necessary to balance the loss due to photodissociation. This gas may be formed in the troposphere by collisions between O or O_3 and N_2.

551.510.53 **1343**

The Height of the Atmospheric Electric-Equilibrium Layer.—H. Israël. (*Ann. Géophys.*, April/June 1952, Vol. 8, No. 2, pp. 253–257. In German.) Continuation of previous work by Israël & Kasemir (*Ann. Géophys.*, 1949, Vol. 5, pp. 313–324). The values of electron concentration corresponding to two limiting assumptions regarding dependence of recombination coefficient (α) on pressure are compared with values deduced from determinations of D-layer ionization; α is found to be proportional to the cube root of the pressure. The height of the equilibrium layer is about 65 km.

551.510.535 **1344**

Relations between Temperature and the Phenomena of Photochemical Dissociation or Ionization in the Upper Atmosphere, particularly in the E Layer.—J. Gauzit. (*Ann. Géophys.*, April/June 1952, Vol. 8, No. 2, pp. 226–231.) A calculation of the initial kinetic energy of oxygen atoms produced by photodissociation of oxygen molecules gives a value corresponding to a temperature $>$ 3 000°K at altitudes between 100 and 130 km.

551.510.535 **1345**

A New Early-Morning Ionospheric Phenomenon.—B. N. Bhargava. (*Nature, Lond.*, 6th Dec. 1952, Vol. 170, No. 4336, pp. 983–984.) Kodaikanal *h'f* records indicate the cessation of ionospheric echoes some minutes to several hours before sunrise and their reappearance at about the time of ground sunrise on about 60% of days during the period March–July 1952. The virtual height of the reflecting layer on reappearance of the echoes was 300–500 km. On mornings when the echoes did not disappear the new reflecting layer appeared suddenly and its height decreased rapidly to that of the overnight layer, viz. 200–250 km.

551.510.535 **1346**

An Investigation of the Ionizing Effect in the E-Layer near Sunrise.—R. Lindquist. (*J. geophys. Res.*, Dec. 1952, Vol. 57, No. 4, pp. 439–458.) Virtual-height/time records for 150-kc/s signals show a sudden decrease in virtual height around ground sunrise. Analysis for the period Jan. 1950–Dec. 1951 shows that the difference between time of occurrence of the sunrise drop and sunrise at the reflection level is constant and independent of season. Absorption is considered the most likely cause of this effect. Calculations of absorption coefficients for O, N_2 and O_2 give results of the right order of magnitude in the case of O_2 only. Ionization of O_2 could be caused by ultraviolet radiation of $\lambda > 910$ Å.

551.510.535 **1347**

The $F_{1.5}$ Layer at Dakar and the Motion of the Sun.—F. Delobeau. (*C. R. Acad. Sci., Paris*, 22nd Dec. 1952, Vol. 235, No. 25, pp. 1673–1675.) The occurrence of a layer between the normal F_1 and F_2 layers has been reported previously [1148 of 1951 (Delobeau et al.)]. The results of observations for the period July 1949 to July 1952 are shown graphically and discussed. Curves for summer, winter, and the equinoxes, showing the number of occurrences of the $F_{1.5}$ layer for each hour of the day, are of similar shape, with maxima shortly after 1200 local time, the curves dropping to zero at about 0800 and 1700. The seasonal curves show maxima about the summer solstice and minima at about the winter solstice. Similar effects (thick F layer) have been observed at Singapore [989 of 1952 (Osborne)].

551.510.535 **1348**

Solar Ionospheric Tides in the F_2 Region.—A. A. Weiss. (*J. atmos. terr. Phys.*, Jan 1953, Vol. 3, No. 1, pp. 30–40.) "The equation of continuity for electrons subject to the influence of a vertical drift harmonic in time has been integrated by numerical methods, taking the processes of ion-production and recombination into account for physical conditions representative of the F_2 region . . . The results of the analysis are applied to a brief discussion of the nature of the information regarding the vertical electron drift which can be derived from measured ionospheric data."

551.510.535 **1349**

Some Practical Determinations of the Electron Content below the Level of Maximum Ionization in the F_2 Region of the Ionosphere.—B. W. Osborne. (*J. atmos. terr. Phys.*, Jan. 1953, Vol. 3, No. 1, pp. 58–67.) Ratcliffe's method (1292 of 1952) was applied to results of observations at Slough and at Singapore during 1949, and to simultaneous *h'f* observations at Penang and Singapore during one week of July 1949. Seasonal and diurnal variations of maximum electron density differ from those of the total number n of electrons in a vertical column of unit cross-section in the F_2 region up to the level of maximum ionization. The variations of n show a greater dependence on the solar zenith angle. Diurnal variations of the latitude gradient of n near the magnetic equator are briefly discussed. It appears probable that, as the latitude alters, the local noon value of n goes through a flat maximum in equatorial latitudes, whereas the noon value of maximum electron density goes through a sharp minimum near the magnetic equator and exhibits the well-known 'equatorial trough'.

551.510.535 : 523.746 : 621.396.11 **1350**

The Differences in the Relationship between Ionospheric Critical Frequencies and Sunspot Number for Different Sunspot Cycles.—S. M. Ostrow & M. Po-Kempner. (*J. geophys. Res.*, Dec. 1952, Vol. 57, No. 4, pp. 473–480.) Statistical analysis of data from Washington, D.C., and Watheroo, Australia, shows significant differences for months near the equinoxes, and also seasonal variations between the 1935–1944 and 1944–1952 cycles. Inconclusive results for other months are ascribed in part to the small sample size of available data. For radio propagation predictions, therefore, only current cycle data should be used.

551.510.535 : 538.566.3 **1351**

Calculation of Absorption in the Ionospheric Propagation of Short Waves.—A. Bolle & P. Dominici. (*Ann. Geofis.*, July 1952, Vol. 5, No. 3, pp. 377–396.) Formulae and graphs necessary for calculation of the absorption in the absence of and in the presence of the geomagnetic field are assembled and explained.

551.510.535 : 551.594.13 **1352**

Conductivity of the Ionosphere.—W. G. Baker & D. F. Martyn. (*Nature, Lond.*, 27th Dec. 1952, Vol. 170, No. 4339, pp. 1090–1092.) The investigations of various workers relative to Balfour Stewart's dynamo theory of geomagnetic diurnal variations are reviewed, and the fundamental principles involved in the production of electric currents in the ionosphere by tidal winds are re-examined. Three conductivities, two of which are related to the Hall effect, appear to be involved. One of these has two relatively small maxima at 140 km height (due mainly to ions) and 75 km (due to electrons). The second has a broad maximum at 105 ± 35 km, thus including all the E-region ionization, and the third has a very pronounced sharp maximum at 100 ± 10 km. Discussion shows that the effective conductivity of the ionosphere, over most of the earth, is some twelve times greater than that deduced when the Hall current is ignored, and near the magnetic equator the conductivity is increased further by a factor of 2·4. Equations developed appear to account quantitatively for the high conductivity required by the dynamo theory, and also for the increased conductivity near the magnetic equator. Near the equator the current system should be in a relatively thin layer centred at about 100 km height. Evidence of the existence of a current sheet between the 93-km and 105-km levels has recently been obtained by Singer et al. (1353 below) in rocket experiments.

551.510.535 : 551.594.13 **1353**

Dynamo Currents and Conductivities in the Earth's Upper Atmosphere.—S. F. Singer, E. Maple & W. A. Bowen, Jr. (*Nature, Lond.*, 27th Dec. 1952, Vol. 170, No. 4339, pp. 1093–1094.) Discussion of the results of rocket measurements reported previously (2713 of 1951). The observed current system would account for the exceptionally large geomagnetic diurnal variations found at Huancayo, and strongly supports Balfour Stewart's dynamo theory of the diurnal variations. By taking account of polarization due to the Hall effect, the large discrepancy between conventionally calculated ionosphere conductivities and the value of the conductivity required by the dynamo theory (using accepted values for the velocity of high-altitude winds) can be eliminated. Further rocket measurements, on both magnetically quiet and disturbed days, are very desirable.

551.594 **1354**

Studies of the Atmospheric Potential Gradient: No. 5 — Current Theory of the Electric Field in the Air: Part 2.—H. W. Kasemir. (*Arch. Met. A, Wien*, 28th April 1952, Vol. 5, No. 1, pp. 56–70.) Particular cases arising from the theory given previously (407 of 1952) are examined in detail, using moderately advanced mathematics.

551.594 **1355**

Studies of the Atmospheric Potential Gradient: No. 6 — Examples of Atmospheric Electrical Phenomena in Foggy Conditions.—H. Israël & H. W. Kasemir. (*Arch. Met. A, Wien*, 28th April 1952, Vol. 5, No. 1, pp. 71–85.) From an examination of numerous records of the atmospheric electric field and the vertical current obtained at stations in lowland and mountainous regions during fog, several types of characteristic reaction are distinguished; these are discussed in detail.

551.594.5 **1356**

Theories of the Aurora Polaris.—S. Chapman. (*Ann. Géophys.*, April/June 1952, Vol. 8, No. 2, pp. 205–225.) The discussion presented deals only with theories based on the action of streams or clouds of neutral ionized gas ejected from the sun.

551.594.5 **1357**

The Geometry of Radio Echoes from Aurorae.—S. Chapman. (*J. atmos. terr. Phys.*, Jan. 1953, Vol. 3, No. 1, pp. 1–29.)

551.594.5 : 537.533[.534] : 538.6 **1358**

The Streaming of Charged Particles through a Magnetic Field as a Theory of the Aurora.—B. C. Landseer-Jones. (*J. atmos. terr. Phys.*, Jan. 1953, Vol. 3, No. 1, pp. 41–57.)

52 + 55] (083.6) **1359**

Landolt-Börnstein Zahlenwerte und Funktionen aus Physik, Chemie, Astronomie, Geophysik und Technik: Vol. 3 — Astronomie und Geophysik. [Book Review]—J. Bartels & P. ten Bruggencate (Volume Eds). Publishers: Springer-Verlag, Berlin-Göttingen-Heidelberg, 1952, 795 pp., £21 14s. (*J. atmos. terr. Phys.*, Jan. 1953, Vol. 3, No. 1, pp. 70–71.) "..should be available in any library catering for meteorologists, geophysicists or astronomers . . . No book written in English contains such a useful and complete collection of information."

LOCATION AND AIDS TO NAVIGATION

621.396.9 **1360**

First Demonstration of Port Radar Equipment in Germany.—(*Funk-Technik, Berlin*, Nov. 1952, Vol. 7, No. 21, pp. 574–575.) Note on demonstrations at Hamburg and Bremen of two types of Decca radar equipment: (*a*) simple equipment for small and medium-size ports; (*b*) more elaborate equipment for large ports. A 12-in. viewing screen is used. The frequency is 9·4 kMc/s.

621.396.9 : 551.5 : 061.3 **1361**

Application of Radar to Meteorology.—R. F. Jones. (*Nature, Lond.*, 13th Dec. 1952, Vol. 170, No. 4337, pp. 1004–1005.) Summarized report of the proceedings at the third Radar Weather Conference, McGill University, Montreal, September 1952.

621.396.9 : 551.578 **1362**

The Scattering of Radio Waves by Meteorological Particles.—N. R. Labrum. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1324–1330.) Calculations are made of the intensity of the signal scattered back by clouds of ice particles or water drops or mixtures of the two. In the case of ice the echo intensity is almost independent of particle shape; in the case of water the intensity increases rapidly as the shape of the drops departs from sphericity. The results are used to explain the 'bright-band' phenomenon. When the scattering particles are not spherical, the polarization of the radiation may undergo alteration.

621.396.9 : 551.578 **1363**

Some Experiments on Centimeter-Wavelength Scattering by Small Obstacles.—N. R. Labrum. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1320–1323.) Measurements were made of the power scattered back from small steel spheres, hemispherical water drops and melting ice particles; waveguide technique was used, the frequency being 3 kMc/s. The observations support the theoretical results reported in 1362 above. The intensity of the echo passes through a maximum at some stage during the transition from ice particles to water drops.

621.396.9 : 551.578.1/.4 **1364**

Cross-Polarization of the Radar Melting-Band.—I. C. Browne & N. P. Robinson. (*Nature, Lond.*, 20th Dec. 1952, Vol. 170, No. 4338, pp. 1078–1079.) Recent observations at Cambridge on 3·2-cm wavelength and at Malvern on 8-mm wavelength are reported which show that the melting particles found just below the freezing level, which give rise to the radar melting band [2222 of 1950 (Hooper & Kippax)], produce back-scattered radiation with a greater cross-polarized component than that given by the rain below and the snow above the freezing level. Separate aerials were used for transmission and reception, the echo intensities being compared for the cases in which the two aerials had (*a*) parallel, (*b*) perpendicular planes of polarization. A possible explanation of the effect is suggested.

621.396.9.001.4 **1365**

Measurements relating to [moving-target] Radar Equipment with Fixed-Target-Echo Elimination.—Cauchois. (See 1446.)

621.396.9.001.57 **1366**

The Use of Dielectric Lenses in Reflection Measurements.—J. R. Mentzer. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 252–256.) In order to minimize the effects of Fresnel diffraction, due to short range, in the measurement of radar echoing areas by means of models, a styrofoam lens with a refractive index of 1·015 and dielectric constant of 1·03 was used in front of the target. The measured broadside radar echoing area of a cylinder, of length about 80% of the lens diameter, was doubled by use of the lens.

621.396.932 **1367**

Quantitative Investigation of the Increased Accuracy of Direction Finding using the C.R. Direction Finder.—H. Gabler, G. Gresky & M. Wächtler. (*Arch. elekt. Übertragung*, Dec. 1952, Vol. 6, No. 12, pp. 507–513.) Report of a comparison of goniometer and c.r.o. equipment, carried out on board the research ship *Gauss* during August 1952. Measurements are tabulated and discussed. The c.r.o. equipment is preferred on account of its objective indication and greater accuracy (viz., to within $\pm$ 1°) especially at low field strengths and in the presence of interference.

621.396.933 **1368**

Synthetic Radar Trainer.—(*Wireless World*, March 1953, Vol. 59, No. 3, pp. 123–124.) A note on electromechanical equipment for simulating the flight paths of aircraft to provide trainee control officers with experience in the interpretation of radar displays.

621.396.933.23 **1369**

Instrument-Approach-System Steering Computer.—W. G. Anderson & E. H. Fritze. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 219–228.) The analysis presented is mainly concerned with the problem of lateral guidance in the I.L.A.S. (Instrument Landing Approach System), the ground equipment for which has been installed at airports throughout the U.S.A. The steering computer described uses data regarding aircraft bank angle, heading, and localizer deviation to determine a correct steering indication for the pilot to follow.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.37 **1370**

Radio-frequency Field Quenching of Ultraviolet Excited Phosphors.—T. Miller. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1289–1293.) Experiments were made with various phosphors to determine the dependence of the quenching action of an applied r.f. field on the strength and frequency of the field. Results are shown in graphs. Sulphide phosphors were found to exhibit the quenching action, while zinc phosphate and zinc orthosilicate did not. Fatigue effects were also investigated.

