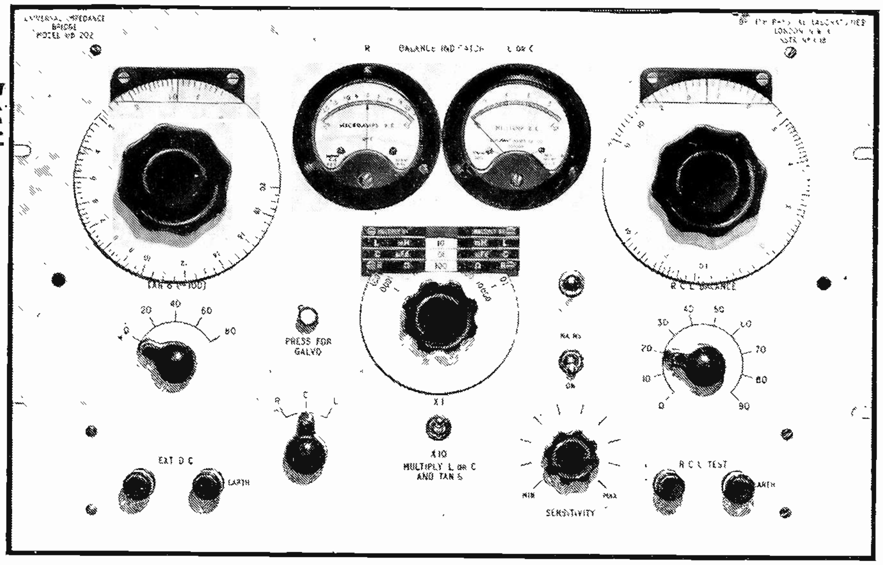
WIRELESS ENGINEER

DECEMBER 1947

VOL. XXIV.   TWO SHILLINGS AND SIXPENCE - - No. 291



UNIVERSAL IMPEDANCE BRIDGE **MODEL UB 202**

THIS is a self-contained universal bridge which measures resistance at DC, Capacity and Inductance at 1000 Cycles. The necessary bridge voltage and null detectors are incorporated in the instrument. Measurements in condensers can be carried out with applied polarising voltage and inductances can be measured with superimposed DC.

Resistance Range .01 ohm to 1 megohm
Capacity Range 10 pf to 1000 mFds
Inductance Range 10 μH. to 1000 Henries

For particulars of this and our full range of measuring instruments write to :—

BRITISH PHYSICAL LABORATORIES

HOUSEBOAT WORKS • RADLETT • HERTS • TELEPHONE : RADLETT 5674-5-

---

1000 different voltage ratios!

DECADE POTENTIOMETER Type 202A

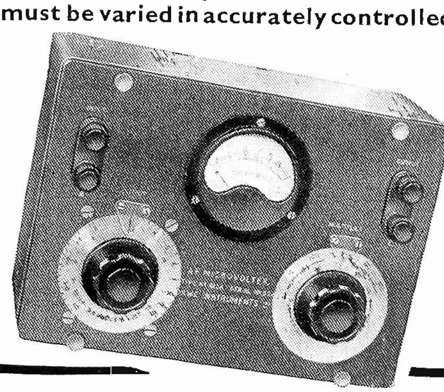
A potential divider of high accuracy for use at audio and carrier frequencies providing voltage ratios between 0·001 and 1·000 in steps of 0·001.

DAWE

Two useful instruments for fidelity determinations ; calibration of valve voltmeters ; amplifier-gain measurements ; and connection to any high impedance circuit where the input voltage must be varied in accurately controlled steps.

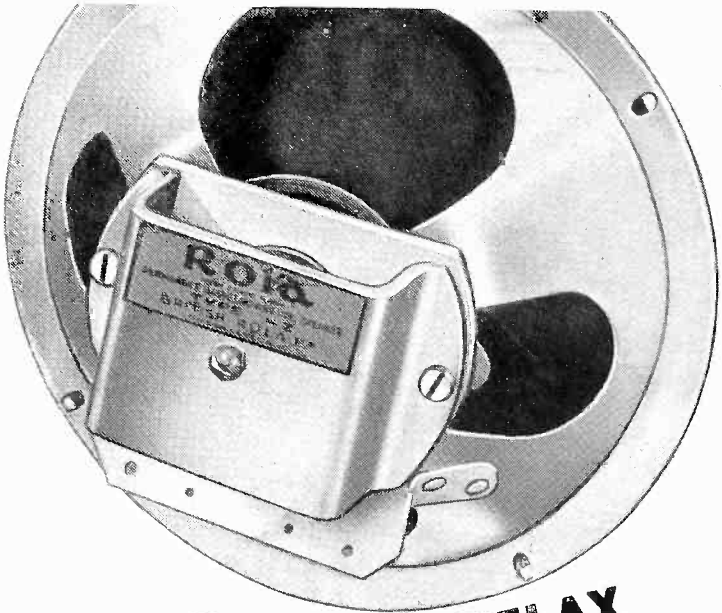
A.F. MICROVOLTER Type 615A

A combination of a variable attenuator and meter which provides accurately known small voltages from an external oscillator.



1 microvolt to 1 volt!

For complete technical data, write : DAWE INSTRUMENTS LIMITED, Harlequin Avenue, Great West Rd., Brentford, Middx. Ealing 1850


Rola

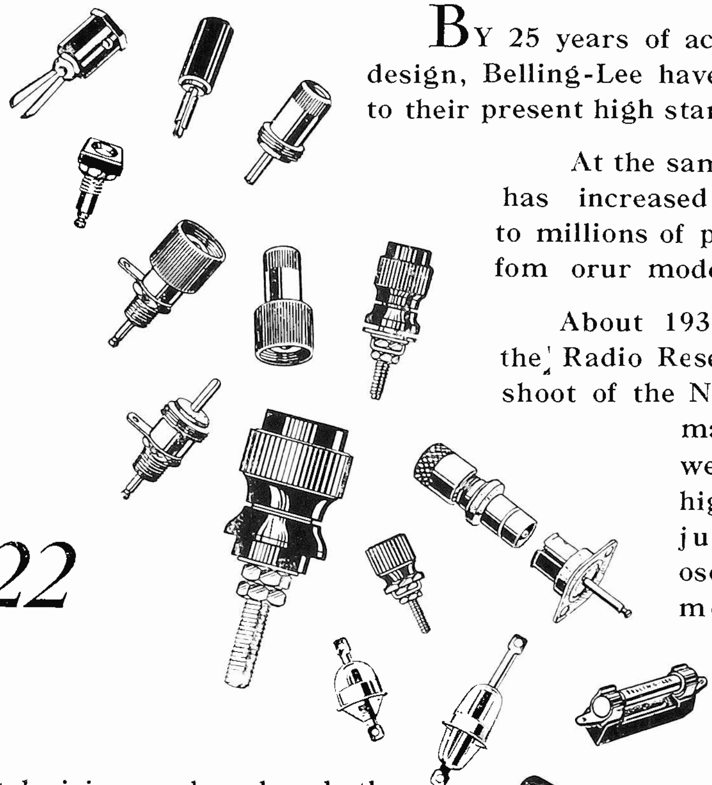
25 Years of achievement—

BY 25 years of achievement and refinement in design, Belling-Lee have helped to bring components to their present high standard.

At the same time Belling-Lee production has increased from the original terminal, to millions of precise components every week fom orur model factory.

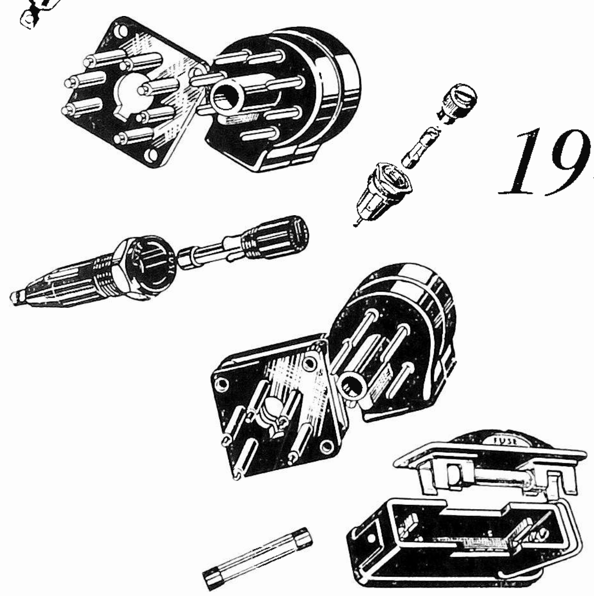
About 1934/35, after co-operation with the Radio Research Station, Slough—an off-shoot of the National Physical Laboratory—many Belling-Lee components were re-designed to carry the higher voltage called for in conjunction with cathode ray oscilloscope technique. This meant that we were well

1922



epared for television and radar, both ojects using many similar components. ntinuous efforts to improve our products, l the closest co-operation with all the sent Research Establishments, keep lling-Lee components always a little ead of normal commercial requirements.

★ We have put aside a proportion of total production effort for the develop-nt of special lines within our scope; at sent these lines are in the "short run" egory, but will, no doubt, develop into bulk production of the future.



1947

ELLING & LEE LTD

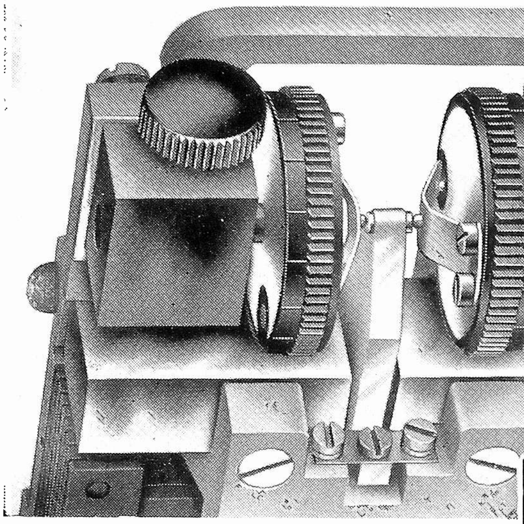
MBRIDGE ARTERIAL ROAD, ENFIELD, MIDDX

nd refinement in design

CARPENTER

High Speed Polarised

RELAY

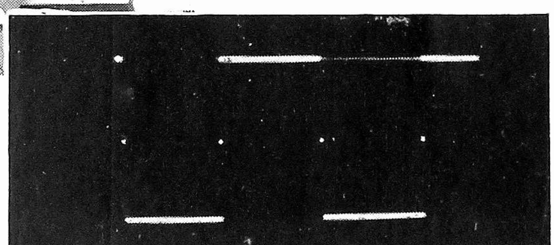


The Carpenter Relay in its standard adjustment reproduces, with a **5 AT** input, square pulses from less than 2 milli-seconds upwards with a distortion of 0.1mS, i.e., 5% for 2mS pulses or 1% at 10mS.

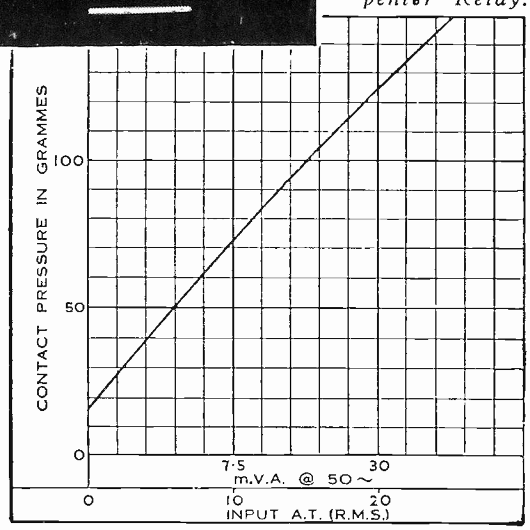
This unequalled performance is due to inherent features of the design of the relay, ensuring short transit time, high sensitivity and low hysteresis.