535.37 : 537.311.33 : 546.482.21 **1371**

Variation of the Luminescence and Electrical Conductivity of CdS Crystals on Irradiation with α Particles.—I. Broser & R. Warminsky. (*Z. Naturf.*, Feb. 1951, Vol. 6a, No. 2, pp. 85–102.)

537.226 + 621.315.611 **1372**

Dielectric Materials.—G. I. Skanavi. (*Priroda*, June 1952, No. 6, pp. 23–32.) The theory of dielectrics is discussed, with particular attention to ceramic materials, including ferroelectrics. The mechanism of electrical conduction in dielectrics is considered in detail and different types of breakdown (thermal, electrical and chemical) are discussed.

537.226 **1373**

Ferroelectric Materials.—S. B. Gurevich & V. G. Panchenko. (*Priroda*, March 1952, No. 3, pp. 54–61.) A general review of the subject. Theoretical interpretations of ferroelectric properties, mainly by Russian physicists, are discussed, and possible practical applications of these materials are indicated.

537.226 **1374**

Ferroelectricity in Oxides of Fluorite Structure.—W. R. Cook, Jr, & H. Jaffe. (*Phys. Rev.*, 15th Dec. 1952, Vol. 88, No. 6, p. 1426.) Ferroelectricity in a simple crystal structure has been found in two compounds. $Cd_2Nb_2O_7$ is of face-centred cubic structure with permittivity rising to a peak as the temperature falls to $-$ 103°C, the Curie point, below which it is ferroelectric. The analogous compound $Pb_2Nb_2O_7$, with rhombohedral symmetry, has a permittivity which also rises with falling temperature.

537.226.1 **1375**

The Relation between Breakdown Strength and Mobility of Charges in a Dielectric.—E. K. Zavadovskaya. (*C. R. Acad. Sci. U.R.S.S.*, 1st Feb. 1952, Vol. 82, No. 4, pp. 565–566. In Russian.)

537.228.1 : 621.396.611.21 **1376**

Piezoelectric Resonators and Oscillators using Quartz and Synthetic Crystals.—R. Bechmann. (*Telefunken Ztg*, Nov. 1952, Vol. 25, No. 97, pp. 229–245.) Properties of different classes of piezoelectric materials are discussed. Elastic and piezoelectric moduli and the modes of vibration for the 32 crystal symmetry classes are listed. Another table gives numerical factors for calculating the mechanical displacement and oscillation constants according to the vibration mode and taking account of the effects of partial electrodes and air gaps on the resonance frequency. Methods of obtaining zero temperature coefficient of frequency are discussed, in particular that in which 'rotated' plates vibrate in a thickness or contour shear mode. Frequency and capacitance constants determined experimentally for such crystals of quartz, EDT and DKT (potassium tartrate hemihydrate) are given.

537.311.31 **1377**

Resistance of Metals at High Current Density in Pulse Conditions.—L. A. Ignat'eva & S. T. Kalashnikov. (*Zh. eksp. teor. Fiz.*, April 1952, Vol. 22, No. 4, pp. 385–399.) The electrical resistance of thin wires was investigated for current pulses lasting several tens of microseconds, with current densities up to 5×10^6 A/cm². For Au, Ag and Cu the resistance values are the same as with weak currents, while for Pt and W the resistance values are several times greater for current densities above 10^6 A/cm².

537.311.32 : 549.514.51 **1378**

Dependence of the Electrical Conductivity of Quartz on the Electrical Field, the Temperature and the Magnetic Field.—P. E. Sarzhevski. (*C. R. Acad. Sci. U.R.S.S.*, 1st Feb. 1952, Vol. 82, No. 4, pp. 571–574. In Russian.)

537.311.33 **1379**

The Measurement of Drift Mobility in Semiconductors.—R. Lawrance & A. F. Gibson. (*Proc. phys. Soc.*, 1st Dec. 1952, Vol. 65, No. 396B, pp. 994–995.) The methods described by Haynes & Shockley (2109 of 1949 and 1928 of 1951) and Shockley et al. (380 of 1950) are modified by using a continuous emitter current in conjunction with the pulsed sweep field.

537.311.33 **1380**

Thermo- and Galvano-magnetic Coefficients for Semiconductors.—E. H. Putley. (*Proc. phys. Soc.*, 1st Dec. 1952, Vol. 65, No. 396B, pp. 991–993.) Formulae derived for these coefficients by Sommerfeld & Frank in 1931, using classical statistics methods, give incorrect results because they are based on the assumption that the only significant contribution to the thermal conductivity is the electronic one, whereas in semiconductors the lattice contribution is normally many times larger than the electronic. Bronstein in 1932 took this into account. Comparison of the two sets of formulae shows agreement for Hall and Nernst coefficients and divergence for Ettingshausen and Righi-Leduc coefficients; an explanation of these facts is presented.

537.311.33 **1381**

Determination of the Effective Mass of Current Carriers in Semiconductors from their Infrared Absorption.—K. B. Tolpygo. (*Zh. eksp. teor. Fiz.*, March 1952, Vol. 22, No. 3, pp. 378–380.) Formulae are derived showing the relation between the optical properties of a semiconductor, the effective mass M and the mean free path of a current carrier. Using these formulae M can be determined experimentally.

537.311.33 **1382**

Energy States of Overlapping Impurity Carriers in Semiconductors.—C. Erginsoy. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 893–894.) An analytical solution is given of the Schrödinger equation for the spherically symmetrical wave function of an impurity carrier in a zero-wave-number state, on the basis of the Wigner-Seitz approximation. This solution reveals certain unforeseen characteristics of the overlapping mechanism.

537.311.33 : 546.561-31 **1383**

The Semiconductor Properties of Cu_2O: Part 1—Production Methods for Operational Stability.—G. Blankenburg & K. Kassel. (*Ann. Phys., Lpz.*, 15th April 1952, Vol. 10, Nos. 4/5, pp. 201–210.) Critical consideration of the process involved in producing Cu_2O by oxidation of Cu showed that an annealing process at 1 075°C for 150 hours was necessary if the resultant product was to contain no trace of Cu or CuO.

537.311.33 : 546.561-31 **1384**

The Semiconductor Properties of Cu_2O: Part 2—Influence of Lattice Defects on the Optical Absorption.—K. Kassel. (*Ann. Phys., Lpz.*, 15th April 1952, Vol. 10, Nos. 4/5, pp. 211–216.)

537.311.33 : 546.561-31 **1385**

The Semiconductor Properties of Cu_2O: Part 3—Dependence of the Electrical Conductivity at Low Temperature on the Oxygen Pressure during a Previous Annealing Process.—G. Blankenburg, C. Fritzsche & G. Schubart. (*Ann. Phys., Lpz.*, 15th April 1952, Vol. 10, Nos. 4/5, pp. 217–231.)

537.311.33 : 546.561-31 **1386**

The Semiconductor Properties of Cu_2O: Part 4—Conductivity Measurements at High Temperatures.—O. Böttger. (*Ann. Phys., Lpz.*, 15th April 1952, Vol. 10, Nos. 4/5, pp. 232–240.) Results at temperatures between 600°C and 1 000°C show that the conductivity is proportional to $p^{\frac{1}{4}}$ (where p is the oxygen pressure during annealing) only for pressures $>10^{-2}$mm Hg.

537.311.33 : 546.561-31 **1387**

The Semiconductor Properties of Cu_2O: Part 5—Interpretation of the Dependence of Electrical Conductivity at Low Temperatures on the [oxygen] Pressure during Annealing.—G. Blankenburg & O. Böttger. (*Ann. Phys., Lpz.*, 15th April 1952, Vol. 10, Nos. 4/5, pp. 241–252.)

537.311.33 : [546.817.221 + 546.817.231 + 546.817.241 **1388**

Intrinsic Conduction in PbS, PbSe, PbTe.—E. H. Putley. (*Proc. phys. Soc.*, 1st Dec. 1952, Vol. 65, No. 396B, p. 993.) Measurements further to those previously noted (3140 of 1952) give supplementary information about the gap between the full and conduction bands for PbSe.

537.311.33 : 621.314.634 **1389**

Temperature Variation of the Rectification Characteristics at Selenium Contacts.—E. W. Saker. (*Proc. phys. Soc.*, 1st Dec. 1952, Vol. 65, No. 396B, pp. 990–991.) Report of measurements made at temperatures of +60°, +20° and −42°C to determine the diffusion potential.

537.533 : 539.379 **1390**

Electron Emission from Cold-Worked Metals.—W. Pepperhoff. (*Z. Metallkde*, Nov. 1952, Vol. 43, No. 11, pp. 402–403.) Mechanical working of metals gives rise to an electron emission which can be demonstrated by its blackening effect on a photographic emulsion. Energy considerations indicate that the emission is a result of the adsorption of oxygen.

537.533 : [546.482.21 + 546.482.31 **1391**

Field Emission from Photoconductors.—L. Apker & E. Taft. (*Phys. Rev.*, 1st Dec. 1952, Vol. 88, No. 5, pp. 1037–1038.) Field emission from single-crystal needles of CdS and CdSe was found to increase greatly when the emitting areas were illuminated by light of wavelength exciting photoconduction. Possible mechanisms are discussed.

537.582 **1392**

Thermionic Constants of Metals and Semiconductors: Part 2—Metals of the First Transition Group.—S. C. Jain & K. S. Krishnan. (*Proc. roy. Soc. A*, 22nd Dec. 1952, Vol. 215, No. 1123, pp. 431–437.) The method of determination described in part 1 (3467 of 1952) can be used for most metals by coating the inner walls of the graphite chamber with a thick layer of the metal. Measurements are reported on metals of the series from Ti to Ni.

538.221 **1393**

Effective Magnetic Distances in Metals, Alloys and Ferromagnetic and Antiferromagnetic Combinations of the Iron Group.—R. Forrer. (*Ann. Phys., Paris*, Sept./Oct. 1952, Vol. 7, pp. 605–621.) Experimental results are reported and shown graphically. The limits of the interaction considered responsible for ferromagnetism are relatively well defined except for the upper limit for Mn and Cr and the lower limit for Ni. The lower limit of the ferromagnetic zone rises steadily from Ni to Cr.

538.221 **1394**

The Thermal and Thermoelectrical Properties of Ferromagnetic Metals.—A. I. Rezanov. (*C. R. Acad. Sci. U.R.S.S.*, 21st Feb. 1952, Vol. 82, No. 6, pp. 885–887. In Russian.) A theoretical discussion relating the properties of the metals to the electronic processes in the crystal lattice.

538.221 **1395**

Ferroxcube.—(*Philips tech. Commun., Aust.*, 1952, No. 4, pp. 3–13.) Properties and various data on available types and grades of ferroxcube are tabulated and shown graphically.

538.221 **1396**

A Survey of the Possible Applications of Ferrites.—K. E. Latimer & H. B. MacDonald. (*Philips tech. Commun., Aust.*, 1952, No. 4, pp. 13–27.) A general review, including curves and tables illustrating the practical design of h.f. transformer and filter-coil cores.

538.221 **1397**

Spontaneous Magnetization of Ferrites.—R. Pauthenet. (*Ann. Phys., Paris*, Sept./Oct. 1952, Vol. 7, pp. 710–747.) The experimental apparatus is described in detail.

The theory of ferrimagnetism accounts satisfactorily for the variations with temperature of the spontaneous magnetization of Ni, Co and Fe ferrites and also for the variations of absolute saturation magnetization of NiZn ferrites with low Zn content. The effects of quenching are interpreted on the basis of Néel's theory (3159 of 1949).

538.221 : 538.632 **1398**

The Hall Effect in Nickel Ferrite.—S. Foner. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 955–956.) Experiments are described which indicate that the Hall effect for a Ni ferrite resembles that for ferromagnetic metals, and is composed of an ordinary effect proportional to the field together with an extraordinary effect proportional to the magnetization.

538.221 : 538.652 **1399**

Magnetostriction of Single Crystals of Cobalt and Nickel Ferrites.—R. M. Bozorth & J. G. Walker. (*Phys. Rev.*, 1st Dec. 1952, Vol. 88, No. 5, p. 1209.) Measurements were made on a crystal of Co ferrite cut parallel to the (001) plane and subjected to field strengths up to 5 000 oersted. An unusually large magnetostriction $\Delta l/l = -540 \times 10^{-6}$ in the [100] direction was observed. On cooling the crystal in a magnetic field the value found was -720×10^{-6}. The results are shown in graphs, together with corresponding results for crystals of Ni ferrite.

538.221 : 621.3.017.31 **1400**

Eddy-Current Losses in Ferromagnetic Materials with Complex Conductivity.—H. Henniger. (*Deutsche Elektrotech.*, Sept. & Oct. 1952, Vol. 6, Nos. 9 & 10, pp. 399–402 & 528–531.) A formula is derived for the eddy-current loss in a coil former of rectangular section and the Q-factor of the coil is deduced. The advantages of ferrites for h.f. applications are noted.

538.221 : [621.317.335.2 + 621.317.411 **1401**

Dielectric Constant and Permeability of Various Ferrites in the Microwave Region.—T. Okamura, T. Fujimura & M. Date. (*Phys. Rev.*, 15th Dec. 1952, Vol. 88, No. 6, p. 1435.) Corrections to paper noted in 2535 of 1952.

538.639 **1402**

Additional Resistance of Ferromagnetic Metals.—A. G. Samoilovich & V. A. Yakovlev. (*Zh. eksp. teor. Fiz.*, March 1952, Vol. 22, No. 3, pp. 350–355.) The effect of spontaneous magnetization of a ferromagnetic crystal on its electrical resistance is considered. The temperature dependence of the additional resistance is established for low temperatures.

546.28 + 546.289 **1403**

Plastic Deformation of Germanium and Silicon.—C. J. Gallagher. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 721–722.) Observations on Ge single crystals are reported. The material becomes ductile at temperatures >500°C; at temperatures <600°C there is a time delay in the deformation. Si single crystals become ductile at temperatures >900°C.

546.28 + 546.289 **1404**

The Plasticity of Silicon and Germanium.—F. Seitz. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 722–724.) Discussion of measurement results obtained by Gallagher (see 1403 above). A possible explanation of the temperature-dependent time delay of the deformation is advanced.

546.289 **1405**

Germanium, produced as a Byproduct, has become of Primary Importance.—A. P. Thompson & J. R. Musgrave. (*J. Metals*, Nov. 1952, Vol. 4, No. 11, pp. 1132–1137.) Description of production methods used in the U.S.A. and in England, with a brief review of the properties and applications of Ge.