● (Above) *Contact mechanism of Relay showing damped compliant mountings of side contacts.*

● (Right) *Unretouched photograph (3 sec. exposure) of oscillogram showing contact performance of Relay in special adjustment for a measuring circuit; coil input 18 AT (25 mVA) at 50 c/s.*



(Below) *Graph showing contact pressures developed at 50c/s against mVA and ampere turns input for type 3E Carpenter Relay.*



There is complete absence of contact rebound at any input power and contact pressures are exceptionally high *(see graph)*. Adjustment can be made with great ease. Moreover, since the armature is suspended at its centre of gravity, the relay has high immunity from effects of mechanical vibration and there is no positional error. Effective screening is provided against external fields. Because of these characteristics, the Carpenter Relay has many applications in the fields of measurement, speed regulation, telecontrol and the like, in addition to the obvious use in telegraph circuits; details of models suitable for such purposes will be supplied willingly on request.

DIMENSIONS IN COVER: $2\frac{7}{8} \times 1\frac{5}{16} \times 4\frac{1}{4}$. **WEIGHT** with standard socket: 22 ozs.

Ask for Booklet 1017 W.E.

TELEPHONE MANUFACTURING CO. LTD.

HOLLINGSWORTH WORKS • DULWICH • LONDON • S.E.21

Telephone: GIPsy Hill 2211 (10 lines)


Output
Transformers
U.O.T.41
Iron Cored
Superhet
Coils
Strip Lighting
Chokes
High Peak Primary
T.R.F. Coils
I.F. Transformers
Type 67
Mains
Transformers
L.F.
Chokes
RM
ELECTRIC LIMITED
TEAM VALLEY, GATESHEAD, 11.

WIRELESS ENGINEER

The Journal of Radio Research & Progress

DECEMBER, 1947

Vol. XXIV. **No. 291**

CONTENTS

Published on the sixth of each month

SUBSCRIPTIONS

Home and Abroad: One Year 32/-. Six Months 16/-.

Editorial, Advertising and Publishing Offices :

DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1

Telephone : WATerloo 3333 (50 lines). Telegrams : Wirenger, Sedist, London.

Branch Offices :

COVENTRY
8-10, Corporation Street.
Telephone : Coventry 5210.
Telegrams :
"*Autocar, Coventry.*"

BIRMINGHAM 2
King Edward House,
New Street.
Telephone: Midland 719 (7 lines).
Telegrams :
"*Autopress Birmingham* 2."

MANCHESTER 3
260, Deansgate.
Telephone :
Blackfriars 4412 (4 lines).
Telegrams :
"*Iliffe, Manchester* 3."

GLASGOW C2
26B, Renfield Street.
Telephone : Central 4857.
Telegrams :
"*Iliffe, Glasgow C2.*"

Vortexion

"SUPER FIFTY WATT" AMPLIFIER

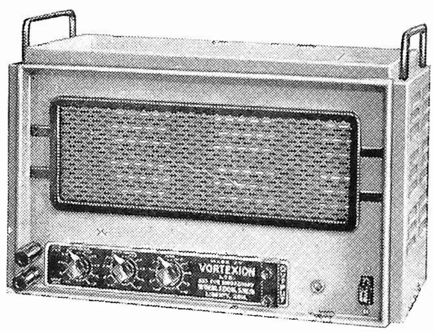
This AMPLIFIER has a response of 30 cps. to 25,000 cps., within ¼ db, under 2 per cent. distortion at 40 watts and 1 per cent. at 15 watts, including noise and distortion of pre-amplifier and microphone transformer. Electronic mixing for microphone and gramophone of either high or low impedance with top and bass controls. Output for 15/250 ohms with generous voice coil feedback to minimise speaker distortion. New style easy access steel case gives recessed controls, making transport safe and easy. Exceedingly well ventilated for long life. Amplifier complete in steel case, with built-in 15 ohm mu-metal shielded microphone transformer, tropical finish.

As illustrated. Price **36½ Gns**

C.P.20A. 15 WATT AMPLIFIER

for 12 volt battery and A.C. Mains operation. This improved version has switch change-over from A.C. to D.C. and "stand by" positions and only consumes 5½ amperes from 12 volt battery. Fitted mu-metal shielded microphone transformer for 15 ohm microphone, and provision for crystal or moving iron pick-up with tone control for bass and top and outputs for 7.5 and 15 ohms. Complete in steel case with valves.

As illustrated. Price **£28 0 0**



RECORD REPRODUCER

This is a development of the A.C.20 amplifier with special attention to low noise level, good response (30—18,000 cps.) and low harmonic distortion (1 per cent. at 10 watts). Suitable for any type of pick-up with switch for record compensation, double negative feedback circuit to minimise distortion generated by speaker. Has fitted plug to supply 6.3 v. 3 amp. L.T. and 300 v. 30 m/A. H.T. to a mixer or feeder unit. **Complete in metal cabinet** and extra microphone stage. *As illustrated.* Price **25½ Gns.**
CHASSIS, without extra microphone stage. Price **£21 0 0.**

Vortexion LIMITED

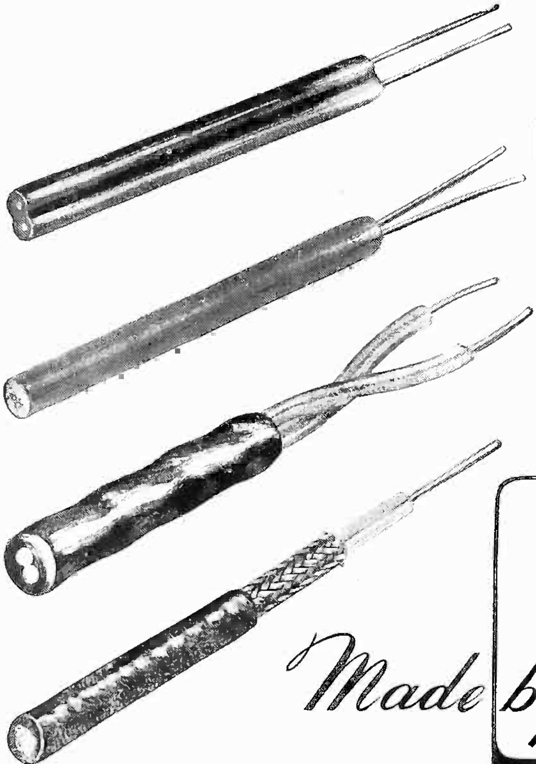
257-261, THE BROADWAY, WIMBLEDON, LONDON, S.W.19

TELEPHONES: LIBerty 2814 and 6242-3.

TELEGRAMS: "VORTEXION, WIMBLE, LONDON."

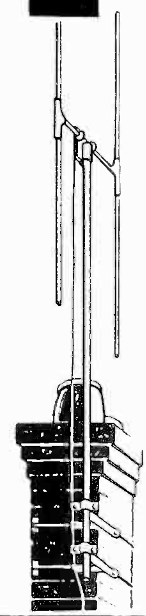
AERIALITE

Television DOWN LEADS



- Polythene Parallel-wire Feeder
- 100 ohm Polythene Parallel-wire Feeder
- Twin Twisted Sheathed 90 ohm Polythene Feeder
- 66/77 ohm Polythene Coaxial Feeder

Aerialite Television Aerial equipment is the result of special study of the needs of this fast-growing form of entertainment. The "down leads" illustrated are all Laboratory controlled in production, are completely reliable and are available from numerous distributors. In case of difficulty write to the sole makers.



Made by

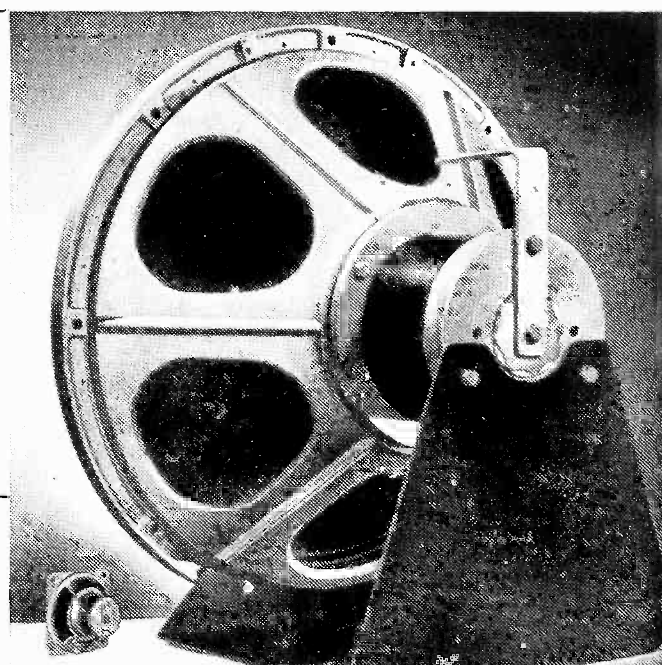
AERIALITE LTD · STALYBRIDGE · CHESHIRE

Member of "The Union of Enterprise and Freedom."

CELESTION

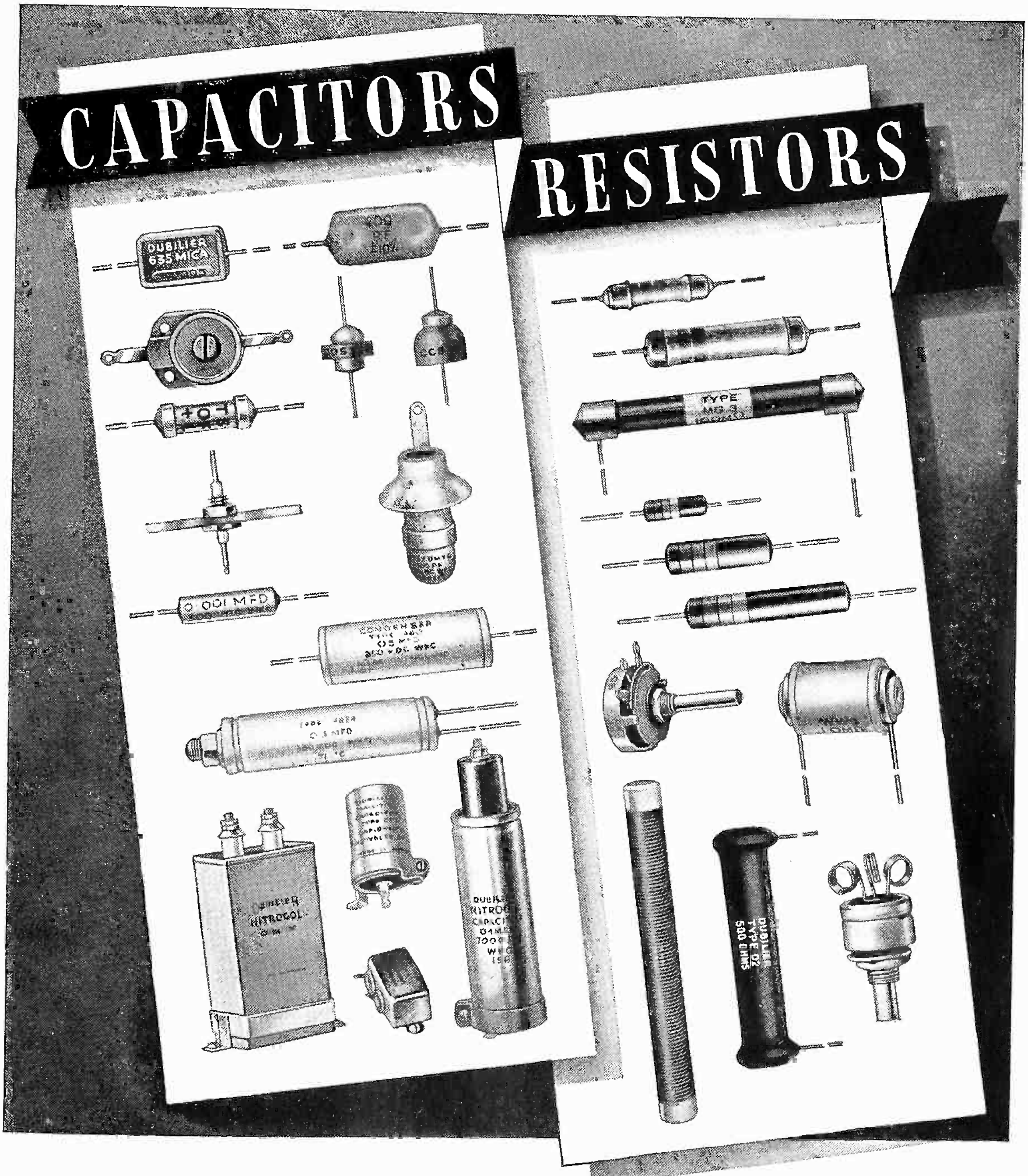
Model P84. An 18″ diameter Speaker with a peak power handling capacity of 40 Watts: suitable for public address purposes.