546.289 : 537.311.33 **1406**

Grain Boundary Barriers in Germanium.—W. E. Taylor, N. H. Odell & H. Y. Fan. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 867–875.) High nonlinear resistance at grain boundaries of n-type Ge has been reported previously [e.g. 1939 of 1950 (Odell & Fan)] and is attributed to surface states as postulated by Bardeen (3086 of 1947). The barriers are able to withstand voltages as high as 100 V because the surface charge increases with increasing applied voltage. Both d.c. and a.c. measurements are reported. At sufficiently low temperatures the barrier capacitance is frequency independent, indicating that the current is mainly electronic, while at higher temperatures the capacitance is markedly frequency dependent, indicating the increasing importance of hole current. The height of the potential barrier above the Fermi level is independent of temperature. A small difference between the measured breakdown voltages for the two directions is attributed to a difference between the impurity concentrations on the two sides of the boundary.

546.289 : 537.311.33 **1407**

Acceptors Produced in Germanium by Quenching from High Temperatures.—C. Goldberg. (*Phys. Rev.*, 15th Nov. 1952, Vol. 88, No. 4, pp. 920–924.) Acceptors were produced in Ge single crystals of both n and p type by very rapid cooling from high temperatures. On the basis of previous experiments by Fuller et al. (2235 of 1952) it is assumed that the acceptor levels are due to Schottky defects. A formula is derived for the equilibrium concentration of ionized Schottky defects; from consideration of this together with the experimental results it is estimated that $1{\cdot}49 \pm 0{\cdot}12$ eV must be supplied to the crystal to form a Schottky defect. The activation energy of self-diffusion produced by a vacancy mechanism is $2{\cdot}0 \pm 0{\cdot}1$ eV.

546.289 : 548.55 : 537.311.33 **1408**

Preparation of Germanium Single Crystals.—L. Roth & W. E. Taylor. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, p. 218.) Corrections to paper abstracted in 744 of March.

546.817.241 : 537.311.33 **1409**

Transistor Action in Lead Telluride.—C. A. Hogarth. (*Proc. phys. Soc.*, 1st Dec. 1952, Vol. 65, No. 396B, pp. 958–963.) Transistor action has been observed in artificial p-type single crystals of PbTe examined at 90°K. The experimental method is described; values of current gain > 1 are reported. Since good rectification and transistor action are observed only at low temperatures, it is not expected that a useful device will be developed from this material.

546.817.824-31 : 537.226 **1410**

Dielectric Properties of Monocrystals of Lead Titanate.—I. N. Belyaev & A. L. Khodakov. (*Zh. eksp. teor. Fiz.*, March 1952, Vol. 22, No. 3, pp. 376–378.) Previous investigations were carried out on polycrystalline samples of $PbTiO_3$, but since these are difficult to obtain in a pure form, experiments were repeated with monocrystals. The results confirm that $PbTiO_3$ has ferroelectric properties.

549.212 : 53 **1411**

Properties of Graphite.—J. P. Howe. (*J. Amer. ceram. Soc.*, 1st Nov. 1952, Vol. 35, No. 11, pp. 275–

282.) Review of present knowledge of the crystal structure and the thermal, electrical, and mechanical properties of graphite. 31 references.

621.775.7 **1412**

Austria is Host to World Congress on Powder Metallurgy.—H. H. Hausner. (*Metal Progr.*, Nov. 1952, Vol. 62, No. 5, pp. 79–83.) Report of the proceedings at a conference held at Reutte, Austria, in June 1952.

MATHEMATICS

517.941.91 : 518.61 **1413**

Numerical and Graphical Integration of Oscillation Equations.—S. Flügge. (*Z. Phys.*, 4th Nov. 1952, Vol. 133, No. 4, pp. 449–450.) The application of recurrence formulae has advantages over the Taylor-series method of integrating equations of the type $d^2y/dx^2 + f^2(x)y = 0$, where f is the variable oscillation frequency. A simple graphical integration method is briefly described.

681.142 **1414**

Design Features of the ERA 1101 Computer.—F. C. Mullaney. (*Elect. Engng, N.Y.*, Nov. 1952, Vol. 71, No. 11, pp. 1015–1018.) Description of a single-address binary-system parallel computer with magnetic storage, in operation since 1951.

681.142 **1415**

Programming a Digital Computer to Learn.—A. G. Oettinger. (*Phil. Mag.*, Dec. 1952, Vol. 43, No. 347, pp. 1243–1263.) "By the application of the techniques described, digital computers can be made to serve as models in the study of the functions and of the structures of animal nervous systems."

681.142 : 517.9 **1416**

The Use of Extrapolation Techniques with Electrical Network Analogue Solutions.—R. Culver. (*Brit. J. appl. Phys.*, Dec. 1952, Vol. 3, No. 12, pp. 376–378.) An outline is given of numerical techniques which can be used, in solving certain differential equations, to estimate the exact result from finite-difference solutions obtained with various mesh sizes.

681.142 : 621.3.015.7 **1417**

Electronic Multiplier using Pulses Modulated in Duration and Amplitude.—E. Flater & K. Fränz. (*Rev. telegr. Electronica, Buenos Aires*, Sept. 1952, Vol. 41, No. 480, pp. 570–573.) A 15-valve analogue computer capable of effecting 1 000 multiplications/sec, accurate to within 1%, is based on the generation of pulses whose duration and amplitude are respectively proportional to the quantities to be multiplied.

681.142 : 621.383 **1418**

Intermittent-Feed Computer-Tape Reader.—B. G. Welby. (*Electronics*, Feb. 1953, Vol. 26, No. 2, pp. 115–117.) Description of a six-photocell system used for reading the teleprinter-tape input to the Ferranti digital computer Mark 1. Five of the cells read the five-hole tape characters, while the sixth is associated with the sprocket holes and provides a signal for controlling the tape movement. Speeds up to 200 characters/sec are attainable. See also 454 of February (Packer & Wray).

001.8 **1419**

The Design and Analysis of Experiments. [Book Review]—O. Kempthorne. Publishers: Chapman and Hall, London; J. Wiley & Sons, New York; 1952, 631 pp., 68s. (*Nature, Lond.*, 13th Dec. 1952, Vol. 170, No. 4337, p. 991.) Presents "the general statistical theory on which all uses of experimental designs rest, together with instructions for constructing, analysing and interpreting some of the more complex designs."

MEASUREMENTS AND TEST GEAR

531.76 : 621.3.015.7 **1420**

Precise Determination of a Time Interval by means of an Electronic Device. Automatic Return to Zero. Choice of Reference Frequency.—A. Peuteman. (*C. R. Acad. Sci., Paris*, 1st Dec. 1952, Vol. 235, No. 22, pp. 1381–1382.) The arrangement described comprises a stable oscillator connected to a counter circuit which operates a flip-flop to produce pulses marking the beginning and end of the time interval. The oscillator frequency is chosen so as to minimize the effects of timing uncertainties inherent in the operation of the circuits.

531.764 : 621.398 **1421**

Time by Telearchics.—(*Wireless World*, March 1953, Vol. 59, No. 3, p. 136.) Brief note on an experimental arrangement for controlling a conventional pendulum clock from pulses radiated at 1-sec intervals by a standard-frequency service, using an electromagnetically operated pawl.

621.3.018.41(083.74) [+ 529.786] : 538.569.4 **1422**

Atomic Clocks and Frequency Stabilization.—C. R. S. Ince. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1408–1409.) Comment on 1659 of 1952 (Townes).

621.3.018.41(083.74) : 621.396 **1423**

[British] **Standard Frequencies.**—(*Wireless World*, March 1953, Vol. 59, No. 3, p. 119.) Announcement of a revision of the schedule of transmissions from Rugby to give a 24-hour service using several of the frequencies 2·5, 5, 10, 15, 20 and 25 Mc/s.

621.311.62(083.74) : 621.316.722.1 **1424**

A Stabilized and Calibrated A.C. Voltage Source.—C. T. J. Alkemade & G. van den Brink. (*Appl. sci. Res.*, 1952, Vol. B3, No. 1, pp. 47–50.) Equipment is described that provides a sinusoidal stabilized a.c. voltage of frequency 50 c/s for use as a reference standard in balance measurements of photoelectric currents obtained with the exciting light beam chopped at the same frequency. The measurements are made by means of an a.c. amplifier and a.c. galvanometer, as described by Milatz & Bloembergen (1908 of 1949).

621.317 [+ 621.398] : 621.39.001.11 **1425**

Modern Signal and Information Theories. Applications to Telecontrol and Measurements.—J. Loeb. (*Rev. gén. Élect.*, Nov. 1952, Vol. 61, No. 11, pp. 499–516.) See also 2535 and 3041 of 1951.

621.317.331(083.74) **1426**

Modified Bridge Method for Absolute Determination of Ohm.—M. Romanowski. (*Canad. J. Phys.*, Nov. 1952, Vol. 30, No. 6, pp. 631–636.) Campbell's original bridge and Picard's modification are examined; by rearranging the components, two other networks for the same measurement can be obtained. A model of one of these was built using manganin circuit elements to reduce temperature effects. No determination of self-inductance is necessary. This bridge requires a mutual inductance equal to twice the value of the standard.

621.317.35 **1427**

The Analysis of Waves containing Harmonics up to the Twelfth.—D. R. Turner. (*Electronic Engng*, Jan. 1953, Vol. 25, No. 299, pp. 30–35.) Description of a method similar to that of Kemp (1374 cf 1952) but applicable to waves containing both even and odd harmonics.

621.317.361 **1428**

Instantaneous Measurement of a Varying Frequency.—L. U. Hibbard & D. E. Caro. (*J. sci. Instrum.*, Nov. 1952, Vol. 29, No. 11, pp. 366–370.) The passage of a rapidly varying frequency through a particular value can be observed by beating the varying frequency with a fixed-frequency reference signal. The output of the mixer valve is peak rectified and displayed on a c.r.o. The method is particularly suitable for frequency/time functions which are linear or have an inflection at the point of observation. Errors due to nonlinear functions are examined. In the case of repetitive functions, the phasing of the fixed oscillator with respect to the varying-frequency signal at the point of observation is effected automatically.

621.317.411 **1429**

A Method of Measuring the Magnetic Permeability of Rod Specimens.—H. Aspden. (*J. sci. Instrum.*, Nov. 1952, Vol. 29, No. 11, pp. 371–374.) Description of a method using a search coil and fluxmeter together with switching arrangements resulting in integration of the effects of repeated reversals of the magnetizing field.

621.317.444 **1430**

A Rotating-Coil Fluxmeter.—M. S. Wills. (*J. sci. Instrum.*, Nov. 1952, Vol. 29, No. 11, pp. 374–376.) A small search coil mounted on a flexible shaft is rotated at a constant speed of about 3 000 r.p.m. in the unknown field, and the alternating e.m.f. picked up is fed to a transformer primary mounted on the other end of the shaft. The e.m.f. from the fixed secondary of the transformer is amplified and measured by a valve voltmeter, giving absolute readings proportional to the flux linkage.

621.317.71 **1431**

Combined Current Integrator and Sensitive Microammeter.—H. A. Enge. (*Rev. sci. Instrum.*, Nov. 1952, Vol. 23, No. 11, pp. 599–600.) An instrument designed for use with e.s. accelerators and capable of integrating currents $>10^{-8}$ A has in the integrator input circuit a compensation resistor which acts also as shunt resistor for the valve voltmeter used as microammeter.

621.317.73 : 621.396.67 **1432**

Impedance-Measuring Apparatus.—M. P. Beddoes. (*Wireless Engr*, March 1953, Vol. 30, No. 3, pp. 69–72.) Apparatus for measuring the impedance of a v.h.f. aerial incorporates a reflectometer which detects the radiation reflected by a 'standards unit' with and without the aerial connected; by this method the detector does not pick up radiation from the aerial. The frequency range of the particular equipment described is 30–60 Mc/s, but this could be extended to 7–100 Mc/s without difficulty. The accuracy is inversely proportional to the impedance measured, the error being $\not> \pm 10\%$ for 1 kΩ.

621.317.733.029.55/.62 **1433**

High-Frequency Bridge with Variable Ratio Arms.—J. E. Houldin & G. T. Thompson. (*Wireless Engr*, Feb. 1953, Vol. 30, No. 2, pp. 32–38.) The bridge is intended for the measurement of unbalanced impedances, such as aerials and cables, of the order of 100Ω at frequencies between 10 and 100 Mc/s. In an experimental model described, the variable ratio arms are in the form of a circular arc of transmission line with a movable feed point. The unknown is measured in terms of a standard resistor, two variable capacitors and the ratio of the lengths of the two line sections. The only auxiliary equipment required is a signal generator giving 2 V r.m.s. and a sensitive d.c. galvanometer. The accuracy depends on the frequency and on the value of the unknown.

621.317.733.083.4 **1434**

Balance Approach in A.C. Measurement Circuits: Part 2 — Wheatstone Bridges.—H. Poleck. (*Arch. tech. Messen*, Nov. 1952, No. 202, pp. 259–262.) The 'convergence factor', a measure of the rate at which a system attains the balance condition, is calculated for a Wheatstone bridge, a potentiometer-type capacitance bridge and a Schering bridge. Part 1: 1660 of 1952.

621.317.74 : 621.317.34 **1435**

Two Diagram Methods for Determination of Network Parameters at Very High Frequencies.—R. Eichacker. (*Fernmeldetech. Z.*, Nov. 1952, Vol. 5, No. 11, pp. 487–496.) Two methods are described for the direct representation of the impedance, admittance, attenuation, phase, reflection coefficient, etc., of networks in polar or derived diagrams. The complex reflection factor, from which all the parameters can be deduced, is determined from measurements of the voltages picked up, in the first method, by four probes spaced $\lambda/8$ apart along a shorted coaxial line terminated by the network in question, and secondly by directional couplers inserted in each half of a symmetrical coaxial system, one half terminated by the network and the other short-circuited, a Rohde & Schwarz '*Z-g*' diagraph being used to determine the vectorial difference between the voltages picked up by the directional couplers. Details are given of the methods of deriving the various network parameters.

621.317.755 **1436**

The B.T.R. Frequency-Shift Cathode-Ray Monitor.—R. Terlecki. (*Strowger J.*, Nov. 1952, Vol. 8, No. 4, pp. 184–189.) Two gating diodes are connected to the c.r.-tube vertical plates in such a way that the alternation of positive and negative pulses arriving from the receiver discriminator causes the beam to trace a V on the screen. A 5-kc/s frequency-sweep oscillator is used to broaden the trace so that inequality of the arms, indicative of receiver mistuning, is easily perceptible.

621.317.755 : 621.314.7 **1437**

Cathode-Ray Tube plots Transistor Curves.—J. Kurshan, R. D. Lohman & G. B. Herzog. (*Electronics*, Feb. 1953, Vol. 26, No. 2, pp. 122–127.) Detailed description of automatic c.r.o. equipment for displaying families of transistor characterisics; both point-contact and junction types can be handled.

621.317.755 : 621.397.6.018.7 **1438**

A Delayed-Trigger Oscillograph.—R. Anderson & J. R. Smith. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 591–596. Discussion, pp. 645–650.) By deriving a trigger pulse from the first of the eight wide pulses in each frame cycle and delaying this pulse by means of a variable delay circuit covering the range 2–22 ms, the variable-speed timebase of the c.r.o. can be fired to enable either a single line or any required portion of the waveform to be displayed. Detailed circuit diagrams of the equipment are given. See also 1762 of 1952 (Fisher).

621.317.757 **1439**

A Photomechanical Wave Analyser for Fourier Analysis of Transient Waveforms.—T. B. Whiteley & L. R. Alldredge. (*J. sci. Instrum.*, Nov. 1952, Vol. 29, No. 11, pp. 358–362.) A photoelectric system is used to derive a signal from repetition of the transient wave by means of a revolving drum. The signal is analysed by application to fixed tuned circuits, the drum speed being gradually reduced so as to obtain a large number of points on the frequency-spectrum curve.

621.317.772 : 621.392.26 **1440**

Squeeze-Section Phase Shifter for Microwave Measurements.—J. J. Brady, M. D. Pearson & S. Peoples. (*Rev. sci. Instrum.*, Nov. 1952, Vol. 23, No. 11, pp. 601–604.) The device comprises a section of standard 3-cm waveguide with slots 25 in. long and 0·0625 in. wide in the broad faces and a calibrated micrometer head for introducing compression at the mid-point of the slot. A calculation is made of the relative wavelength change as a function of wall displacement. A table of values is given from which calibration curves can be drawn.

621.317.78 : [537.312.6 : 621.316.86 **1441**

Power Measurement with Thermistors at High Frequencies.—H. Groll. (*Fernmeldetech. Z.*, Nov. 1952, Vol. 5, No. 11, pp. 522–527.) Various types of thermistor, including some of the bead type suitable for h.f. measurements, are described, with illustrations, and also arrangements for power measurements on coaxial lines. The thermistors used have resistances, when cold, of 1–500 kΩ, with power ratings from 1 to 50 mW. For higher powers, thermistors may be connected in parallel with a coaxial line terminated by its characteristic impedance.

621.317.784.029.64/.65 **1442**

A Microwave Vibration Wattmeter.—A. L. Cullen. (*Nature, Lond.*, 27th Dec. 1952, Vol. 170, No. 4339, pp. 1121–1122.) A method of measuring microwave power is described in which a short magnetic dipole is suspended horizontally at its mid-point by a quartz fibre inside a high-Q cavity resonator fed through a waveguide. By repeatedly switching the power on and off, the dipole can be made to oscillate through an angle depending on the frequency, the power applied to the cavity at resonance, and the physical constants of the quartz fibre. The method is independent of the value of Q and of the characteristics of the dipole and should therefore be particularly suitable for use at millimetre wavelengths. Tests at a wavelength of 3·2 cm show that a deflection of about 30 cm at a scale distance of 1 m can easily be obtained with a power of 100 mW or less.

621.317.79 : 621.396.822 **1443**

The Ogiver, a Radio-Noise Meter.—A. W. Sullivan. (*Radio & Telev. News, Radio-electronic Engng Section*, Dec. 1952, Vol. 48, No. 6, pp. 3–5.) Description, with detailed circuit diagram, of an instrument for measuring the fraction of time that a noise wave exceeds a prescribed voltage level. The instrument is a development of that described by Hoff & Johnson (1953 of 1952), a closed loop having been added to permit change of the variable to be measured.

621.385.832.001.42 **1444**

The Life Testing of Cathode-Ray Tubes.—R. C. Hart. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 537–541. Discussion, pp. 571–576.) An outline of methods used and of safety precautions necessary.

621.396.9 : 621.317.7 **1445**

A Compact Radar Test Unit.—G. W. Bridger & C. A. Sempers. (*Marconi Instrumentation*, Dec. 1952, Vol. 3, No. 8, pp. 136–145.) Equipment Type-TF890A designed for the 3-cm waveband comprises (*a*) a signal generator with either c.w. or pulse output at a level continuously variable over a range of 66 db below 1 mW, with a further fixed attenuation of about 50 db available, (*b*) a power monitor, using a thermistor bridge, for measuring r.f. mean powers up to 50 W, (*c*) a spectrum analyser using a modulated local oscillator, a mixer and i.f. amplifier to provide a series of pulses distributed linearly over the transmitter frequency spectrum and proportional to its power at these points. Operation of the equipment is described.

621.396.9.001.4 **1446**

Measurements relating to [moving-target] Radar Equipment with Fixed-Target-Echo Elimination.—J. Cauchois. (*Ann. Radioélect.*, Oct. 1952, Vol. 7, No. 30, pp. 288–295.) The principles of the elimination of echoes from fixed objects are outlined and stability requirements in equipment for moving-target indication are noted. Block diagrams and outline descriptions of c.r.o. methods of measuring frequency drift are given. In the case of the klystron local oscillator, a second stabilized klystron is used to obtain a test-frequency signal which is checked (*a*) by heterodyning in a commercial receiver, (*b*) by a sensitive frequency discriminator centred on 100 kc/s, or (*c*) by a phase comparator operating in conjunction with a stable medium-frequency generator. Methods (*b*) and (*c*) may be adapted for checking the coherent oscillator. Magnetron stability both during and between pulses may be measured on a calibrated wide-band frequency discriminator. A heterodyne method for checking the operation of the local-oscillator/coherent-oscillator assembly is described.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.321.9 : 623.896 **1447**

Ultrasonic Recorder gauges Torpedo Depth.—C. E. Goodell. (*Electronics*, Feb. 1953, Vol. 26, No. 2, pp. 118–121.) For measuring the depth of a torpedo on a test run, a dummy head is used containing a pulse transceiver and ultrasonic transducer; the depth indication is obtained from the pulses reflected back from the ocean surface and is continuously recorded. A transducer with wide radiation angle is used.

537.565 : 621.316.729 **1448**

Two Systems for the Synchronization of Pulsed High-Energy Ion Beams.—G. von Dardel, E. Hellstrand & C. Taylor. (*Appl. sci. Res.*, 1952, Vol. B3, No. 1, pp. 35–46.)

538.24.001.8 : 621-44 **1449**

Contour Recording by Magnetic Tape.—R. R. Perron. (*Elect. Mfg*, June 1951, Vol. 47, No. 6, pp. 130–131.) Equipment is described in which a p.w.m. method is used to record, on magnetic tape, a set of pulses representing a particular contour to be reproduced. Reproduction is effected via an amplifier, a flip-flop circuit, and a servo system. Up to 1 000 copies can be made, using ordinary coated-paper tape.

621.316.7 : 621.392.5 **1450**

Realization of Correction Circuits.—V. V. Bulgakov. (*Bull. Acad. Sci. U.R.S.S., tech. Sci.*, Jan. & May 1952, Nos. 1 & 5, pp. 21–40 & 699–723. In Russian.) Correction circuits used with automatic regulators and servo-mechanisms for improving their frequency characteristics are considered. All basic types of quadripole section are analysed. The circuits do not contain mutual inductors, nor, in the majority of cases, ideal elements, i.e., resistance-free inductors or loss-free capacitors. Methods are indicated for selecting quadripole sections so as to realize any given rational function.

621.316.718.5 **1451**

General Considerations on Electronic Speed Regulators.—R. Larguier. (*Ann. Radioélect.*, Oct. 1952, Vol. 7, No. 30, pp. 279–287.) A simplified mathematical treatment to determine design requirements for stability and accuracy. In respect of inertia and friction coefficients these are different from those obtaining in the design of position servomechanisms.

621.365.54† **1452**
The High-Frequency Heating of Metals.—R. Wälchli. (*Bull. schweiz. elektrotech. Ver.*, 13th Dec. 1952, Vol. 43, No. 25, pp. 1015–1028.) Illustrated description of the principles and applications of induction heating in soldering, heat treatment, etc.

621.365.55† **1453**
High-Frequency Dielectric Heating.—A. Goldstein. (*Bull. schweiz. elektrotech. Ver.*, 13th Dec. 1952, Vol. 43, No. 25, pp. 1005–1015.) Discussion of the theory of the process in relation to the molecular structure of dielectric materials and description of its application in different industries.

621.384.612 **1454**
The Strong-Focusing Synchrotron — a New High-Energy Accelerator.—E. D. Courant, M. S. Livingston & H. S. Snyder. (*Phys. Rev.*, 1st Dec. 1952, Vol. 88, No. 5, pp. 1190–1196.) Strong focusing is produced by use of alternate converging and diverging magnetic lenses. A design for a 3×10^{10} eV proton accelerator is discussed.

621.384.622.1 **1455**
Radial Focusing in the Linear Accelerator.—J. P. Blewett. (*Phys. Rev.*, 1st Dec. 1952, Vol. 88, No. 5, pp. 1197–1199.) Application to linear accelerators of the focusing mechanism described in 1454 above.

621.385.833 **1456**
Double Focusing of Charged Particles with a Wedge-Shaped, Nonuniform Magnetic Field.—R. M. Sternheimer. (*Rev. sci. Instrum.*, Nov. 1952, Vol. 23, No. 11, pp. 629–634.)

621.385.833 **1457**
Electron Microscopy by Reflection.—C. Fert & R. Saporte. (*C. R. Acad. Sci., Paris*, 10th Dec. 1952, Vol. 235, No. 23, pp. 1490–1492.) Description of the features of an experimental microscope in which the specimen and the electron beam are inclined slightly to the axis of the objective, for the examination of polished opaque surfaces at nearly grazing incidence of the beam.

621.385.833 **1458**
Experimental Study of the Electrostatic Immersion Objective with Plane Electrodes.—A. Septier. (*C. R. Acad. Sci., Paris*, 22nd Dec. 1952, Vol. 235, No. 25, pp. 1621–1623.)

621.385.833 **1459**
A Method for the Measurement of Spherical Aberration of an Electrostatic Electron Lens.—D. W. Shipley. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1310–1316.)

621.385.833 : 538.691 **1460**
Focusing Properties of a Combination of a Radially Decreasing Magnetic Field and a Cylindrical Electric Field.—D. Fischer. (*Z. Phys.*, 4th Nov. 1952, Vol. 133, No. 4, pp. 455–470.) Analysis shows that such a field combination produces both radial and axial focusing and is superior in respect of resolving power and intensity to a uniform-field system.

621.387.4 **1461**
Counter Tubes with Methylene Halides as Vapour Admixture.—H. Neuert & H. Gutbier. (*Z. Phys.*, 4th Nov. 1952, Vol. 133, No. 4, pp. 451–454.)

621.387.42 **1462**
Discharge Mechanism in Argon Counters.—L. Colli & U. Facchini. (*Phys. Rev.*, 1st Dec. 1952, Vol. 88, No. 5, pp. 987–998.) A study of the multiplication curves and pulse shapes obtained with counters filled with pure Ar or with mixtures of Ar and CO_2 at pressures from 150 to 1 000 mm Hg.

621.387.424 **1463**
Properties of Argon-Bromine Counters.—D. van Zoonen & G. Prast, Jr. (*Appl. sci. Res.*, 1952, Vol. B3, No. 1, pp. 1–17.) The properties of counters using an Ar-Br mixture for quenching are compared with those of counters using an argon-alcohol mixture.

621.387.424 **1464**
The Apparent Dead Time of a Geiger Counter, measuring an Intensity of Radiation which varies periodically.—H. Daams. (*Appl. sci. Res.*, 1952, Vol. B3, No. 1, pp. 29–34.) A formula is derived for correcting the effect of the dead time of a G-M counter when measuring periodically varying radiation. Experiment shows that with increasing frequency of the variation the count goes through a maximum value.

PROPAGATION OF WAVES

538.566 : 551.510.535 **1465**
Differential Equation for Electromagnetic Rays in a Nonuniform Ionized Absorbing Medium with Slowly Varying Parameters.—H. Arzeliès. (*C. R. Acad. Sci., Paris*, 22nd Dec. 1952, Vol. 235, No. 25, pp. 1619–1621.) The notation and results of a previous note (196 of January) are used and a general differential equation for the phase lines is developed. The phase lines coincide with the e.m. rays giving the mean direction of energy propagation. Application of the results to propagation in the ionosphere, where absorption is slight, is discussed briefly.

538.566.2 **1466**
Reflection of Electromagnetic Waves Obliquely from an Inhomogeneous Medium.—J. R. Wait. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1403–1404.) A solution is derived for reflection from a plane boundary between a homogeneous medium and one in which the permittivity varies exponentially with distance from the boundary.

538.566.3 : 551.510.535 **1467**
Calculation of Absorption in the Ionospheric Propagation of Short Waves.—Bolle & Dominici. (See 1351.)

621.396.11 **1468**
Some Notes on Theory of Radio Scattering in a Randomly Inhomogeneous Atmosphere.—H. Fine. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, p. 294.) Booker & Gordon (1757 of 1950) defined an auto-correlation function of permittivity as a space correlation. Staras (N.B.S. Report No. 1662) has proposed the use of a time correlation function and derived an expression for the average received power due to scattering, whereas Booker & Gordon considered the instantaneous power. From practical considerations it would seem that the average power is the more useful, as the instantaneous power fluctuates greatly with time. A third definition of correlation is proposed and discussed, with correlation in the time-space domain.

621.396.11 **1469**
Graphical Solution of Sky-Wave Problems.—R. A. Helliwell. (*Electronics*, Feb. 1953, Vol. 26, No. 2, pp. 150, 152.) A chart is presented which relates great-circle distance, virtual height of reflection, equivalent path distance, angle of departure and angle of incidence at the ionosphere so that any three of these magnitudes can be determined if the other two are known.

621.396.11 **1470**

New Determinations of the Velocity of Radio Waves.—C. I. Aslakson. (*Trans. Amer. geophys. Union*, Dec. 1951, Vol. 32, No. 6, pp. 813–821.) A new value of 299 794·2 ± 1·4 km/s is deduced for the velocity of propagation of radio waves in vacuo. This value was obtained by comparison of long-distance geodetic measurements with results obtained with improved shoran equipment. A value of 299 793 km/s has been adopted by the U.S. Air Force for shoran measurements. For previous work see 206 and 2610 of 1950.

621.396.11 : 551.5 **1471**

Tropospheric Wave Propagation in a Duct of Non-uniform Height.—H. G. Hay & R. S. Unwin. (*Proc. phys. Soc.*, 1st Dec. 1952, Vol. 65, No. 396B, pp. 981–989.) The mode theory of tropospheric refraction presented by Booker & Walkinshaw (2892 of 1947) is extended to cover the case where the refractive-index profile varies along the transmission path, the path being considered as a series of zones within each of which the profile is constant. The duct width and the lapse rate of modified refractive index at infinite height are found for each zone and are used in conjunction with published propagation curves to estimate the field-strength distribution in the region beyond the horizon of a transmitter. Though the method is general, the final formula applies specifically to situations in which the field is adequately described by the first mode alone and the refractive-index profile in each zone is represented by a one-half power law curve. Results obtained by applying the theory are in good agreement with experimental results obtained during an investigation in New Zealand [200 of 1951 (Milnes & Unwin)].