Model P_2VO. A $2\frac{1}{2}$″ diameter Speaker, weighing only $3\frac{1}{2}$ ozs., designed for small personal radios.



CELESTION LTD KINGSTON-ON-THAMES, SURREY

TELEPHONE: KINGSTON 5656-7-8-9



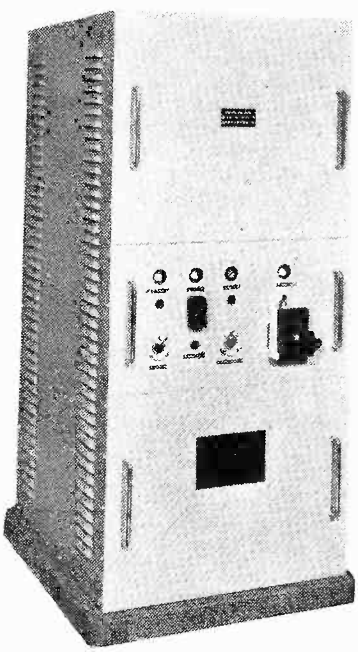
For more than 30 years, radio and electrical designers and engineers in all parts of the world have found their most exacting requirements met by the unrivalled Dubilier ranges of capacitors and resistors, renowned for their constancy and complete reliability under the most arduous operating conditions. These capacitors and resistors, so important in Radio, Radar, and Television equipment, are being continuously developed and extended in order to provide for every conceivable application.

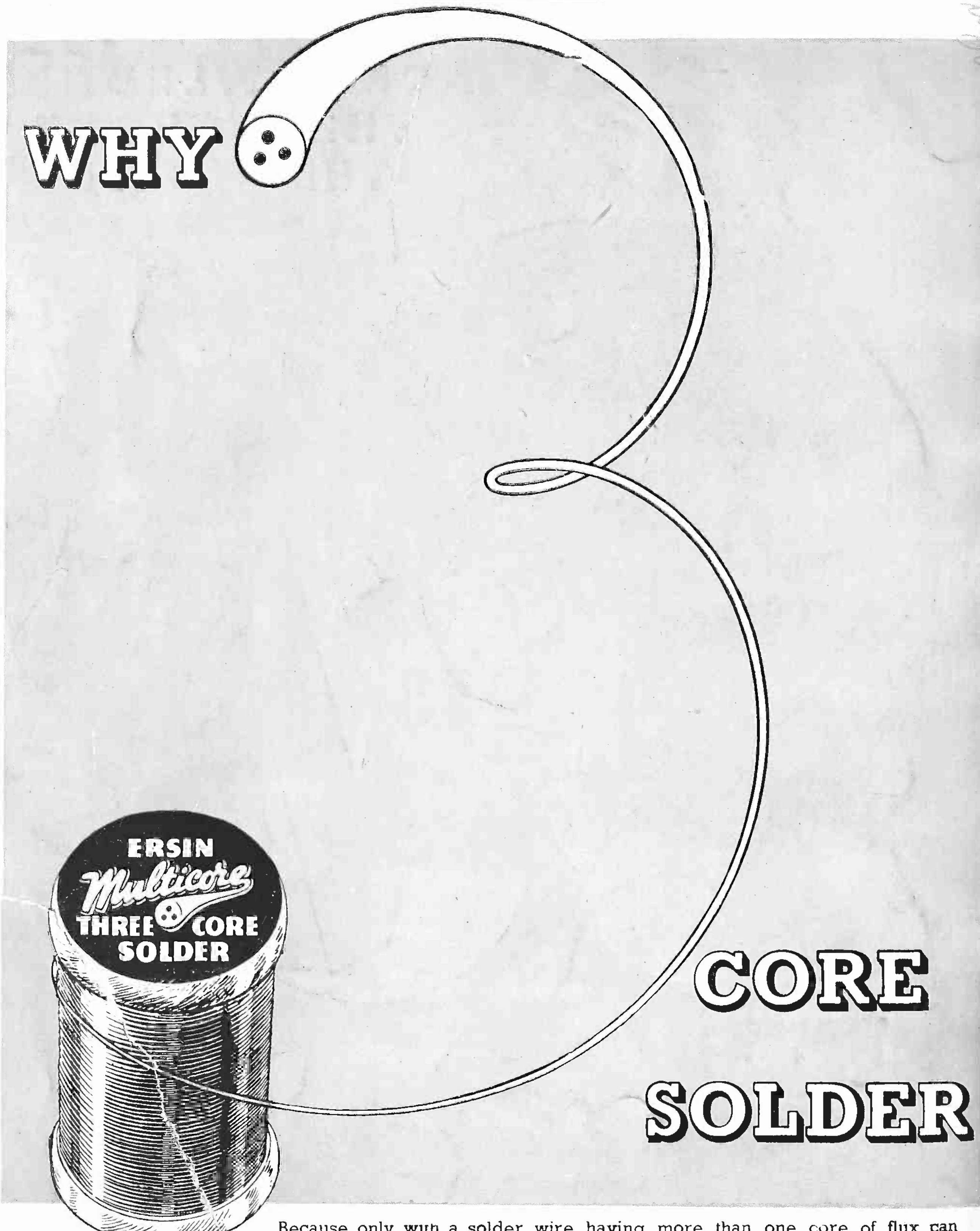
Dubilier capacitors and resistors owe their unvarying quality, technical excellence and high degree of stability to the close control which is maintained throughout all stages of their manufacture.

Full technical data and prices supplied upon request.

DUBILIER
CONDENSER CO. (1925) LTD.

DUBILIER CONDENSER CO. (1925) LTD., DUCON WORKS, VICTORIA ROAD, NORTH ACTON, W.3
Telephone : Acorn 2241 (5 lines)
Cables : Hivoltcon, London
Telegrams : Hivoltcon, Phone, London
Marconi International Code
DI2A





Printed in Great Britain for the Publishers, Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1, by The Cornwall Press Ltd., Paris Garden, Stamford Street, London, S.E.1.

WIRELESS ENGINEER

Vol. XXIV. DECEMBER 1947 No. 291

EDITORIAL

The B.B.C. Silver Jubilee

WE take time off this month from the more abstruse side of "wireless" to devote it to the most far-reaching levelopment of it in the number of human)eings it directly affects, namely radio ›roadcasting. The occasion is the twentyıfth anniversary of British broadcasting and ve take great pleasure in congratulating the 3.B.C. on reaching its Silver Jubilee and in vishing it " many happy returns of the day."

The story of the first 25 years of the B.B.C. as been told in detail both in print and in roadcasting during the past few weeks, and ıe highlights of 25 years of programmes ave been called to our minds by broadcast alks, feature programmes and recordings. ut it is on the engineering side that we ould wish to dwell because it seems to us ıat too little is known about it, a fact to hich the relatively great freedom from terruption of programme services due to chnical breakdown has certainly conibuted.

Starting in 1922 with some few engineers ıder the inspiring enthusiasm of Capt. P. P. ckersley, 1-kilowatt transmitters carried e British Broadcasting Company's proammes to a mere handful of listeners, any of them amateur and experimenters. ıose were the days of *Experimental Wireless* more senses than one, for this journal was founded under that name shortly afterwards in October 1923. The addition of *Wireless Engineer* to the title did not come until later—in September 1924.

In 1929 Sir Noel Ashbridge (then Mr. Ashbridge) became Chief Engineer of the British Broadcasting Corporation, to be followed in this post in September 1943 by Mr. H. Bishop, although Sir Noel Ashbridge remains the Corporation's principal technical adviser. It is on Sir Noel Ashbridge's and Mr. Bishop's shoulders then that the main burden of directing the growth of the B.B.C. engineering division has fallen. A few figures will most eloquently express this growth. At the outbreak of war in 1939, the B.B.C. was operating sixteen long- and medium-wave transmitters with a total power of 900 kW and eight short-wave transmitters with a total power of 450 kW—the engineering-divison staff totalling 1,675. Major developments between 1922 and 1939 included in these figures are the Regional twin-wave transmitting stations of which Brookmans Park, opened in 1929, was a pioneer not only in this country; the Empire broadcasting station at Daventry of which two transmitters were opened in December 1932; and the long-wave 150-kW transmitter at Droitwich which came into service in 1934. The old Daventry 5XX 25-kW long-wave transmitter, which it replaced, was opened in July 1925, and was at that time unique in the world.

The peak of engineering-division effort came during the war, in 1943 and 1944, when the B.B.C. operated a total of 121 broadcasting transmitters with an aggregate power of 6,240 kW. Of these 43 were short wave with a total power of 3,105 kW. Studio and recording facilities expanded very greatly; disc consumption, for instance, increasing from the pre-war figure of 250 per week to 5,000 per week. The engineering-division staff at its maximum in 1944 totalled 4,137. At the present time it totals some 3,700 for the sound and television services. The latter was started in the London area on 2nd November 1936, was interrupted by the war on 1st September 1939, and was resumed on 6th June 1946. The B.B.C. has plans for extending this service so as to bring far more potential viewers within range.

We have quoted the above figures because we believe that the size and extent of the operations of the B.B.C. engineering division are not generally known. But we do not thereby suggest that size alone is what matters. The smallest staff which will properly carry out the work is generally a surer sign of efficiency, and the engineering division of the B.B.C. will be judged by the public it exists to serve not by its size but by the technical service it provides. The B.B.C. itself does not claim to be able to give a perfect service of all three domestic programmes to all listeners in the British Isles but the limitations of coverage, which affect mostly the Third Programme (only 50% of listeners in primary service areas of this programme is the B.B.C. claim, while 97% is the corresponding figure for the Home and Light programmes), are due to wavelength shortage over which the B.B.C. has no control. It is good news, therefore, although insufficiently publicized as yet, that the B.B.C. is at present building a high-power experimental station near London which will serve as a prototype to a chain of ultra-short-wave frequency-modulation stations which it is hoped will ultimately solve most coverage problems.

Where the B.B.C. does have full control over transmission facilities, as in the technical quality of the radiated transmissions it is fair to say that while the quality is not always impeccable and does not always satisfy "quality enthusiasts," it does reach a satisfactorily high standard for a large proportion of transmissions and is very frequently well ahead of the quality produced by the receivers in the hands of the ordinary listener. We believe the B.B.C. itself to be "quality conscious" and welcome the inauguration of the frequency-modulation transmissions as a means of extending the already good quality, available to the few who live close to existing B.B.C. stations, to a far wider audience.

The B.B.C. has set high technical standards in its 25 years of existence and it has with but relatively few lapses been able to preserve those standards. But the enduring interest in broadcasting for the large majority of people is in what comes out of the loudspeaker and not in the technical means by which it reaches them. And so we cannot conclude this editorial without referring to one to whom is due in so large a measure the high standards of culture and public service which have come to be inherent in British broadcasting—Lord Reith. To quote some words of the present Director-General of the B.B.C., Sir William Haley, K.C.M.G., in a recent article in the *Radio Times*: "No celebration of the B.B.C.'s Silver Jubilee can be complete without an appraisal of what British broadcasting, and the nation as a whole, owes to him. There are few homes that have not benefited by his imaginative concept of what ends broadcasting could serve. Life for millions in this generation has been made richer and fuller by his efforts. He came to launch broadcasting. No chart or course existed. There was no experience to draw upon, no traditions to guide. He went forward with energy, vision, and faith. There were opponents. They were not serious. There was a vast multitude who saw little in the new invention and who did not much care to what use it was put. That was most serious. The story will one day be told how Mr. Reith, as he then was, went about, cajoling, urging, bullying, exhorting those forces that stand for what is best in the community to realize what broadcasting could do for them. There is little he foresaw that has not since come to pass. Not all his dreams, perhaps, have been realized. But there is none yet proved finally incapable of realization."

L. W. H.

SIGNAL-NOISE RATIO IN RADAR*

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

(*G.E.C. Research Laboratories, Wembley, England. Formerly of Standard Telephones and Cables, London.*)

SUMMARY.—Small pulse signals are difficult to detect when mixed with noise. A method is described by which the visibility of these pulses is improved.

The principle is to cut either the upper part or the lower part of the received signal by a limiter. On a cathode-ray tube it appears then as a brilliant line in which the brilliancy is increased or decreased at the positions of the signal pulses. It is shown that the visibility of very small pulses is appreciably increased.

Apart from its practical importance, this study is an example of the application of statistics to radio problems.

THE object of this study is to describe a method of increasing the visibility of small pulses on the cathode-ray ubes of pulse receivers, particularly when hese pulses are mixed with strong noise.

The method is deduced from the law of istribution of the peak amplitudes in the oise.

In Fig. 1 are represented a noise (a), a gnal pulse (b), the resultant of the noise nd the signal pulse (c). In addition some ther curves are shown, and their purpose ill now be explained.

The noise may be regarded as the resultant f an infinite number of impulses of very hort duration, the amplitudes being distriuted at random. However, these ampliudes follow Gauss's law of distribution, and we trace a curve the ordinates of which epresent the peak amplitude of the noise ulses and the abscissae the proportion of ulses having a given peak amplitude (that , the value of the probability for a noise ulse to have a given amplitude) we get a ırve such as the one shown in Fig. 1 (a). he most probable value of the noise-pulse mplitude is zero, and the probability ecreases very quickly when the amplitude creases either positively or negatively. If is the amplitude of the pulses and p the obability, this curve may be represented the equation :

$$p = \frac{k}{\sqrt{\pi}} e^{-k^2 z^2} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

ıere k is a constant connected to the rootean-square value $\overline{\alpha_n}$ of the noise amplitude the relation :

$$k = \frac{1}{\overline{\alpha_n}\sqrt{2}} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Now the movement of the spot of the thode-ray tube being at random, the time during which the spot is at a certain amplitude follows the same kind of law, and the distribution of the intensity in the shaded area produced by the movement of the spot also follows the same law. That is to say, the curve of Fig. 1 (a) also represents the law of the vertical distribution of the intensity in the shaded area produced by the noise. This intensity is maximum on the abscissa line and decreases very quickly when one goes off it.

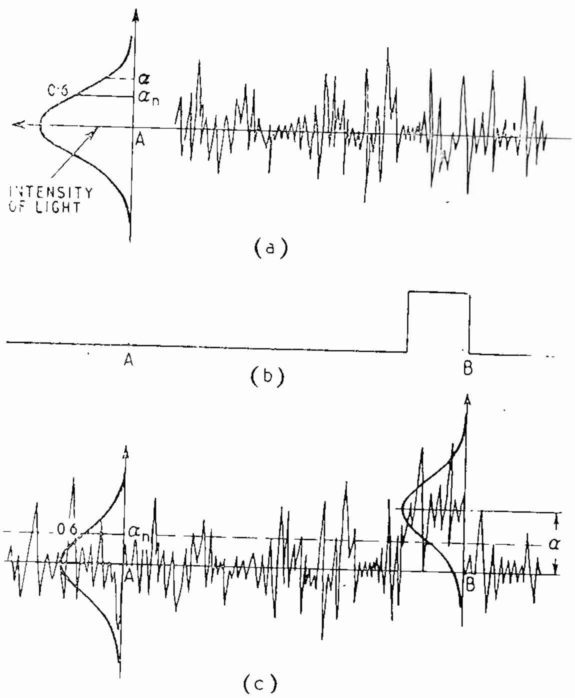


Fig. 1. *Shows a small recurrent signal appearing on the cathode-ray tube of a sensitive radar receiver in the presence of strong noise. The noise and signal are shown at (a) and (b) respectively, and combined at (c).*

It must be noted that this is really a hypothesis, exactly as Gauss's law of distribution. It is shown in statistics that if a number of independent events occur at

* MS. accepted by the Editor, November 1946.

random, the law of distribution of all the events added together is Gauss's law provided that the number of independent events is great. The above hypothesis is probably correct. However, even if the intensity distribution follows a different kind of law, the general principles of the method explained below can still be applied.

Now let us see what happens when the signal pulses are mixed with the noise. Fig. 1 (c) represents the resultant of the noise and the pulses. When a signal pulse appears, it lifts up the noise by an amount equal to the amplitude of the signal pulse. There is also traced the intensity distribution law for a point A where there is no signal pulse and for a point B where the signal pulse is present. The intensity distribution law is the same, but the pulse raises the curve by an amount equal to its amplitude.

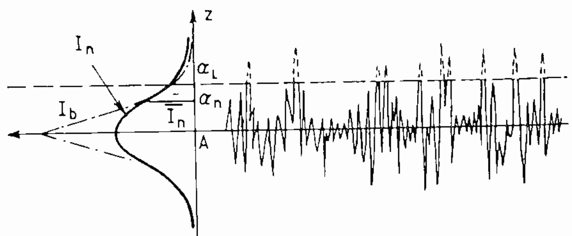
We are now in a position to find out the value of the minimum amplitude of the signal pulse which can be visible; that is, the minimum value of the signal/noise ratio for which the presence of a signal pulse can be detected.

In Fig. 1 (c), the root-mean-square noise amplitude (standard deviation in statistics) has been represented by the ordinate $A\alpha_n$. The intensity of light for this point is about 0.6 of the maximum. Assuming that a variation of 40 per cent is the minimum which can be visible, one can see that the minimum lift of curve B to make this lift detectable is equal to $A\alpha_n$.

Thus, the minimum signal/noise ratio for visibility of the signal pulses is unity.

A method with which much smaller values of signal/noise ratio can be detected will now be described. The principle is to add an amplitude limiter to the receiver, placed anywhere before the cathode-ray tube.

Let us examine the effect of this limiter on the intensity distribution on the cathode-ray tube. Assume first no pulse signals. Without the limiter the intensity distribution curve is assumed to be Gauss's curve as represented in Figs. 1 (c) and 2 (a). Assume now that the limiter cuts all amplitudes above a given value $A\alpha_L$ [Fig. 2(a)]. Then all the intensity of light which is above the horizontal line passing through point α_L is concentrated on this line. This is due to the fact that whenever the spot has a tendency to cross the line and trace a curve above it, it is stopped by the limiter and stays on this boundary line during the time which it would have spent above it without the limiter. Thus the average intensity on this line is equal to the area of the intensity distribution curve above this line. This average intensity is negligible when $A\alpha_L$ is great and increases gradually when $A\alpha_L$ decreases and becomes maximum when $A\alpha_L = 0$. The law is the same for negative values of $A\alpha_L$, provided that the limiter stops the spot when it tries to cross the limiter line. This has been assumed in tracing the intensity distribution curves of Fig. 2. The curve representing the average intensity on the limiter line as a function of $A\alpha_L$ is given in Fig. 2 (a). It is a curve having a sharp cusp for $A\alpha_L = 0$, whereas the amplitude of the noise intensity distribution varies very slowly for very small values of $A\alpha_L$. Starting from zero value, if $A\alpha_L$ increases by a very small quantity the noise intensity light will not vary, but if we use a limiter the variation will be important. This property is used in order to increase the visibility of very small pulses. The principle is to use a limiter, preferably adjusted so that $A\alpha_L$ is small or zero, and to observe on the boundary line produced by the limiter, the difference of intensity between the points where there is only noise and the points where the noise is mixed with a signal pulse.



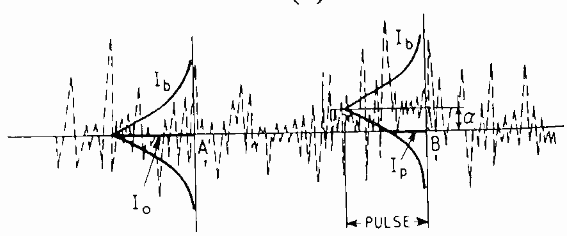


Fig. 2. *Noise on a c.r. tube is shown at (a) for the case of a limiter operating at the level $A\alpha_L$ and at (b) with the addition of a signal pulse of amplitude α.*

Fig. 2 (b) represents the average intensity of light on the boundary line for two points; one, A, where there is no signal pulse and one, B, where the noise is mixed with a signal pulse. The pulse has the effect of ifting up the curve by a height equal to the amplitude of the pulse. The average ntensity on the boundary at point A is I_0, he maximum amplitude of the curve, and t point B it is I_p. The difference $I_0 - I_p$ s proportional to α when α is small because he curve near the cusp is approximately onstituted by two lines. Without the imiter for very small values of α there is no ppreciable variation of intensity as has een explained above, and as is shown in ig. 1 (c).

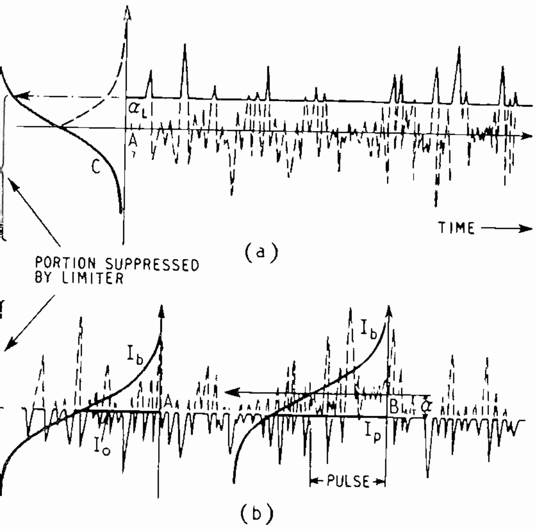


Fig. 3. *The conditions are the same as for Fig. 2, but the limiter is assumed to stop the spot from crossing the boundary line. It is confined above it for (a) and below it for (b) irrespective of the value and sign of* $A\alpha_L$.