621.396.11 : 551.510.535 : 523.746 **1472**

The Differences in the Relationship between Ionospheric Critical Frequencies and Sunspot Number for Different Sunspot Cycles.—Ostrow & PoKempner. (See 1350.)

621.396.11 : 621.396.81 **1473**

Statistical Fluctuations of Radio Field Strength far beyond the Horizon.—S. O. Rice. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 274–281.) Statistical properties of the fluctuations are derived on the basis of the Booker-Gordon scattering theory. Expressions are obtained for the periods of the fluctuations in time, in space, and in frequency. These expressions extend closely related results obtained by Booker, Ratcliffe and others.

621.396.11.029.51 **1474**

Oblique Incidence Propagation at 300 kc/s using the Pulse Technique.—J. M. Watts. (*J. geophys. Res.*, Dec. 1952, Vol. 57, No. 4, pp. 487–498.) Data derived from experiments over the 1185-km sea path from Wildwood, New Jersey, to Bermuda during March–June 1951 are presented. Included are photographs of typical pulse envelopes obtained and graphs of (*a*) time-delay differences between surface and sky waves and (*b*) sunrise transition times.

RECEPTION

621.396.82 **1475**

The Effective Value of Modulated Oscillations.—M. Kulp. (*Frequenz*, Oct. 1952, Vol. 6, No. 10, pp. 290–295.) Expressions are derived for the r.m.s. values corresponding to various complex a.m. and f.m. waveforms. Bessel-function relations used in deriving the expressions and in calculating interference with reception (2325 and 2886 of 1952) are listed.

621.396.828 : 621.395.34 **1476**

The Suppression of Radio Interference from Telephone Apparatus.—A. F. Jones. (*G.E.C. Telecommun.*, Nov. 1952, No. 15, pp. 36–42.) A review, with reference to B.S.I. specifications, of methods recommended for suppression of interference from electrical apparatus, and application of these methods to automatic telephone apparatus.

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11 **1477**

Correlation versus Linear Transforms.—M. J. E. Golay. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 268–271.) Discussion indicates that while the correlation concept is useful in communication theory, it does not constitute a useful operational concept in communication or radar practice. On the other hand, operation of many systems could possibly be improved by a system based on storage on magnetic tapes of the sign only of the amplitude of signals submerged in noise, with linear transformation and presentation of the transforms at cinematographic speed.

621.39.001.11 **1478**

'Ideal Coding' versus 'Redundancy'.—D. A. Bell. (*Wireless Engr*, March 1953, Vol. 30, No. 3, pp. 73–74.) An examination is made of some implications of Theorem 2 of Shannon's paper on communication in the presence of noise (1649 of 1949). A three-dimensional model showing the power and uncertainty associated with a three-digit signal is used to illustrate discussion of the risk of errors. 'Shannon coding' should in principle be more effective than 'redundancy' for reducing errors.

621.39.001.11 : 001.891 **1479**

Some Problems and Methods of Communications Research.—W. Meyer-Eppler. (*Fernmeldetech. Z.*, Nov. 1952, Vol. 5, No. 11, pp. 514–522.) Discussion of various problems of communication theory, mainly from the physical, linguistic and psychological points of view.

621.39.001.11 : 061.3 **1480**

Applications of Communication Theory.—(*Nature, Lond.*, 20th Dec. 1952, Vol. 170, No. 4338, pp. 1051–1053.) Summarized report of the proceedings at a symposium at the Institution of Electrical Engineers, London, September 1952, with the limited objective of examining what of practical value had resulted from applying the theoretical work discussed at the previous symposium (981 of 1951) to the problems of electrical communication. The proceedings are to be published by Butterworths Scientific Publications.

621.39.001.11 : [621.398 + 621.317 **1481**

Modern Signal and Information Theories. Applications to Telecontrol and Measurements.—J. Loeb. (*Rev. gén. Élect.*, Nov. 1952, Vol. 61, No. 11, pp. 499–516.) See also 2535 and 3041 of 1951.

621.395.44 : 621.315.052.63 : 621.316.7 **1482**

Frequency-Shift Carrier-Current Equipment for Telemetering and Other Control Functions.—R. W. Beckwith. (*Elect. Engng, N.Y.*, Nov. 1952, Vol. 71, No. 11, pp. 1026–1031.) Two circuits are described: (*a*) a Hartley-type oscillator with a 2-crystal network in the grid circuit; frequency shift is effected by a reactance-valve or diode switching circuit and is effectively limited by the crystals to precise predetermined values; (*b*) a highly stable discriminator based on the series and parallel resonance of a crystal in one arm of a bridge circuit.

621.396.41 : 621.396.619.16 **1483**

Input Circuit and I.F. Amplifier of 24-Channel Equipment using Pulse-Phase Modulation.—H. Behling. (*Fernmeldetech. Z.*, Nov. 1952, Vol. 5, No. 11, pp. 502–511.) A detailed account of the development and performance of equipment for the frequency band 1·9–2·1 kMc/s, with a mean i.f. of 120 Mc/s.

621.396.619.13 : 621.3.018.78 **1484**

Distortion of a Frequency-Modulated Signal by Small Loss and Phase Variations.—F. Assadourian. (*Elect. Commun.*, Dec. 1952, Vol. 29, No. 4, pp. 314–320.) Reprint. See 2027 of 1952.

621.396.65 : 621.396.41 **1485**

V.H.F. Trunk Radio in Nyasaland.—L. E. Strazza. (*G.E.C. Telecommun.*, Nov. 1952, No. 15, pp. 3–14.) Description of a multichannel f.m. 70–88-Mc/s system operating between twelve principal towns. The total route length is over 330 miles, much of this being over mountainous and difficult terrain.

621.396.931 **1486**

Problems of Radio Transmission for Mobile Telephony Systems.—W. Klein. (*Tech. Mitt. schweiz. Telegr.-Teleph Verw.*, 1st Nov. 1952, Vol. 30, No. 11, pp. 331–347. In German.) The particular difficulties encountered in a mountainous country like Switzerland are discussed. Results of field-strength measurements in Zürich on frequencies of 36·5 and 160 Mc/s are reported and f.m. and ph.m. systems compared. Technical data for equipment operating in the 80-Mc/s and 160-Mc/s bands are tabulated and the effect of external interference, particularly from motor-cars, is investigated in some detail. The possibility of communication with trains is considered and measurements of interference voltages on 200 Mc/s in a train going from Olten to Zürich are shown for the cases in which the measurement equipment was installed (*a*) directly behind the engine, (*b*) at the rear of the train.

621.396.932.029.62 **1487**

V.H.F. Harbour Radio.—J. Mohrmann. (*Telefunken Ztg*, Nov. 1952, Vol. 25, No. 97, pp. 207–214.) Description of the f.m. communication system operating in the 2-m band at Hamburg and other ports in North Germany. For full duplex working, transmitter and receiver use a common aerial with separating filters. A two-tone selective call system is used.

621.396.97.029.62 + 621.397.61.029.62] : 061.3 **1488**

The U.S.W. Conference, Stockholm, 1952.—E. Augustin. (*NachrTech*, Oct. 1952, Vol. 2, No. 10, pp. 289–292.) An account of the proceedings, mainly contrasting the rejected Russian proposals with those finally adopted. See also 3560 of 1952 (Stepp).

SUBSIDIARY APPARATUS

621-526 **1489**

Stability of Control Systems. Study of a Common Type of Equation.—J. Kuntzmann, J. Daniel & Min-Yuan Ma. (*Rev. gén. Élect.*, Nov. 1952, Vol. 61, No. 11, pp. 532–538.) See also 2619 of 1952.

621.311.6 : 621.396.933.2 **1490**

Converting Direct Voltage to Alternating Voltage at High Power.—D. Engberts. (*Electronica*, 8th Nov. 1952, Vol. 5, No. 109, pp. 177–178.) Description of a unit providing a 60-c/s supply for a radio beacon at Schiphol. An inverter circuit with balanced Hg-vapour-filled thyratrons is used, and the maximum continuous power output is 600 VA with an overall efficiency of 50%. Considerably higher supply frequencies can be provided by using thyratrons with different gas fillings.

621.317.733 : 621.311.6 **1491**

Use of a Bridge Circuit for supplying Several Loads independently from a Common Voltage Source.—W. Hübner. (*Arch. tech. Messen*, Dec. 1952, No. 203, pp. 285–288.) A circuit suitable for measurement purposes and adapted for both d.c. and a.c. supplies has the source arranged in one arm of a bridge and two loads respectively in the two diagonals. Modification to accommodate more loads is indicated.

TELEVISION AND PHOTOTELEGRAPHY

621.397.2 **1492**

Improvements effected in Facsimile Equipment.—M. Frank. (*Ann. Geofis.*, July 1952, Vol. 5, No. 3, pp. 441–458.) Modifications to the apparatus previously described (237 of 1951) are fully discussed. Changes in circuit design include the derivation of the synchronous-motor frequency by division from the subcarrier, and a comparator unit at the receiving end to maintain a constant phase relation between subcarrier and receiver oscillator frequencies.

621.397.5 : 535.623/.624 **1493**

Colour Television.—L. C. Jesty. (*Nature, Lond.*, 27th Dec. 1952, Vol. 170, No. 4339, pp. 1094–1097.) Report of a discussion on visual problems in television, at a meeting of the Physical Society Colour Group, May 1952.

621.397.5(083.74) **1494**

Factors affecting the Choice of Television Channels and Standards in South American Countries.—J. P. Arnaud. (*Rev. telegr. Electronica, Buenos Aires*, Sept. 1952, Vol. 41, No. 480, pp. 563–569, 573. Discussion, *ibid.*, Oct. 1952, Vol. 41, No. 481, pp. 696–697.) F.C.C. standards are discussed. The significance of effective radiated power, frequency, distance, aerial height, terrain and meteorological aspects are considered in relation to the choice of frequency bands. For South America, use of the lowest F.C.C. band is recommended, providing 5 channels of 6 Mc/s width between 54 and 88 Mc/s.

621.397.62 **1495**

The British Television Receiver.—A. J. Biggs & E. O. Holland. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 577–590. Discussion, pp. 645–650.) "An account of the typical British domestic television receiver of the present day. During the last two or three years, intensive development has resulted in a product which is basically simple yet capable of refined performance. The general arrangement of a receiver and its controls is described. Some of the background of circuit development is given with reference to the detailed technical aspects. More attention is paid to considerations involved in such matters as the video stage, vision- and sound-interference limiters, synchronizing-signal separation and radiation from line timebases. An account of the steps that have to be taken to render a receiver safe is included. Where possible, design trends of the near future are indicated." 35 references.

621.397.62 **1496**

A Consideration of Some Factors influencing the Design of Television Receivers for Mass Production.—M. Reed, A. B. Atkinson & D. S. Clarke. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No.19, pp. 624–630. Discussion, pp. 645–650.) Three main aspects of design are considered: (*a*) circuit arrangements which take account of the effect of stray couplings on performance and of tolerance variations in mass-produced components; (*b*) mechanical constructions permitting a high production rate together with adequate flexibility for the production of different types of receiver; (*c*) cabinet construction giving ease of assembly and maximum accessibility for servicing.

621.397.62 **1497**

Design Considerations for Combination U.H.F. and V.H.F. Receivers.—W. B. Whalley. (*Tele-Tech*, Nov. 1952, Vol. 11, No. 11, pp. 36–38 . . 110.) Choice of i.f. and different designs of u.h.f. tuning unit are particularly discussed. Suitable u.h.f. valves are noted with references to their use in the various receiver units. Converter design is briefly considered.

621.397.62 **1498**

On Overcoming the Non-interlacing of Television Receivers which are Accurately Synchronized.—G. B. Townsend. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 643–645. Discussion, pp. 645–650.) The principal cause of incorrect interlacing is found to be variation in the amplitude of the frame flyback. Means of reducing this variation are suggested and a circuit giving constant-amplitude flyback is described which can be applied in the majority of domestic receivers.

621.397.62 **1499**

Flywheel Synchronization.—B. T. Gilling. (*Wireless World*, March 1953, Vol. 59, No. 3, pp. 137–140.) A simple method of providing automatic control of receiver synchronization is described, using a double-diode frequency discriminator.

621.397.62 **1500**

D.C. Restoration in Television.—W. T. Cocking. (*Wireless World*, March 1953, Vol. 59, No. 3, pp. 102–107.) An explanation is given of the way in which the d.c. component is lost when the composite video signal is passed through the *RC* coupling between the video stage and the synchronizing-signal separator of a standard receiver. The use of a diode to restore the d.c. level is described, with numerical illustrations; this diode is normally constituted by the grid-cathode path of the pentode used as separator.

621.397.62 : 535.623 **1501**

Compatible Color TV Receiver.—K. E. Farr. (*Electronics*, Jan. 1953, Vol. 26, No. 1, pp. 98–104.) Description of a 42-valve receiver designed for the N.T.S.C. system, with details of the various sections and explanation of their operation, and with a complete circuit diagram. Its performance on monochrome transmissions is comparable to that of current monochrome receivers.

621.397.62 : 621.314.63 **1502**

The Applications of the 'Metal Rectifier' in Television Receivers.—A. H. B. Walker. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 560–571. Discussion, pp. 571–576.) A direct comparison is made between the d.c. characteristics of Se and thermionic rectifiers, the importance of the correct choice of rectifier and working point is stressed, and applications of Se and Cu_2O rectifiers in television-receiver circuits are described.

621.397.62 : 621.385 **1503**

Television Valves and the A.C./D.C. Receiver.—S. N. Doherty, E. Jones & B. R. Overton. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 524–536. Discussion, pp. 571–576.) An examination is made of the features of the design of television receivers which are affected by the use of an a.c./d.c. power supply. The valve requirements of each stage are studied and the characteristics of a suitable range of valves are outlined. Detailed circuit diagrams are given of four typical receivers, a narrow-angle-tube receiver and two wide-angle-tube receivers for the British 405-line system, and a wide-angle-tube receiver for the continental 625-line system.

621.397.62 : 621.396.621.54 **1504**

The Design of a Superheterodyne Receiver for Television.—D. H. Fisher, P. A. Segrave & A. J. Watts. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 609–623. Discussion, pp. 645–650.) Discussion of the factors affecting the complete specification and design of r.f. and i.f. amplifiers for use in television receivers for the British system and also for the systems adopted in Europe and the U.S.A. The choice of the i.f. and the determination of the optimum frequency response are considered, and choice of valves and problems of gain control discussed. A method of obtaining the recommended characteristics in mass-produced receivers is described and an outline specification is given of visual-alignment equipment for production use.