In Fig. 2 it has been assumed that the miter stops the spot where it tries to cross e limiter line upwards for $A\alpha_L$ positive d downwards for $A\alpha_L$ negative. The tensity distribution of light on the boundary e is then a symmetrical curve as shown on g. 2 (b). In practice, the limiter behaves a way which is independent of the position the boundary line. The intensity distribu- n of light on the boundary line has then an ymmetrical shape as shown in Fig. 3 (a) for imiter stopping the spot where it crosses boundary line downwards, and in g. 3 (b) for a limiter stopping the spot ere it crosses the boundary line upwards. g. 3 (b) shows this curve in the absence a signal pulse (point A) and in the presence a signal pulse (point B).

To obtain an idea of the improvement roduced by this method some calculations necessary.

Let I_n be the noise-light intensity for an ordinate of abscissa z. The law of distribution of the intensity of light is given by

$$I_n = \frac{k}{\sqrt{\pi}} e^{-k^2 z^2} \quad \ldots \quad (3)$$

where k is a constant connected to the root-mean-square value of I_n by the relation.

$$k = \frac{1}{\bar{I}_n \sqrt{2}} \quad \ldots \quad (4)$$

Let I_b be the intensity of light on the boundary line $z = \alpha$ when there is a limiter. Then we have

$$I_b = \int_\alpha^\infty I_n \, dz = \int_0^\infty I_n \, dz - \int_0^\alpha I_n \, dz$$

$$= \frac{1}{2} - \frac{k}{\sqrt{\pi}} \int_0^\alpha e^{-k^2 z^2} dz = \frac{1}{2} - \frac{1}{\sqrt{\pi}} \int_0^{k\alpha} e^{-t^2} dt$$

$$2 I_b = 1 - \theta(k\alpha) \quad \ldots \quad (5)$$

where $\theta(k\alpha)$ is the well-known integral used in statistical problems. Numerical tables of this integral exist and from these tables the curve of Fig. 4 can be traced. In this figure there is also included the curve representing I_n, and to make the comparison easier, the curves have been drawn with the same maximum amplitude. The root-mean-square amplitude of the noise is represented by the abscissae α_n as in Fig. 1 (c). The intensity $\bar{I}_n$ corresponding to the root-mean-square amplitude is also indicated. It can be seen that with curve I_b the same amplitude $\bar{I}_n$ can be obtained with half the deflection α_n; that is to say, with half the amplitude of the signal pulse which will be necessary with curve I_n. *Thus, the above method improves the signal-to-noise ratio by about 6 db.*

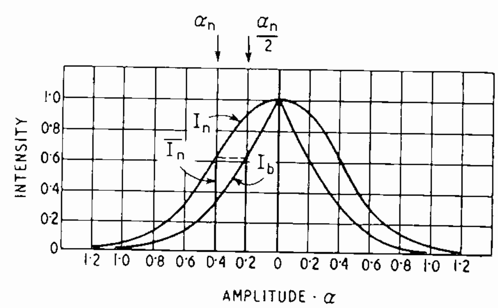


Fig. 4. *The average intensity distribution of light on a horizontal line on the cathode-ray tube versus the distance of this line from the axis, without limiter (curve* I_n*) and on the boundary line when a limiter is used (curve* I_b*).* α_n *and* $\bar{I}_n$ *are respectively the root-mean-square values and the intensity of the noise.*

It may be noted that the adjustment of the limiter may be independent of the amplitude of the noise and signal pulses, if one chooses a limiter suppressing either the positive or the negative part of the signals. Any kind of limiter can be used. Usually a diode connected in shunt on the signal is used. Depending on the connections, either the positive or the negative part of the signal is suppressed.

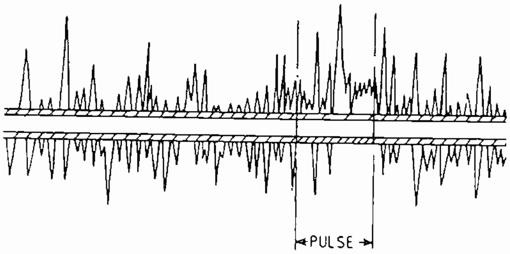


Fig. 5. *Shows a recurrent pulse of small amplitude as it appears on a c.r. tube when a limiter is used; (a) corresponds to a limiter suppressing the negative deflections and (b) the positive deflections.*

Fig. 5 is a sketch to show how a recurrent pulse of small amplitude will appear on the screen of the c.r. tube when a limiter is used; (a) corresponds to a limiter suppressing the negative part of the trace and (b) the positive part. The pulse is assumed to be positive; that is, to lift the noise upwards. This lift is visible in (a) by a great number of positive peaks where the pulse appears and in (b) by a reduced number of negative peaks. The boundary lines in (a) and (b) appear as bright traces with sudden changes of brightness where the pulse appears, reduced in (a) and increased in (b). As explained above, it is easier to detect the presence of the recurrent pulse by this sudden change of brightness than by the average increase or reduction of the number and amplitude of the noise peaks.

The work reported in this paper was commenced in Paris in 1939 at the Laboratories of the L.M.T. It also forms the subject of Patent No. 581698 granted to Messrs. Standard Telephones and Cables Limited to whom acknowledgments are due for permission to publish this paper.

WAVELENGTH LAWS OF SPLIT-ANODE MAGNETRONS*

By G. H. Metson, M.C., Ph.D., M.Sc., B.Sc. (Eng.), A.M.I.E.E.

(*Post Office Engineering Department*)

1. Introduction

THE two principal modes of operation of a magnetron are commonly described as the 'A' mode and 'B' mode respectively.

The 'A' mode occurs when the "critical" or skimming condition,

$$E_a = \frac{H^2 d^2}{181}$$

is closely observed and the wavelength of the associated resonator bears a simple numerical relationship to the flight-time of an electron over its cardioid path. The flight-time is characterized by Okabe's relationship,

$$\lambda = \frac{10.650}{H}$$

and the generated wavelength by,

$$l = n\frac{\lambda}{4}$$

where l is the length of a Lecher-wire system resonator, H is the magnetic intensity, and n a series of even integers. The appearance of even integers only is significant and shows that the A-mode oscillations originate from a generator of zero internal impedance. In general, the oscillation is a weak one and becomes increasingly difficult to develop for values of n greater than 6.

The B-mode is entirely different in character from the A-mode in that it appears to be independent, within wide limits, of flight-time and is essentially a function of the resonator system. If the resonator is a Lecher wire, the generated wave will be found proportional to the effective length of the Lecher system and generally independent of the electrical parameters of the tube. Thus, if the length of the Lecher system is l cm, the generated wave-length λ cm will conform to the linear equation

$$\lambda = ml + c \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where m and c are constants of tube geometry.

* MS accepted by the Editor, November 1946.

The analytical significance of this equation is the prime concern of this article.

2. Experimental Method

The B-mode wavelength laws for three different tubes were measured over a series of ranges extending from 50 cm to 350 cm. The wavelengths refer to measurements on heavy-gauge parallel copper rods and may be regarded as corresponding to waves propagated in free space. The experimental procedure was conventional and consisted of the generation of oscillations in a tube with a specific length l cm of resonating Lecher wire attached to the anode plates. The wave-length λ cm of the generated wave was measured on a second Lecher wire of considerable length and coupled to the resonator by a loop aerial system. Variation of λ with l was then measured over a range suitable to the circumstances of a particular experiment.

Two of the tubes were of the two-plate split-anode type and the third of the four-plate split-anode type.

3. B-Mode Wavelength Laws

The B-mode wavelength laws, or λ/l characteristics were measured under the several sets of circumstances indicated in Fig. 1.

one develops with the magnetic-field strength considerably greater than the "critical" value while the other sets in with H only slightly greater than the "critical" value. The first mode will be described as the B_1-mode and the second as the B_2-mode.

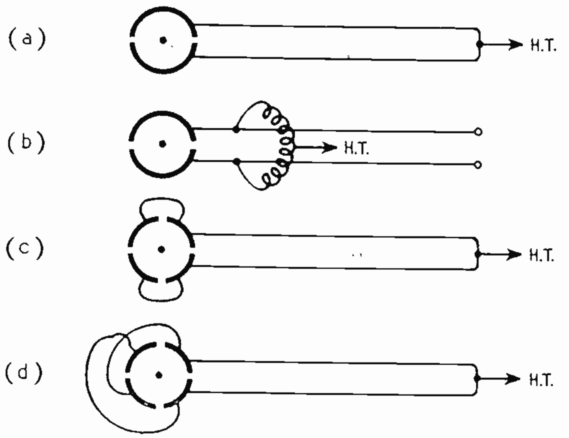


Fig. 1. *Various operational arrangements are shown: (a) Normal operation of two-plate tube, wavelength λ; (b) open-circuited operation of two-plate tube, wavelength $\lambda^{o/c}$; (c) two-plate operation of four-plate tube, wavelength λ^{II}; (d) four-plate operation of four-plate tube, wavelength λ^{IV}.*

In all cases the λ/l characteristic was found to conform to Equ. (1). A summary of the laws obtained is set out in Table 1.

TABLE I.

Tube No.	Oscillation Law	Remarks
1	$\lambda = 3.84l + 41$	Normal 2-plate operation
1	$\lambda^{o/c} = 1.94l + 24$	Lecher system open-circuited
2	$\lambda = 3.84l + 46$	Normal 2-plate operation
3	$\lambda^{II} = 4.47l + 50$	2-plate mode of 4-plate tube
3	$\lambda^{IV}_{B_1} = 4.31l + 60$	4-plate B_1-mode of 4-plate tube
3	$\lambda^{IV}_{B_2} = 1.39l + 14.4$	4-plate B_2-mode of 4-plate tube

Two points shown here require brief explanation. The open-circuited driving of a magnetron shown at (b) is unusual but can be readily achieved by feeding the h.t. plate voltage through an inductance consisting of a few suitably spaced turns of wire connected across the Lecher system. Two symmetrical arrangements of connecting the plates of a four-plate tube are possible and are shown at (c) and (d) respectively. With the four-plate connection (d) it is possible to drive the magnetron into two distinct and separate B-type modes;—

4. Resonance in a Lecher System

A Lecher system is essentially a parallel-wire transmission line and is, therefore, capable of solution by classical methods. Under conditions of free oscillation or resonance the λ/l characteristic for such a system is given by,

$$l = n\lambda/4 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where $n = 1, 3, 5 \ldots$ for dissimilar terminations

and $n = 2, 4, 6 \ldots$ for similar terminations.

The terminations referred to are either zero or infinite impedances.

The B-mode oscillation bears many of the physical characteristics of free-oscillation or resonance but, if such is actually the case, the general law

$$\lambda = ml + c$$

must be reconciled with the classical case of resonance defined in Equ. (2). If, for example, the general equation for normal two-plate operation of the tube is evaluated, it will be found that the Lecher system is always short of an integral number of quarter-wavelengths by a length Δ. This is shown for a typical example in Fig. 2. The quantity Δ is obviously related to the λ/l characteristic by the equation

$$\lambda = 4(l + \Delta) \quad .. \quad .. \quad (3)$$

It may be well at this stage to assign some formality to this function Δ and it will therefore be defined as the shortest length that must be added to a Lecher system oscillating in the B-mode to make it equal in length to an integral number of quarter-wavelengths.

Numerical evaluation of the Δ/λ characteristics from Equ. (1) and (3) has been made for the three tubes and the results are set out in Fig. 3. The characteristics are all linear.

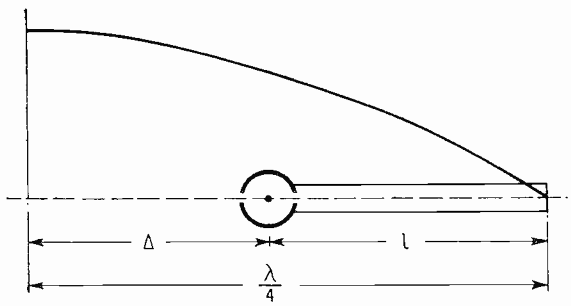


Fig. 2. *Normal two-plate oscillation.*

5. Development of Length Δ

Assuming free resonance, it would appear that the internal impedance of the B-mode generator must identify itself with the impedance of a length Δ of Lecher wire open-circuited at its distance end. This assumption can now be put to test by development of the transmission characteristics of the open-circuited Lecher system of length Δ.

If the Lecher system has a complex propagation constant p and characteristic impedance Z_0, then the sending-end impedance of a length Δ of line open-circuited at its distant end is given by,

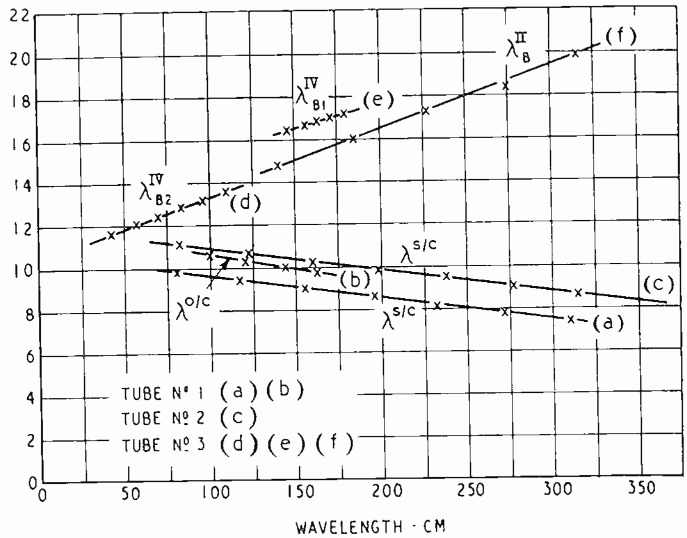


Fig. 3. *Variation of Δ with λ; curves (a) and (b) are for tube No. 1, (c) for tube No. 2, and (d), (e) and (f) for tube No. 3.*

$$Z = Z_0 \coth p\Delta$$
$$= Z_0 \coth (\alpha + j\beta)\Delta$$

where α = attenuation constant

and β = phase constant.

Expanding the complex hyperbolic

$$Z = Z_0 \frac{\cosh (\alpha + j\beta)\Delta}{\sinh (\alpha + j\beta)\Delta}$$

$$= Z_0 \frac{\cosh \alpha\Delta \cos \beta\Delta + j \sinh \alpha\Delta \sin \beta\Delta}{\sinh \alpha\Delta \cos \beta\Delta + j \cosh \alpha\Delta \sin \beta\Delta}$$

The characteristics of the Lecher system are such that the attenuation in nepers per cm will be very small numerically and as Δ is also small, the hyperbolic functions of $\alpha\Delta$ may be written,

$$\cosh \alpha\Delta = 1$$
$$\sinh \alpha\Delta = 0$$

without sensible error. Inserting these in the full expansion,

$$Z = Z_0 \frac{\cos \beta\Delta}{j \sin \beta\Delta}$$

$$= -jZ_0 \cot \beta\Delta \quad .. \quad .. \quad .. \quad (4)$$

The quandrantal rotor indicates that the impedance is wholly reactive. The phase constant β defines the angular rotation of line. It therefore expresses itself in terms of wavelength λ as,

$$\beta = \frac{2\pi}{\lambda}$$

whence,

$$Z = Z_0 \cot (2\pi \Delta/\lambda) \quad \quad .. \quad .. \quad (5)$$

The characteristic impedance Z_0 is directly derivable from the primary constants of the Lecher system and at high frequencies is given by,

$$Z_0 = \sqrt{L'/C'} \quad .. \quad .. \quad (6)$$

where L' and C' are the inductance and capacitance per unit length of the system.

The impedance Z of the open-circuited system of length Δ is calculable from Equs. (5) and (6) and the values for tubes Nos. 1 and 3 are set out in Fig. 4 over the range 100–500 Mc/s.

Since the impedances are wholly reactive and Fig. 4 shows them to be capacitive in character, it is apparent that the curve of the figure can be recast as "capacitance frequency" characteristics. Thus,

$$Z = \frac{1}{\omega C}$$

where

$$\omega = 2\pi f.$$

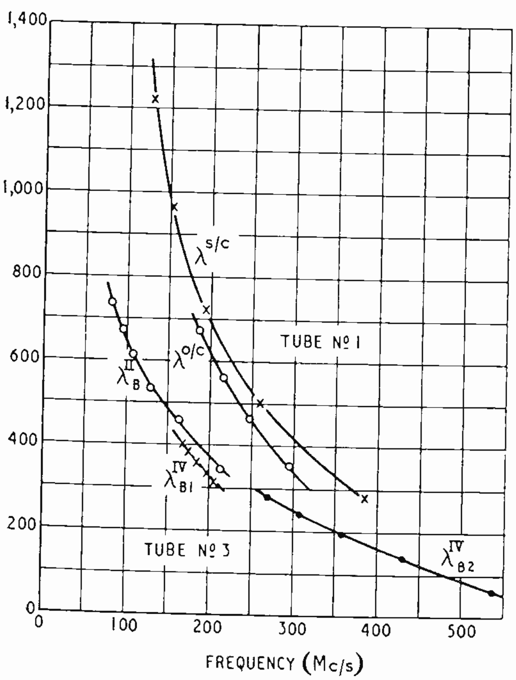


Fig. 4. *Variation of Z with frequency.*

This readjustment has been made and the C/f characteristics are set out in Fig. 5. It should be emphasized at this point that the value of C in micromicrofarads at any particular wavlength λ cm represents the equivalent of the open-circuited length Δ which must be added to the Lecher system

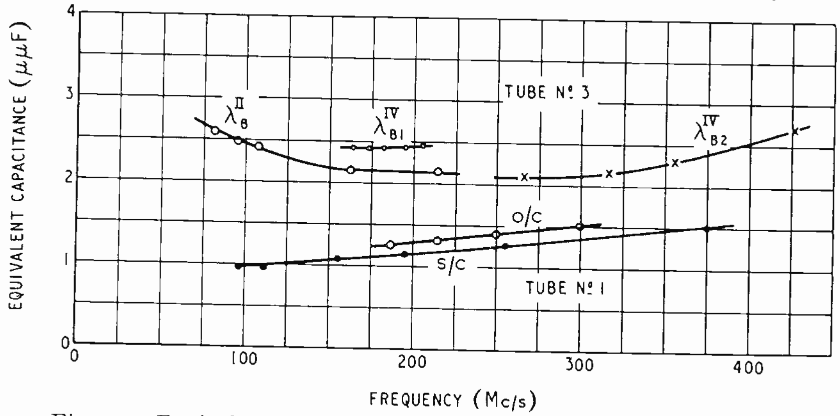


Fig. 5. *Equivalent capacitance of tube as a function of frequency.*

to make it equal to an integral number of quarter-wave lengths.

Examination of the curves brings to light two significant points. First, the equivalent capacitance for the Δ of a tube is sensibly independent of the condition under which the tube operates; e.g., close-circuited or open-circuited Lecher resonator; B_1- or B_2-mode; 2-plate or 4-plate connection. Secondly, having regard to the great frequency range involved, nearly 350 Mc/s, the equivalent capacitance shows remarkably small variation with frequency. Neglecting fractional variations over the frequency range, mean constant values are,

Tube No. 1 $\quad C = 1.2\ \mu\mu F$

Tube No. 3 $\quad C = 2.4\ \mu\mu F$

Tube No. 2 has been omitted in these later characteristics as it is similar in form to Tube No. 1 and gives rise to similar results, —vide Fig. 3.

Constancy of equivalent capacitance for Δ over the frequency range at once gives rise to the implication that it can be identified with the electrostatic capacitance of the magnetron anodes—the magnitude of 1–2$\mu\mu$F would appear to be of comparable order. The capacitances of the plates of the two tubes have therefore been calculated and the results are set out in Table 2.

From these results it is apparent that the equivalent capacitance of Δ approximates closely to the constant electrostatic capacitance of the magnetron anodes.

5. Frequency Prediction

Identification of the equivalent capacitance with the electrostatic capacitance of the anode plates enables the frequency of a tube to be determined by a purely analytical process. Thus, Equ. (3) relating λ, l and Δ may be generalized to account for all B-type modes.

TABLE II

Tube	Radius	θ*	Axial length	Calculated Anode Capacitance ($\mu\mu$F)	Equivalent Capacitance of Δ ($\mu\mu$F)
No. 1 ..	0.47 cm	12.2°	2.0 cm	1.74	1.2
No. 3 ..	0.35 cm	10.2°	2.0 cm	2.39	2.4

* Angle subtended at tube centre by anode gap.

$$n\frac{\lambda}{4} = l + \Delta \qquad \ldots \quad \ldots \quad \ldots \quad (7)$$

where $n = 1$ for fundamental mode (B_1)
$n = 3$ for 2nd harmonic mode (B_2), etc.

Then from Equ. (5)

$$Z = Z_0 \cot (2\pi\Delta/\lambda)$$
$$= \frac{1}{\omega C}$$

or $$\Delta = \frac{\lambda}{2\pi}\tan^{-1}\omega C Z_0$$

Whence

$$n\frac{\lambda}{4} = l + \frac{\lambda}{2\pi}\tan^{-1}\omega C Z_0$$

or $$\lambda = \frac{4\pi l}{\pi n - 2\tan^{-1}\omega C Z_0} \qquad \ldots \quad \ldots \quad (8)$$

where λ = generated wavelength
l = actual length of Lecher system
C = electrostatic capacitance of plates
Z_0 = characteristic impedance of Lecher system
$\omega = 2\pi f$
$n = 1, 3, 5 \ldots.$

The discrete frequencies at which a tube may operate at any value of l can therefore be calculated from the geometry of the anode and Lecher wires.

6. Conclusions

The general B-mode oscillation law of a split-anode magnetron with Lecher wire resonator,

$$\lambda = ml + c_{\cdot}$$

is in complete accord with the classical wavelength laws of a freely resonating transmission line with dissimilar terminations, viz

$$l = n\frac{\lambda}{4}$$

where $n = 1, 3, 5 \ldots.$

The analagous form for the magnetron case may be written

$$l' = n\frac{\lambda}{4} \qquad \ldots \quad \ldots \quad \ldots \quad (9)$$

where $l' = l + \frac{\lambda}{2\pi}\tan^{-1}\omega C Z_0$

In conclusion it may be pointed out that the only difference between the basic wavelength laws for the A-mode and B-mode lies in the apportionment of the integer n. For the A-mode, n is always an even integer whereas for the B-mode, n is a series of odd integers. In other words, the A-type generator has zero internal impedance whilst the B-type generator has an internal impedance numerically equal to infinity. Using a Lecher system with two bridges of suitable form and spacing it is actually possible to generate both A-mode and B-mode simultaneously, an unusual phenomenon of some theoretical interest.

The work described in this paper was carried out in the Queen's University of Belfast in 1938-39.

A CORRECTION

In the October Editorial on " Ohm and his Law " at the foot of the first column on p. 285, the date 1929 should, of course, be 1829.

G.W.O.H.

VALVE OSCILLATOR*

Operation and Properties

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

(Post Office Research Station)

1. Introduction

It was recognized as long ago as the early 1920's that the dependence of the frequency of oscillation of a valve oscillator on the non-linear properties of the maintaining circuit was a problem requiring elucidation. It has for that reason been the subject of several investigations[1], theoretical and practical, references to which are made here in order to put the present analysis in correct perspective.