621.397.62 : 621.396.622.63 : 546.289 **1505**

The Use of the Germanium Rectifier in Television Receivers.—R. T. Lovelock. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 551–559. Discussion, pp. 571–576.) Discussion of the use of Ge rectifiers in high-voltage-level and low-voltage-level television rectifier, mixer, and interference-suppression circuits. The performance to be expected from available commercial types of rectifier is indicated.

621.397.62 : 621.396.662 : 621.396.611.4 **1506**

Cavity Tuner for U.H.F. Television.—H. Fogel & S. Napolin. (*Electronics*, Feb. 1953, Vol. 26, No. 2, pp. 101–103.) The tuner incorporates three cavity elements, two for the channel selector and the third for the local oscillator. Each element comprises a section of coaxial line with capacitive tuning controlled by plunger.

621.397.621 : 621.396.615.17 **1507**

Frame-Scanning Output Circuits for Wide-Angle Cathode-Ray Tubes.—D. H. Covill. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 603–608. Discussion, pp. 645–650.) Comparison of two basic types of deflector coil shows that the type using a slotted core is considerably more efficient for frame scanning. Analysis of transformer-coupled scanning circuits indicates that the lowest value of transformer-primary inductance should be that which corresponds to zero rate of change of anode current at the beginning of the scan. Various linearizing circuits are discussed and a complete frame timebase for scanning a 16-in. c.r. tube with a 70° deflecting angle and final-anode voltage of 13 kV is described, with full circuit details.

621.397.7 **1508**

The 100-kW E.R.P. Sutton Coldfield Television Broadcasting Station.—P. A. T. Bevan. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 196–218.) Detailed description of the complete installation, which represents the basic general arrangement at later stations, where certain variations are introduced. See also 854 of 1952 (Bevan & Page).

621.397.7 **1509**

Brief Survey of the Television Installation of Radio Basle.—(*Bull. schweiz. elektrotech. Ver.*, 13th Dec. 1952, Vol. 43, No. 25, pp. 1028–1035.) The service area of the transmitter, the arrangement of the station and the operating conditions are described. The vision signal is conveyed by radio link from the studios at Münchenstein to the transmitter site at Gempenfluh 4 km away, where it is reradiated by a 500-W a.m. transmitter on 62·25 Mc/s. F.m. is used for the sound channel. Short descriptions are given of the studio and camera, the control room, and the transmitter installation on the Gempenfluh.

621.397.8 **1510**

Wenvoe Service Area.—(*Wireless World*, March 1953, Vol. 59, No. 3, p. 107.) A population of nearly 4·5 million is served by this 50-kW television transmitter brought into service in December 1952. A map shows field-strength contours estimated from measurements on the 5-kW stand-by transmitter.

621.397.82 **1511**

The Performance of Television Receiver Installations in the Presence of Interference.—A. J. Biggs & R. A. Mills. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 597–602. Discussion, pp. 645–650.) Test results, for 10 different receivers, on the pickup of interference by the aerial system and receiver circuits, and on the susceptibility to mains-borne interference, indicate that the performance of the average British commercial receiver is satisfactory and that changes to achieve interference immunity do not involve radical modifications of receiver design.

621.397.9 **1512**

A Survey of some Television Applications for Industry, Scientific Research, and Education.—J. E. Telfer. (*Proc. Instn Radio Engrs, Aust.*, Dec. 1952, Vol. 13, No. 12, pp. 407–426.)

TRANSMISSION

621.396.611.21 : 621.3.016.352 **1513**

Methods for Improving the Frequency Stability of Transmitters.—W. Herzog. (*Telefunken Ztg*, Nov. 1952, Vol. 25, No. 97, pp. 257–264.) Methods considered are the use of (*a*) two crystals in a bridge circuit, (*b*) a compensating resistance, (*c*) a second valve increasing the mutual conductance of the oscillator. A circuit is described from which two different frequencies can be derived according to the polarity of the coupling transformer. See also 80 and 2734 of 1952.

621.396.619.2 : 621.314.7 **1514**

The Transistor as Modulator.—(*Radio tech. Dig., Édn franç.*, 1952, Vol. 6, No. 5, pp. 247–259.) An account of the frequency modulator described by Koros & Schwartz (3147 of 1951), together with brief details of amplitude modulators described in "The Transistor", published by Bell Laboratories, 1951.

VALVES AND THERMIONICS

621.314.632 + 621.314.7] : 546.289 **1515**

Germanium Crystal Valves.—R. T. Lovelock. (*G.E.C. Telecommun.*, Nov. 1952, No. 15, pp. 29–35.) An account of the operating principles and development of point-contact and junction-type Ge units.

621.314.7 **1516**

Large Current Amplifications in Filamentary Transistors.—W. van Roosbroeck. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1411–1412.) A formula is derived for the current multiplication factor α_e of the transistor, and its significance is discussed by considering limiting cases. Possible ways of increasing α_e are indicated.

621.383.27 + 621.385.15 **1517**

A Simple Activation for BeCu Multipliers.—F. J. Fitz-Osborne. (*Canad. J. Phys.*, Nov. 1952, Vol. 30, No. 6, pp. 658–659.) A multiplication factor comparable with that resulting from more complicated methods is obtained by heating the plates to about 650°C in an inert gas.

621.383.27 **1518**

Investigation of the Dark Current of Photocells with Secondary-Electron Multiplication.—N. Schaetti & W. Baumgartner. (*Helv. phys. Acta*, 1st Nov. 1952, Vol. 25, No. 6, pp. 605–611. In German.) The increase in dark current and the improvement of sensitivity to red light after each illumination of Li-Sb and Cs-Sb photocathodes indicates that the work function of the cathode is lowered by illumination, resulting in an increase of thermal emission. The change in cathode emission after irradiation alternately with blue and red light is comparable with that of infrared-irradiated phosphors.

621.383.27 **1519**

Remodulation in Electron Multiplier Cascades.—H. E. Kallmann. (*Proc. Inst. Radio Engrs*, Feb. 1953, Vol. 41, No. 2, pp. 282–283.) Increase of the originally low depth of modulation in a cascade type of electron multiplier is obtained by taking the modulation voltage from an intermediate dynode and applying it to a control grid following a later dynode. Results of tests of the method are reported.

621.383.27 **1520**

A Practical Form of Infrared-Sensitive Multiplier.—W. Baumgartner & N. Schaetti. (*Helv. phys. Acta*, 1st Nov. 1952, Vol. 25, No. 6, pp. 611–615. In German.) Measurements are reported on a photomultiplier cell having a Li-Sb cathode and with a Ce-Sm phosphor layer on the outside of the glass wall of the cell. Sensitivity is a maximum at a wavelength of 1·05 μ; its value is about 50 times less than that for a Cs_2O cathode, but the dark current at the first dynode of the multiplier is 10^{-14} A compared with 10^{-11} A for a similar Cs_2O cathode.

621.385 : 621.397.62 **1521**

Cathode-Ray Tubes and Valves for Television Receivers.—J. D. Stephenson, F. H. Powell, T. W. Price & F. M. Walker. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 479–498. Discussion, pp. 571–576.) A survey of progress in Great Britain in the design and manufacture of valves and c.r. tubes specially for television receivers, from the early days of the art and particularly since 1945. Mechanized production methods have been developed giving production speeds rivalling those of any other country.

621.385 : 621.397.62 **1522**

Television Valves and the A.C./D.C. Receiver.—Doherty, Jones & Overton. (See 1503.)

621.385.029.6 + 621.396.677 **1523**

Attenuation of Wire Helices in Dielectric Supports.—R. W. Peter, J. A. Ruetz & A. B. Olson. (*RCA Rev.*, Dec. 1952, Vol. 13, No. 4, pp. 558–572.) Attenuation curves are presented for the range 2·6–3·6 kMc/s. Attenuation increases linearly with frequency and nearly linearly with the ratio of free-space velocity to phase velocity; it has a very flat minimum at a wire-diameter/pitch ratio of 1:3 and varies as the square root of the resistivity of the metal which forms the helix surface. Of the dielectric supports investigated, 707 precision-bore glass tubing showed the highest loss. Quartz tubing is better, but fluted 707 glass tubing causes the lowest loss, as it supports the helix at only three points of the circumference.

621.385.029.63/.64 **1524**

New Developments in Traveling-Wave Tubes.—W. J. Dodds, R. W. Peter & S. F. Kaisel. (*Electronics*, Feb. 1953, Vol. 26, No. 2, pp. 130–133.) Descriptions are given of a low-noise wide-band valve for operation at 3 kMc/s [see also 277 of January (Peter)] and of a medium-power type for operation in commercial relay equipment at about 2 kMc/s. The latter has a length only slightly over 7 in. Narrow-band types are described in which the helix is modified to act as a filter, and the possibility of using focusing magnets as for radar magnetrons is briefly indicated.

621.385.029.63/.64 **1525**

Notes on the Influence of the Plasma Oscillation in Transit-Time Valves.—F. Lüdi. (*Z. angew. Math. Phys.*, 15th Sept. 1952, Vol. 3, No. 5, pp. 390–393.) According to the theory of the travelling-wave valve previously developed [1518 of 1951 (Frey & Lüdi)], the plasma oscillation is of importance in klystron and double-beam valves, but not in the travelling-wave valve. This last conclusion does not agree with the results of other workers [3166 of 1951 (Warnecke et al.)]; the theory is re-examined and an explanation for the discrepancy is advanced.

621.385.029.63 **1526**

Experimental Study of the Interaction of Space-Charge Waves within an Electron Beam moving in Crossed Electric and Magnetic Fields.—P. Guénard & H. Huber. (*Ann. Radioélect.*, Oct. 1952, Vol. 7, No. 30, pp. 252–278.) Detailed account of experiments noted earlier [278 of January and 904 of March (Warnecke et al.)] in an investigation of (*a*) amplification, (*b*) oscillations, and (*c*) other effects due to space-charge waves in crossed-field valves. Specially constructed valves were used. The presence of an auxiliary anode in the interaction space increases both the gain and the rise in gain as current is increased. Diocotron oscillation frequencies are in agreement with simple theory based on a square-law distribution of space charge. Results of measurements on a valve with interdigital-type anode indicate a Maxwellian distribution of electron energy with considerable thermal agitation; an empirical formula for the negative-electrode or 'sole' current is similar in form to that for diocotron gain. The importance of the diocotron effect is emphasized and anomalies in magnetron theory in respect of efficiency and gain are explained. 45 references.

621.385.032.216 **1527**

An Experimental Investigation of an Oxide-Coated Cathode.—N. D. Morgulis & Ya. P. Zingerman. (*C. R. Acad. Sci. U.R.S.S.*, 11th Dec. 1951, Vol. 81, No. 5, pp. 783–785. In Russian.) An investigation of the potential gradient through the coating.

621.385.032.216 **1528**

Studies of the Oxide Cathode.—L. S. Nergaard. (*RCA Rev.*, Dec. 1952, Vol. 13, No. 4, pp. 464–545.) A review article, with 64 references, discussing known phenomena associated with BaO cathodes, reporting new experimental work and suggesting a hypothesis to account for the experimental results. This hypothesis assumes that the cathode has mobile donors uniformly distributed in the oxide when no current is being drawn. When current is drawn, electrolysis occurs in the oxide layer and the donors migrate towards the base, leaving a donor depletion layer near the emitting surface. This layer has properties approaching those of the intrinsic material. Under equilibrium conditions electrolysis is balanced by back diffusion. Evidence that the donors may be F centres formed from oxygen vacancies is adduced. Energy levels are computed. A diode with BaO-SrO cathode which can be operated as an amplifier is incidentally described.

621.385.032.216 **1529**

Photoconductivity Study of Activation of Barium Oxide.—H. B. DeVore. (*RCA Rev.*, Dec. 1952, Vol. 13, No. 4, pp. 453–463.) The long-wavelength tail of the photoconductivity curve has, for increasing cathode activation, thresholds at about 2·3 and 1·4 eV. These indicate the development of donors at these levels below the conduction band. Two possible explanations are considered.

621.385.032.216 : 621.396.822 **1530**

Noise in Interface Resistance.—H. O. Berktay. (*Wireless Engr*, Feb. 1953, Vol. 30, No. 2, pp. 48–49.) A brief note pointing out that the noise resistance of a valve with oxide cathode is related to the impedance between coating and core of the cathode.

621.385.032.216 : 621.396.822 **1531**

On the Flicker Noise Caused by an Interface Layer.—W. W. Lindemann & A. van der Ziel. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1410–1411.) Measurements on Type-6SJ7 pentodes are reported.

621.385.032.216 : 621.396.822 **1532**

Excess Thermal Noise Due to Current Flow through (BaSr) Oxide Coating.—K. Amakasu. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1330–1332.) Experimental results indicate that (*a*) the excess noise due to the passage of the current is proportional to the square of the current, (*b*) the noise intensity is inversely proportional to the frequency, (*c*) the noise depends greatly on the activation of the cathode.

621.385.3 **1533**

Current Division in Plane Positive-Grid Triode.—S. Deb. (*Indian J. Phys.*, Aug. 1952, Vol. 26, No. 8, pp. 377–392.) The openings between the grid wires are assumed to act as thin cylindrical lenses free from aberration. Formulae are derived for the cases of (*a*) reflection and (*b*) no reflection of electrons from the anode. For (*a*) the formula is identical with that of Jonker (2087 of 1946); for (*b*) the expressions given by Spangenberg (3417 of 1940) and by Jonker & Tellegen (2087 of 1946) follow as special cases.

621.385.3 **1534**

Potential Distribution for Space-Charge-Limited Current between a Plane Accelerating Grid and Parallel Anode.—E. G. Ramberg & L. Malter. (*J. appl. Phys.*, Dec. 1952, Vol. 23, No. 12, pp. 1333–1335.) Expressions are derived based on the assumption of a Maxwellian distribution of electron velocities. The distribution is determined by Langmuir's diode functions in combination with a function depending on the current in the grid-to-anode space, which is represented graphically.

621.385.3.029.62 **1535**

Siemens U.S.W. and Television Transmitting Valves.—W. Müller. (*Fernmeldetech. Z.*, Nov. 1952, Vol. 5, No. 11, pp. 528–533.) An account of the development and construction of a series of air-cooled disk-seal triodes: Types RS 1021, RS 1071 and RS 1011 for 220 Mc/s, and Type RS 1001 for 100 Mc/s. Output powers are respectively 1·25, 5, 12 and 11 kW, and characteristic slopes 30, 40, 60 and 40 mA/V.

621.385.3.029.63 **1536**

U.H.F. Triode Design in Terms of Operating Parameters and Electrode Spacings.—L. J. Giacoletto & H. Johnson. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 51–58.) Graphs are constructed by means of which the ratio between grid input conductance and transconductance can be determined approximately from the geometrical data; from this ratio the r.f. gain and noise factor are found by means of further graphs. The possibility of effecting improvements by changing design parameters is studied. The performance predicted by the approximate theory given agrees satisfactorily with experimental results obtained by other workers.