The methods of tackling the problem have depended to some extent on the most favoured contemporary types of maintaining circuit. In most analyses an LC oscillator has been regarded as a combination of a parallel resonant circuit and a negative resistor, the prime function of the latter being to neutralize the losses occurring in the former. Because incomplete neutralization results in no oscillation, and exact neutralization had no practical significance until recently, over-neutralization was the only condition considered. The oscillations generated would be expected to have infinite amplitude if the negative resistor obeyed Ohm's Law. But in practice the current (i) —voltage (v) relationship of all negative resistors eventually departs from linearity in such a manner as to impose a limitation on the amplitude. While it is not difficult to appreciate that the non-linearity causes the waveform of the signal generated to be other than sinusoidal, it is less obvious that the frequency of the oscillation will differ from that calculated from a knowledge of the constants of the resonant circuit and of the susceptance of the negative resistor.

Appleton and Greaves[2], adopting this picture of an oscillator, assumed that the non-linear relationship could be expressed by a power series, a relationship which, even when limited to a few terms, is a fair approximation to the characteristics of the dynatron and some other negative resistors. The amplitude, the fundamental frequency and the harmonic content of the signal generated were obtained by solving the equation

$$\frac{d^2 v}{dt^2} + \left\{\frac{R}{L} + \frac{\phi'(v)}{C}\right\} \frac{dv}{dt} + \frac{v}{CL} = 0, \text{ where}$$

$\phi'(v)$ is derived from the power series. The results showed that the frequency depended on the coefficients of v, v^2 . . . etc, in the power series as well as on C and L, the constants of the resonant circuit.

Ten years later Moullin[3] considered the effect of the curvature of the characteristic of the dynatron on the frequency of an oscillator of which the dynatron forms the negative resistor. He adopted a similar power series relationship and showed that the fundamental frequency is affected by the phase and magnitude of the harmonic components contained in the signal generated. He deduced that the fundamental frequency ($\omega/2\pi$) would be given by

$$\omega^2 = \omega_0^2 \left[1 - F^2\left\{1 + \sum_2^{\infty} \left(\frac{I_n}{I_1}\right)^2\right\}\right]$$

where F is the power factor of the resonant circuit, I_n is the amplitude of the current of the nth harmonic which flows into this circuit, and $\frac{\omega_0}{2\pi}$ the limiting frequency which obtains when $\sum_2^{\infty} \left(\frac{I_n}{I_1}\right)^2$ is made vanishingly small. Moullin was unable to confirm his relationship experimentally. Another effect —the change of interelectrode capacitance with change of operating conditions of the dynatron—undoubtedly predominated, but it is not clear from his paper that he made best use of the admittedly limited technique then available to reduce its relative importance. In an appendix to his paper he extended the work of Appleton and Greaves sufficiently to show that the results of his analysis, based so largely on physical arguments, were in agreement with those obtained by the earlier workers based on rigid mathematics.

Simultaneously Groszkowski[4] studied the general problem in a paper called "The

* MS accepted by the Editor, November 1946.

interdependence of frequency variation and harmonic content, and the problem of constant-frequency oscillators." He rejected the method of Appleton and Greaves on the grounds that it proves to be extremely laborious to apply, especially where negative resistors having complicated *i-v* relationships are concerned and that the results obtained are not easily interpreted for practical purposes. In its place he developed an analysis based on the fact that over one cycle of the fundamental frequency of oscillation the equation $\int idv = 0$ must hold. This relationship is equivalent to a statement that there exists in any self-maintaining oscillating circuit a balance of both "real" and "imaginary" power. The former is obtained when the energy dissipated in the resistance of the components of the resonant circuit is exactly provided by the maintaining circuit and the latter when the mean magnetic energy in the inductor of the resonant circuit equals the mean electric energy in the capacitor of the circuit. The second condition, involving "wattless" energy, must be satisfied even in the presence of harmonics, whose currents flow chiefly through the capacitor, thereby increasing the electric energy more than the magnetic.

Equilibrium is restored by the fundamental frequency readjusting itself to some value, lower than that obtaining in the absence of harmonics, at which the magnetic energy due to the fundamental frequency exceeds the corresponding electric energy by the requisite amount. Groszkowski's analysis avoided the necessity of initially specifying the law connecting i and v of the negative resistor and led, via mathematics simpler than that found necessary by Appleton and Greaves, to the result

$$\frac{\omega - \omega_0}{\omega_0} = -\tfrac{1}{2}\{3m_2^2 + 8m_3^2 + \ldots + (n^2 - 1)\,m_n^2 \ldots\}$$

where m_n is the ratio of the voltage of the nth harmonic, measured across the resonant circuit, to that of the fundamental. The results of Appleton and Greaves were shown to be in agreement with this relationship. Experimentally Groszkowski was more successful than Moullin; he obtained confirmation to a moderate degree of accuracy. Finally he went some way towards generalizing the problem for the triode oscillator with back coupling; e.g., the Hartley. A little later van der Pol[5], who had already made very important contributions to non-linear circuit theory, tackled the problem of this type of oscillator generally; he derived Groszkowski's relationship by starting from the fundamental differential equation.

Now Groszkowski's relationship can be applied to any oscillator. But for any particular one a knowledge or calculation of the harmonic content to be expected is necessary before any exact prediction of the frequency can be made; individual circuits therefore still require individual analyses, which will in general be complicated. Groszkowski's result is independent of the phase angles of the harmonic components, and might therefore seem to be at variance with the conclusions drawn by Moullin relating to these angles. But it must be remembered that Moullin was using a particular *i-v* law from which in turn (*a*) he calculated the phases of the voltages of the harmonics generated, (*b*) he deduced that these harmonics would affect the frequency of oscillation and (*c*) he noted that if the phases of the harmonics were changed by certain amounts the harmonics would cease to have any such influence. An additional conclusion should, however, be drawn from his work, namely that such changes of phase can be made to take place completely in his two-terminal network only if the amplitudes of these voltages are simultaneously reduced to zero.

2. The Circuit to be Analysed

The circuit to be considered in detail here is that suggested by Lynch and the author[6], who analysed qualitatively some aspects of its performance and claimed for it certain advantages which will be dealt with later. Fig. 1 gives the circuit in all necessary detail. The circuit can, for the purpose of analysis, be split in two ways; either by the broken line or by the dotted line.

For the first division the two sections may be classed as the resonant circuit and the negative resistor. Considered alone the latter has already received attention by Brunetti and Greenough[7] and others[8,9]. But its properties, so thoroughly investigated there, and found to be so superior to those of many other negative resistors, have been only those manifest over the linear range of operation; whereas some aspects of its performance outside this range need to be considered when it forms part of an oscillator. This division, though corresponding to that used by

Appleton and Greaves, Moullin and Groszkowski, is not pursued.

For the second division the classifications are discriminating circuit and maintaining circuit or amplifier A. Both parts are three-terminal networks, and their properties are considered in the following sections.

2.1 *The Discriminating Circuit*

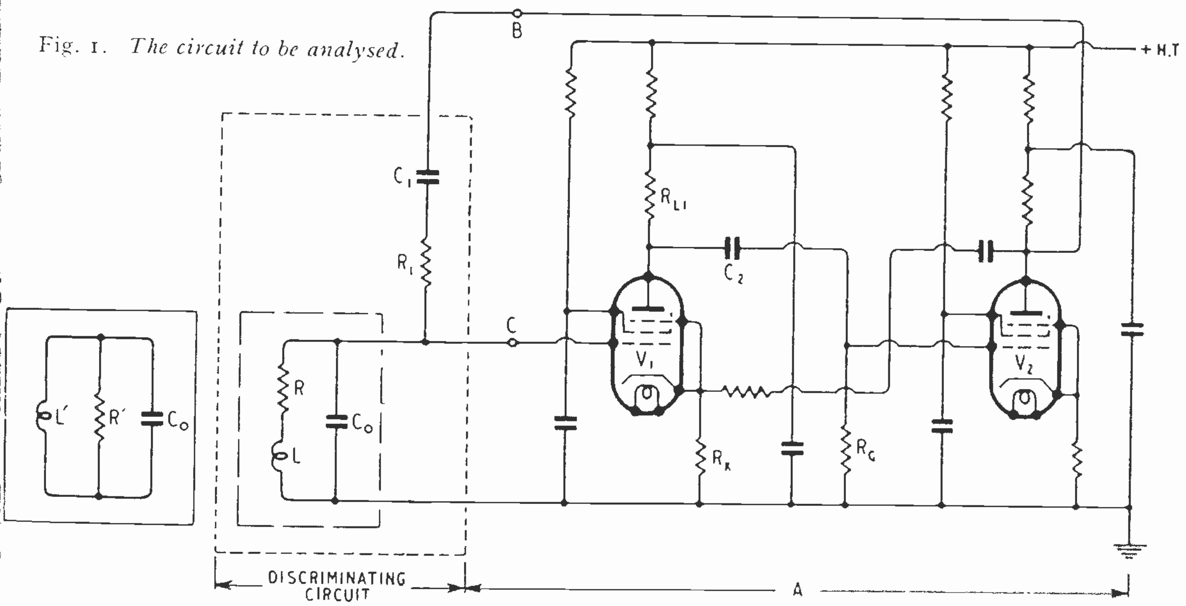
The discriminating circuit consists of a blocking capacitor C_1 of large value, a resistor R_1 and the resonant circuit here represented as a capacitor C_0 in parallel with an inductor of series inductance L and series resistance R; the magnification, Q, of the inductor is therefore $\omega L/R$. The equivalent resonant circuit, at the frequency $\omega/2\pi$, shown in the full line square of Fig. 1, where $L' = L(1 + 1/Q^2)$ and $R' = R(1 + Q^2)$, is in general preferred in this article. The parallel resonant frequency of the inductor and capacitor is $\frac{\omega_0}{2\pi} = \frac{1}{2\pi\sqrt{L'C_0}}$ and, at this frequency, the ratio $\frac{R' + R_1}{R'}$ will be called z'.

the frequency concerned, $\omega/2\pi$, is in the range 10 c/s–1 Mc/s, straightforward designs will meet these requirements sufficiently well.