621.385.3.029.64 **1537**

Synthetic Study on Amplification Constants of Triodes.—Y. Koike & S. Yamanaka. (*Technol. Rep. Tohoku Univ.*, 1951, Vol. 16, No. 1, pp. 1–7.) Continuation of work noted in 3287 of 1952. Planar and cylindrical systems are studied both theoretically and experimentally, using large-scale models in a water tank. The formula previously obtained is confirmed and the correspondence between the two configurations is indicated.

621.385.4/.5 : 621.396.822 **1538**

The Limiting Sensitivity of Amplifier Valves: Part 2 — Theory of the Screen-Grid Valve.—H. Rothe & E. Willwacher. (*Arch. elekt. Übertragung*, Dec. 1952, Vol. 6, No. 12, pp. 493–498.) The noise figure of a screen-grid valve is regarded as composed of two terms, F_{tr} and F_v. F_{tr} is the contribution due to the valve connected as a triode, with screen and anode strapped; its value was determined in part 1 [1203 of April (Rothe)]. F_v results from the actual division of current between screen and anode, and depends on the input admittance, which in turn is strongly influenced by the cathode inductance. The analysis is based on the equivalent circuit of the valve incorporated in a tuned h.f. amplifier.

621.385.832 **1539**

Development of an Improved Graphechon Storage Tube.—W. T. Dyall, G. R. Fadner & M. D. Harsh. (*RCA Rev.*, Dec. 1952, Vol. 13, No. 4, pp. 546–557.) More accurate alignment and the addition of a target shield ring reduce position errors and double the signal/noise ratio. See also 2061 of 1949 (Pensak).

621.385.832 : 621.397.62 **1540**

Design Factors in Television Cathode-Ray Tubes.—L. S. Allard. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 499–507. Discussion, pp. 571–576.) Tube size, beam focusing and deflection systems are discussed, and the electron optics of c.r.-tube guns is considered in detail, both direct-vision and projection-type tubes being treated.

621.385.832 : 621.397.62 **1541**

A Univoltage Electrostatic Lens for Television Cathode-Ray Tubes.—C. T. Allison & F. G. Blackler. (*Proc. Instn elect. Engrs*, Part IIIA, 1952, Vol. 99, No. 19, pp. 508–513. Discussion, pp. 571–576.) Discussion shows that it may be possible to produce television c.r. tubes for operation with the focusing electrode connected to the cathode, if a minimum final-anode potential of 12 kV is adopted. Measurements on experimental tubes, which are described, indicate that the best value of the focus potential is zero, with a final-anode potential of 14 kV, a first-anode potential of 300 V and a beam current of 250 μA.

621.387 **1542**

Ignition, Discharge and Deionization Processes in Gas Triodes.—E. Knoop. (*Z. angew. Phys.*, Oct. 1952, Vol. 4, No. 10, pp. 386–390.) Continuation of investigation noted in 3212 of 1950 (Knoop & Kroebel). The time taken for the main (cathode/anode) discharge to develop from the preliminary (grid/anode) discharge depends on the intensity of the ion current to the grid, which in turn depends on grid resistance and bias. Deionization time was measured for triodes with various gas fillings; this also depends on grid resistance and bias, and decreases with increasing grid current because of the increased rate at which the grid space-charge layer spreads into the plasma.

621.396.615.141.2 **1543**

Determination of the Natural Oscillations and Mode Changes of a Multicavity Magnetron Oscillator.—A. Leblond, J. Nalot & O. Doehler. (*C. R. Acad. Sci., Paris*, 10th Dec. 1952, Vol. 235, No. 23, pp. 1494–1496.) Regarding the magnetron anode as a section of a plane transmission line of periodic structure closed on itself, the natural oscillations of a cavity correspond to points of intersection of certain straight lines with the retardation-factor/wavelength characteristic of the line [3615 of 1952 (Guénard et al.)]. The abscissae of these points define the resonance wavelengths, and the ordinates the beam velocities at which synchronization may occur, a 'jump' to another mode being likely if the ordinates are close together. A graph of this kind is useful in the first stage of the design of new magnetrons.

621.396.615.142.2 **1544**

A Floating-Drift-Tube Klystron.—M. Chodorow & S. P. Fan. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 25–31.) 1951 I.R.E. National Convention paper. A theoretical and experimental investigation is made of the type of klystron having a single cavity and two gaps separated by a drift tube whose potential is independently controlled, so that it is useful as a f.m. oscillator. The theory is similar to that of the reflex klystron, but the design is inherently capable of giving greater efficiency and power output. By varying the cavity shape it is possible to obtain either high efficiency at low bandwidth (22%, 4 Mc/s) or lower efficiency with greater bandwidth (6%, 15 Mc/s).

621.396.615.142.2 : 621.396.619.13 **1545**

F.M. Distortion in Reflex Klystrons.—R. L. Jepsen & T. Moreno. (*Proc. Inst. Radio Engrs*, Jan. 1953, Vol. 41, No. 1, pp. 32–36.) The harmonic distortion introduced by a frequency-modulated reflex klystron is computed by expanding in a power series the expression giving frequency as a function of reflector voltage and relating the coefficients of this series to the harmonic distortion components. Design for low distortion is briefly discussed. A method of measuring the distortion components is described; results are in good agreement with the computed values. The distortion is low enough for the valve to be useful in many transmitters and relay applications.

621.396.615.142.2 : 621.396.65.029.64 **1546**

Reflex Klystrons for Centimetre Links.—A. H. Beck & A. B. Cutting. (*Proc. Instn elect. Engrs*, Part IIIA, April/May 1952, Vol. 99, No. 18, pp. 357–366. Discussion, pp. 472–478.) "The development of reflex-klystron oscillators suitable for use as f.m. transmitter valves in links operating in the 3·6–4·2-kMc/s band is described; details of the performance in this and neighbouring bands are given. Since the valves use the copper/glass construction with external resonant circuits, their use is not limited to the applications described."

MISCELLANEOUS

621.38(061.4) **1547**

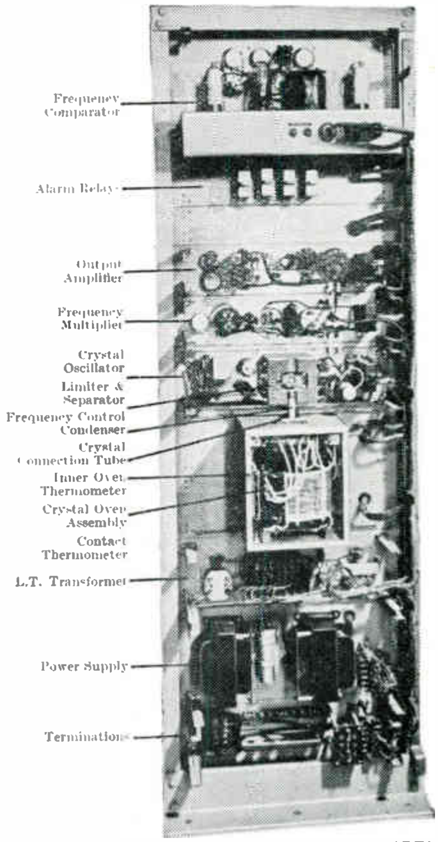
British Electronic Instruments in Research and Industry.—J. A. Saxton. (*Nature, Lond.*, 22nd Nov. 1952, Vol. 170, No. 4334, pp. 877–878.) A note on the many different kinds of instrument at the exhibition in London, Sept. 1952, arranged by the Scientific Instrument Manufacturers' Association of Great Britain, with an outline of the subjects discussed in the papers presented at the symposium associated with the exhibition.

621.39 : 68 **1548**

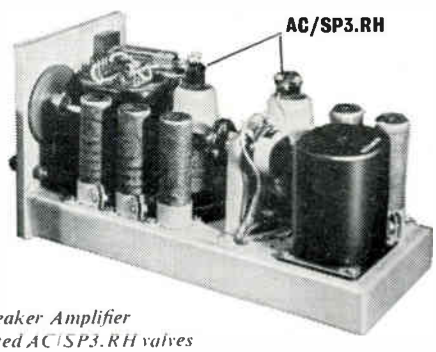
Pioneer Industrial Activity in High-Frequency Technology.—G. Guanella, F. Jenny & P. Waldvogel. (*Bull. schweiz. elektrotech. Ver.*, 4th Oct. 1952, Vol. 43, No. 20, pp. 834–840.) Illustrated account of developments in Switzerland in the production of various types of transmitting valves and equipment for beam radiocommunication systems.

the B.B.C. make wide use of this valve

The Ediswan Mazda AC/SP3.RH is an indirectly heated Pentode with a special heater construction designed to reduce hum due to A.C. fields within the valve. Its high working slope makes it very suitable for use in audio frequency stages employing negative feed back. The high-slope short grid-base characteristic renders it suitable also as an harmonic generator and as an oscillator in high stability crystal drive equipment. Provided precautions are taken to minimise hum due to external wiring the AC/SP3.RH may also be successfully employed in the early stages of amplifiers where the reduction of hum noise and microphony is of primary importance. Many of these valves have been supplied to the British Broadcasting Corporation for use in their special recording, amplifying, and crystal controlled precision drive equipments, some of which are illustrated on this page.

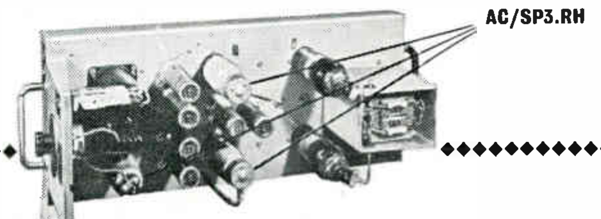


B.B.C. Crystal Drive Equipment (Type CP-17E) using nine AC/SP3.RH valves in the crystal maintaining amplifier, frequency divider, frequency multiplier and oven temperature relay.



B.B.C. Type D. Recorder Line Amplifier LFA/1 using two pentode connected AC/SP3.RH valves

B.B.C. Type D. Recorder Loudspeaker Amplifier LSM/7 using three pentode connected AC/SP3.RH valves



TYPICAL OPERATING CONDITIONS

Anode Voltage (Va)	250	250	250	250
Screen Voltage (Vg2)	80	100	160	200
Grid Bias (Vg1)	1.25	1.7	2.75	3.5
Anode Current (mA)	7.8	7.9	10.5	12.3
Screen Current (mA)	2.45	2.5	3.3	3.85
Mutual Conductance (mA/V)	7.0	7.0	7.45	7.6
Anode AC Resistance (ra) (Meg ohms)	0.55	0.55	0.4	0.3
Input Capacity (Hot) (μμF)	20	19.9	19.7	19.5

RATING

Heater Voltage	V_h	4.0
Heater Current (Amps)	I_h	1.0
Maximum Anode Voltage	V_a	250
Maximum Screen Voltage	V_{g2}	250
Mutual Conductance (mA/V)	g_m	7.7

Taken at $V_a = 250$; $V_{g2} = 100$; $V_{g1} = 1.5$

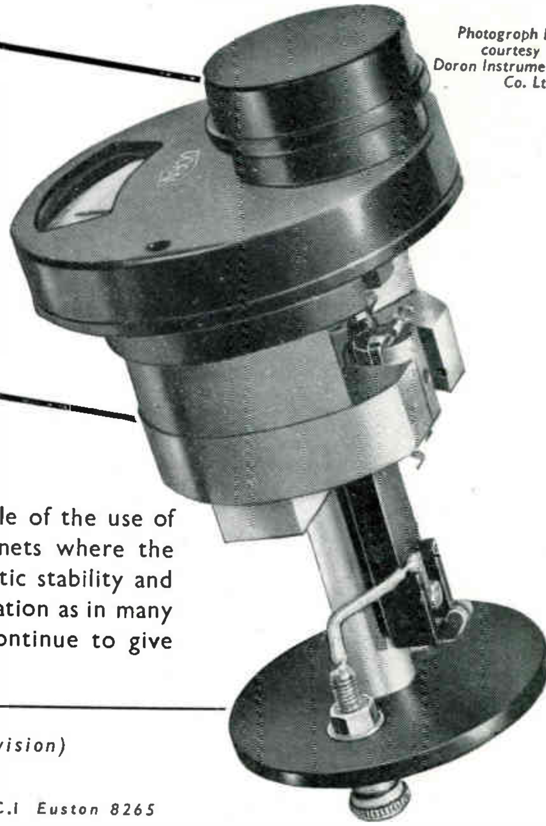
BASE

British 7 pin
Pin No. 1 Metallising
Pin No. 2 Anode
Pin No. 3 Suppressor Grid (G3)
Pin No. 4 Heater
Pin No. 5 Heater
Pin No. 6 Cathode
Pin No. 7 Screen (G2)
Top Cap Control Grid (G1)

EDISWAN
MAZDA
VALVES AND CATHODE RAY TUBES

THE EDISON SWAN ELECTRIC COMPANY, LTD., 155 CHARING CROSS ROAD, LONDON, W.C.2
Telephone — Gerrard 8660 *Member of the A.E.I. Group of Companies* Telegrams — Ediswan Westcent London

MUREX 'SINCOMAX' MAGNETS are used in DORAN GALVANOMETERS



Photograph by courtesy of Doron Instrument Co. Ltd.

Another typical example of the use of Murex 'Sincomax' Magnets where the need is for high magnetic stability and efficiency. In this application as in many others Murex Sintered Magnets continue to give accurate and reliable service.

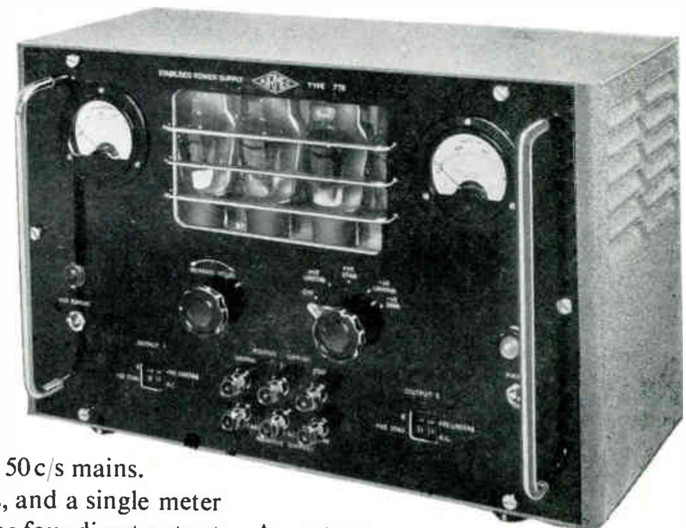
MUREX LIMITED *(Powder Metallurgy Division)*

RAINHAM · ESSEX · *Rainham, Essex 3322*

London Sales Office: Central House, Upper Woburn Place, W.C.1 *Euston 8265*

AIRMEC

STABILISED POWER UNIT TYPE 776



THIS UNIT, which is available for immediate delivery, operates on 100-130 or 200-250V, 50c/s mains. It is fitted with both voltage and current meters, and a single meter switch enables them to be connected to any of the four direct outputs. An output control enables the stabilised positive supply to be varied continuously between 200 and 350V, and a separate switch controlling all D.C. outputs is fitted for convenience of operation.

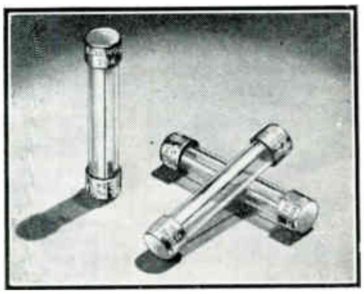
OUTPUTS

- **Positive:** Stabilised output continuously variable from 200-350V at maximum currents of 200-100 mA. Unstabilised output of 500V at 200 mA.
- **Negative:** Stabilised output of 85V at 5 mA. Unstabilised output of 500V at 3 mA.
- **Alternating:** 6.3V at 5 amps.

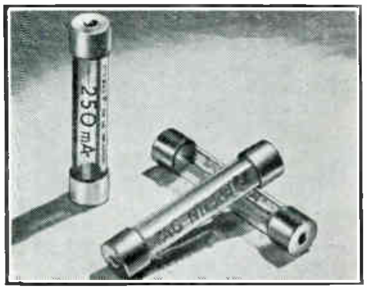
Full details of this or any other Airmec instrument will be forwarded gladly upon request.

AIRMEC LIMITED HIGH WYCOMBE · BUCKINGHAMSHIRE

Telephone: High Wycombe 2060 *Cables:* Airmec High Wycombe



The "Belling-Lee" page for Engineers



LIGHT DUTY CARTRIDGE FUSES

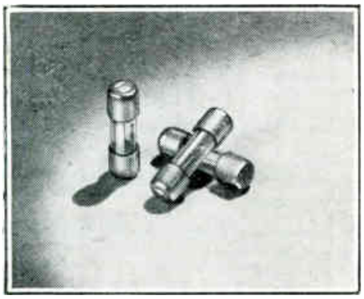
The "Belling-Lee" fuses referred to on this page represent our basic range only. Details of our full range will gladly be sent on application.

L.1055 STANDARD (GLASS—$1\frac{1}{4}'' \times \frac{1}{4}''$)

"Belling-Lee" L.1055 fuses comply with the dimensional requirements of the last published edition of B.S. 646(B). This is now out of print and under revision. In the meantime, our L.1055 fuses are being made to meet the modified blowing tests recommended by the appropriate R.E.C.M.F. Standardisation panel as follows :—

> "The fuse shall blow within 10 seconds on a steady a.c. or d.c. overload 100% greater than its rated current: this is similar to the B.S. 646(B) requirement of blowing within 1 minute on a 75% overload, but is much more practical from the point of view of the user."

These general purpose fuses are made in ratings from 60 mA to 25 amps, but we do not guarantee that ratings above 7 amps will clear the high prospective currents specified for the lower ratings.



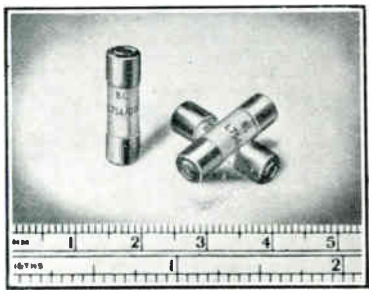
L.338 "MAG-NICKEL" DELAY FUSE (GLASS—$1\frac{1}{4}'' \times \frac{1}{4}''$)

This fuse, while conforming to the dimensions and blowing requirements of our L.1055, can withstand a surge of 20 to 30 times its rated current, for periods not exceeding 1/100th sec. without shortening its normal life through embrittlement. The overall construction, exclusive to the "Belling-Lee" "Mag-Nickel" fuse, gives a greater degree of thermal interia, the element consisting of nickel wire carrying beads of magnesium. This technique is restricted to two ratings, 250 and 500 mA, but owing to their surge resisting properties these fuses can often be used in circuits where ordinary fuses of up to 3A rating would be necessary.

L.562 MINIATURE FUSE (GLASS $\frac{5}{8}'' \times \frac{3}{16}''$)

Originally designed to meet service requirements, the construction and capabilities of this miniature fuse, resulted in the introduction of specification R.C.L.261.1.

They are designed to blow within ½ second on 100% overload, and give reliable service in ratings between 50 mA and 7 A.

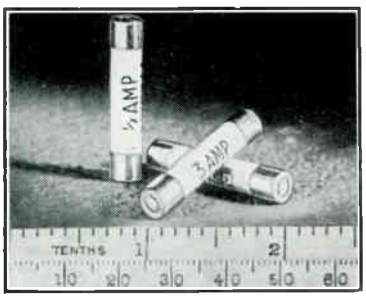


L.754 "MINIFUSE" (CERAMIC $\frac{5}{8} \times \frac{3}{16}$)

The miniature fuse range is extended downwards with the introduction of the "Minifuse", the design of which is unique. Only long development enabled such a fine element to be handled in production, and to give reliable service in the 10, 15, and 25 mA ratings. They are designed to blow within approximately 1 second on 120% overload.

L.693 H.R.C. (CERAMIC $1\frac{1}{4}'' \times \frac{1}{4}''$)

Now under development.



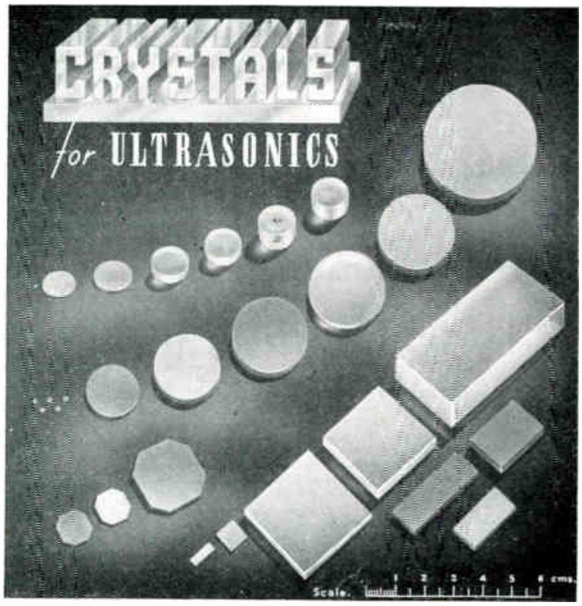
Manufacturers and Technical Organisations on our mailing list will shortly be receiving copies of the "Belling-Lee" 1953 General catalogue, in which full details are given of our range of circuit protection devices.

If you would like to be placed on our list, please write quoting P. 365/W.E.

BELLING & LEE LTD

CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND


J-1
ADVANCE



Belling & Lee, Ltd., Cambridge Arterial Road, Enfield, Middlesex, require research assistants in connection with work on electronic components, fuses, interference suppressors and television aerials. Applicants must be graduates of the I.E.E. or possess equivalent qualifications together with similar laboratory experience. Salary will be commensurate with previous experience: five-day week, contributory pension scheme. Applications must be detailed and concise, and will be treated as confidential.

Pye Telecommunications, Ltd., Ditton Works, Cambridge, have vacancies for senior and junior engineers. Experience in V.H.F. design and engineering is essential. Vacancies also exist for engineers with specialist experience in multi-channel V.H.F. Telephony. Salary according to qualifications and experience. Please apply, stating age, qualifications and experience, to the Personnel Manager.

EXPERIENCED RADIO TESTERS AND INSPECTORS

Required for production of communication and radio apparatus. Also instrument makers, wirers and assemblers for factory test apparatus. Apply Personnel Manager, E. K. Cole, Ltd., Ekco Works, Malmesbury, Wilts.

The De Havilland Engine Co., Ltd. Electronic Engineer required, interested in physical measurement rather than construction of apparatus, required for vibration measurement and analysis on gas turbine and piston engines. Please write in confidence stating age and full details of previous experience to the Personnel Officer, The de Havilland Engine Co., Ltd., Stag Lane, Edgware, Middlesex.

APPOINTMENTS—The engagement of persons answering these advertisements must be made through the local office of the Ministry of Labour and National Service, etc., if the applicant is a man aged 18-64 or a woman 18-59 inclusive, unless he or she or the employer is excepted from the provisions of The Notification of Vacancies Order, 1952.

Electronics Engineer. Graduate or equivalent standard required for the Research Laboratories of British Insulated Callender's Cables, Ltd., at 38 Wood Lane, Shepherds Bush, for the development and making of test equipment for dealing with all types of electric cables, transmission lines, etc. The candidate should have had previous experience in this field. Applications should be made in writing to the Staff Officer, B.I.C.C., Ltd., 21 Bloomsbury Street, W.C.1.

Foreman Communications required for Aden Refinery Project. Age limits 30/45 years. All previous experience must have been in servicing and maintaining private broadcast station and radio telephony. Only those with wide experience and proved ability should apply. Good salary, free messing and accommodation.—Apply in first instance, in writing, giving complete details of past history to George Wimpey & Co., Ltd., Overseas Personnel Office, The Old Police Station, Hammersmith Broadway, W.6.

SENIOR DEVELOPMENT ENGINEERS

are required for work on small electro-mechanical devices. High technical and personal characteristics are essential and a university degree is desirable. The positions hold promise of considerable responsibility and involve control of staff. Salary is commensurate with ability and experience. Excellent working conditions in modernly-equipped laboratories. Bus services to Kingston, London, Guildford, pass the premises. Five-day week, canteen, pension scheme, sports and social club with recreational facilities. Applicants must be of British nationality and should submit details of age and experience to The Manager, Cottage Laboratories, Ltd., Portsmouth Road, Cobham, Surrey.

Medical Research Council. Radiobiological Research Unit, Atomic Energy Research Establishment, Harwell, want Electronics Technician to be responsible for development and maintenance of equipment for detection and measurement of ionising radiations. Previous experience in this branch of Electronics desirable. Salary, in the ranges £410-£475 or £495-£580. Applications within fortnight, giving names two referees, to Director.

A **Senior Engineer** is required for a Microwave Laboratory. A good working knowledge of wave-guide practice and theory backed by experience is essential. Applicants should have a broad scientific interest and preferably a first-class degree in physics and mathematics. Salary in the range of £800-£1,100 per annum. The field of work includes guided transmission, propagation and electro-magnetic properties of semi-conductors.

Applications should be in writing and addressed to the Personnel Manager, Standard Telecommunication Laboratories, Ltd., Progress Way, Enfield, Middx.

A **Senior Research Engineer** is required for an Electronics Laboratory. A good working knowledge of circuit practice and theory, backed by experience, is essential. Applicants should have a broad scientific interest and preferably a degree in physics or electrical engineering. Salary £850-£1,100, according to qualifications. The work covers new developments in telecommunication systems and techniques in the central laboratories of a large manufacturing organization.

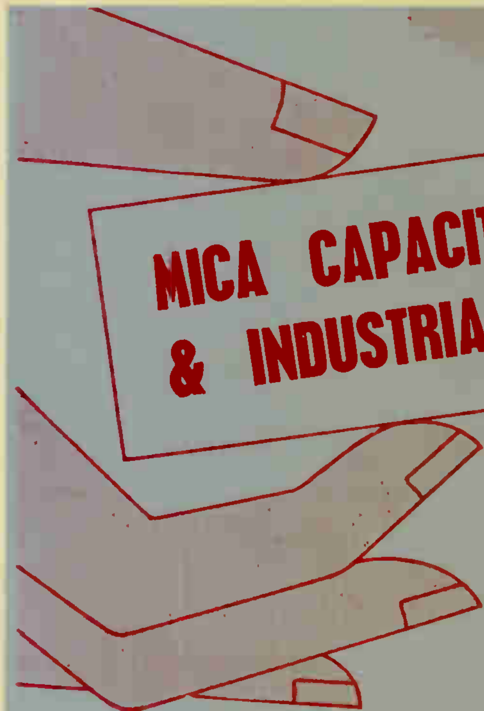
Applications should be in writing and addressed to the Personnel Manager, Standard Telecommunication Laboratories, Ltd., Progress Way, Enfield, Middx.

Planning Engineer required by Ministry of Supply, London, for planning and progressing production Army radar and signals equipment. Qualifications: British of British parentage. Recognised apprenticeship or equivalent. Experienced modern machine shop practice. Knowledge production methods and plant layout for electronic and light engineering work. O.N.C. desirable. Salary: within £623 (at age 30)-£733 p.a. Appointment unestablished, but opportunities to compete for establishment may arise. Application forms from: Ref. E.A.242, Ministry of Labour and National Service, London Appointments Office, 1-6 Tavistock Square, London, W.C.1.

Department of Scientific and Industrial Research require Experimental Officer (unestablished) in Radio Research Organisation, Teddington, Middlesex, for abstracting scientific and technical articles on radio research and development. H.N.C. or higher qualifications with considerable knowledge and experience of some branch of radio research or development. Ability to read technical French and German useful. Minimum age 26; salary in the range £628-786. Forms from M.L.N.S. Technical and Scientific Register (K), 26 King Street, S.W.1, quoting D268/52A.

Index to Advertisers

Printed in Great Britain for the Publishers, Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1, at The Baynard Press by Sanders Phillips & Co., Ltd., Chryssell Road, London, S.W.9.



MICA CAPACITORS FOR TRANSMITTERS & INDUSTRIAL ELECTRONIC EQUIPMENT

Mica capacitors designed and built to handle R.F. power are available in a variety of housings and sizes. The range includes open clamp construction and stacked mica types in porcelain or metal tank containers.

The standard range of metal tank types covers four sizes of cast aluminium containers and is extended with steel and non-ferrous tanks.

A greatly improved Mark 51 version of the HUNT-INGRAM (Mycalex product) type of R.F. Capacitor is now available. Full details on request.

The very special nature of these types, however, means that to provide for efficiency and economy in use, specific designs must often be prepared to meet individual needs. Hunts specialise in such work and enquiries from designers are most welcome.

OPEN CLAMP CONSTRUCTION TYPES L.74 AND L.75 *Alternative to oil filled tanks for handling considerable R.F. Power in limited space.*

PORCELAIN CASED TYPE L.76 *Range includes ratings up to 10 kVA and D.C. Voltages up to 10 kV peak.*

METAL TANK TYPE L.73—oil filled—for application where the R.F. conditions exceed 10 kVA.

REGISTERED TRADE MARK

HUNTS CAPACITORS

THE TRADE MARK OF RELIABILITY

ESTABLISHED 1901

A. H. HUNT (Capacitors) LTD. WANDSWORTH, LONDON, S.W.18 BATtersea 1083