2.22 *Performance Outside the Linear Range of Operation.*

As the level of the input signal supplied to the amplifier increases, the ratio of output voltage V_0 to input voltage V_1 at first remains n_0 to a high degree of accuracy. With the assumptions, justified by normal practice, that the signal level at the control grid G_1 of V_2 is several times that between the control grid G_1 and the cathode K of V_1, that the anode voltage and maximum possible anode excursion of V_2 are such that "bottoming" does not occur for negative values of V_{G1} of this valve, and that V_1 and V_2 have approximately similar characteristics, the first sign that the limit of the linear region has been reached will appear in one of two ways. Either (*a*) the signal applied to the control grid of V_2 will, at its maximum negative value, drive this grid to its cut-off point, or (*b*) it will, at its maximum positive value, cause this grid to draw current, i_G. With normal operating conditions for V_2, (*a*) and (*b*) are about equally likely to occur first. When (*a*) occurs first any further increase of V_1, here assumed to be sinusoidal in waveform, causes the output signal to become distorted in the manner shown in Fig. 2(*b*). When (*b*) occurs first this further increase of V_1 does not cause the corresponding section of the waveform of

Fig. 1. *The circuit to be analysed.*



2.2 *The Maintaining Circuit or Amplifier.*

2.21 *Linear Operation*

In the following analysis, whenever low levels of input signal are concerned, it will be assumed that the amplifier (*a*) has a high overall voltage gain, n_0, despite the degeneration, which is preferably heavy, (*b*) introduces negligibly small phase shift and (*c*) has a low value of output impedance and a high value of input impedance. Where the output voltage to show appreciable distortion provided the input impedance of V_2 during the period of the drawing of grid current is much greater than R_{L1}. But a secondary effect of importance takes place; an additional charge accumulates on the plates of C_2 biasing the control grid of V_2 in the negative direction by a voltage V_G, which is given approximately by the relationship

$$\int_0^{2\pi/\omega} i_G \, . \, dt = \frac{V_G}{R_G} \cdot \frac{2\pi}{\omega}$$

provided $\omega C_2 R_G \gg 1$. This change of the operating conditions of V_2 makes effect (*a*) now much more probable, and it occurs with further increase of V_1; moreover because (*a*) and (*b*) are about equally likely to occur first, only a small excess of the critical value is necessary to ensure that effect (*a*) comes into operation. The degeneration which is applied to the amplifier ensures that the waveform of the anode current, when overloading occurs, approximates to that which would be expected if the anode current versus control-grid voltage characteristic were strictly linear down to an abrupt cut-off. It ensures also that the distortion of the signal at the other extremity is small because it much reduces the loss of overall gain which results from the shunting of the nominal load of V_1 by the input impedance of V_2, whose value becomes increasingly lower and therefore more comparable with R_{L1} as V_1 is so much increased that i_G attains large values (e.g., 10–100 μA). The waveform can thus be accurately represented as a sine wave with one extremity, that shown by the dotted section, removed (see Fig. 2, paying no regard here to the relative amplitudes, for progressive stages of overloading). Analysis shows that this waveform has the following Fourier coefficients, the A's referring to the sine terms and the B's to the cosine terms;

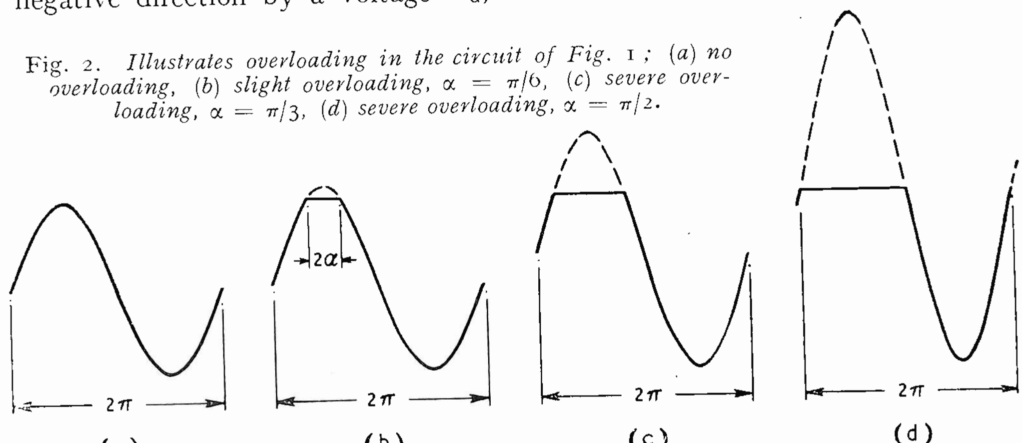


Fig. 2. *Illustrates overloading in the circuit of Fig. 1; (a) no overloading, (b) slight overloading, $\alpha = \pi/6$, (c) severe overloading, $\alpha = \pi/3$, (d) severe overloading, $\alpha = \pi/2$.*

$$B_0 = \frac{E}{\pi}\left\{\alpha \cos \alpha - \sin \alpha\right\}$$

$$A_1 = \frac{E}{\pi}\left\{\pi - \alpha + \sin\alpha\cos\alpha\right\}, \quad B_1 = 0$$

and for higher terms

$$A_n = \frac{E(1 - \cos n\pi)}{2\pi n(n^2 - 1)}\left\{(n+1)\sin(n-1)\left(\frac{\pi}{2} - \alpha\right) + (n-1)\sin(n+1)\left(\frac{\pi}{2} - \alpha\right)\right\} \quad (1)$$

which = 0 when n is even

$$B_n = -\frac{E(1 + \cos n\pi)}{\pi(n^2 - 1)}\left[(1 - \cos n\pi) - \frac{1}{2n}\left\{(n+1)\cos(n-1)\left(\frac{\pi}{2} - \alpha\right) + (n-1)\cos(n+1)\left(\frac{\pi}{2} - \alpha\right)\right\}\right]$$

which = 0 when n is odd.

E is the amplitude of the parent sine wave and α is the angle shown in Fig. 2.

A simple analysis of the complete oscillator can be based on the coefficient A_1. If a sinusoidal signal of frequency $\omega_0/2\pi$ is attenuated z times by the discriminating circuit (from B to C) and z is less than n_0, oscillations of frequency $\omega_0/2\pi$ will build up; distortion of the output waveform will occur and increase until α has the value which satisfies the relationship

$$z = \frac{n_0}{\pi}(\pi - \alpha + \sin\alpha\cos\alpha) \quad \ldots \quad (2)$$

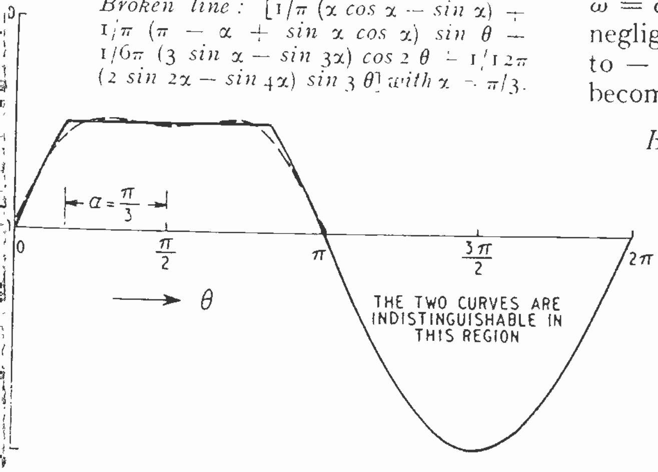
when equilibrium will be reached; clearly here $z = z'$. The inadequacy of this analysis will now be shown.

3. Derivation of Oscillator Characteristics

3.1 *Frequency of Oscillation.*

The derivation of the frequency, amplitude and harmonic content of the oscillation is here carried out with the complete circuit regarded as a loop, earth being one of the two terminals at every stage; all a.c. potentials will be expressed with respect to earth. The method resembles that used by Nyquist[10] when he considered the problem of the stability of degenerated amplifiers.

Fig. 3. *Full line:* $\sin\theta$ *for* $0<\theta<\pi/6$ *and* $5\pi/6<\theta<2\pi$, 0.5 *for* $\pi/6<\theta<5\pi/6$. *Broken line:* $[1/\pi(\alpha\cos\alpha - \sin\alpha) + 1/\pi(\pi - \alpha + \sin\alpha\cos\alpha)\sin\theta + 1/6\pi(3\sin\alpha - \sin 3\alpha)\cos 2\theta + 1/12\pi(2\sin 2\alpha - \sin 4\alpha)\sin 3\theta]$ *with* $\alpha = \pi/3$.



Suppose the loop is left uncompleted at one point (e.g., B Fig. 1), thereby preventing oscillations from occurring. The steady state of oscillation can then be found, even without closing the break, in the following way. Terminate the right-hand side of the break with an impedance Z, equal to that measured across the other—the left-hand—side of the break (here known as the input of the broken loop), and across the left-hand side connect a signal generator of controllable fundamental frequency, waveform and amplitude and of low impedance. Then when a signal voltage is found which is reproduced across Z in all respects, it is that which would appear at that point were Z and the generator removed and the break closed.

As a first step towards finding this complex signal, that signal produced by the amplifier when overloaded by a large-valued sinusoidal input of frequency $\omega/2\pi$ will be assumed to be fed to the input of the break. With the origin of the time scale suitably chosen this signal can be written

$${}_1V_B = A_1 \sin\omega t + B_2\cos 2\omega t + A_3\sin 3\omega t,$$

where A_1, B_2 and A_3 have the values given by Equ. (1). The d.c. component and the terms involving $n\omega t$ for $n>3$ have been ignored. (Fig. 3 shows the effect of ignoring the terms above $3\,\omega t$ when there is severe overloading).

This signal gives rise to one, V_C, at C where

$$V_C = A_1'\sin(\omega t + \phi_1) + B_2'(\cos 2\omega t + \phi_2) + A_3'\sin(3\omega t + \phi_3).$$

If $|(\omega - \omega_0)/\omega_0| \ll 1$ and $R_1 \gg \omega LQ$, ϕ_1 is given by $\dfrac{\omega - \omega_0}{\omega_0} = -\dfrac{\phi_1}{2Q}$ and the ratio A_1'/A_1 differs from that which applies when $\omega = \omega_0$, namely $1/z'$, to an extent which is negligible here. ϕ_2 and ϕ_3 each approximate to $-\pi/2$, more and more closely as z' and Q become higher.

$$B_2' = \frac{2B_2}{3(z'-1)Q} \text{ and } A_3' = \frac{3A_3}{8(z'-1)Q}$$

Writing $B_2'/A_1' = C_2$ and $A_3'/A_1' = C_3$, V_C reduces to

$$A_1'\{\sin(\omega t + \phi_1) + C_2\sin 2\omega t - C_3\cos 3\omega t\}.$$

V_C is in turn amplified by A, the resultant signal n_0V_C being limited if, during the positive half-cycle of the fundamental frequency, it exceeds a value, say, $n_0A_1'\cos\alpha_1$. (This does not mean that limiting begins exactly at time $(\pi/2 - \alpha_1)/\omega$, because the presence of the harmonics nearly always modifies the time at which the total signal has the amplitude $+n_0A_1'\cos\alpha_1$; knowledge of the time difference is not necessary here).

The essential feature of this analysis lies in expressing fully the result of this limiting action for which there is no known Fourier expression. The action can, however, be reduced to a simple form of non-linearity, for dealing with which several methods have been proposed. Of these, that used by Cooper[11] deals adequately and yet in a simple way with the problem. In this method the positive half-wave rectification of a signal V, whose modulus must, however, never exceed π, is shown to produce a signal

$$\frac{V}{2} + \frac{2}{\pi} V \sum_{1}^{\infty} \frac{1}{m} \sin mV, \text{ where } m \text{ is odd only} \quad \ldots \quad (3)$$

The signal at the output of A, ${}_0V_B$, can be expressed as

$$n_0 A_1' [\cos \alpha_1 - \{\cos \alpha_1 - \sin (\omega t + \phi_1) - C_2 \sin 2\omega t + C_3 \cos 3\omega t\}]$$

subject to the condition that

$$\{\cos \alpha_1 - \sin (\omega t + \phi_1) - C_2 \sin 2\omega t + C_3 \cos 3\omega t\}$$

be taken as zero whenever its value is negative. Now $|\cos \alpha_1 - \sin(\omega t + \phi_1)|$ can never exceed 2 and C_2 and C_3 are both $\ll 1$. Hence an expression for the signal obtained by the perfect half-wave rectification of $\{\cos \alpha_1 - \sin (\omega t + \phi) - C_2 \sin 2\omega t + C_3 \cos 3\omega t\}$ can be obtained by substituting this quantity for V in (3). Moreover because, from arguments based on physical grounds, the products of the half-wave rectification of kV are k times those of the half-wave rectification of V, the signal ${}_0V_B$ can be written

$${}_0V_B = n_0 A_1' \left[\cos \alpha_1 - \left\{\frac{V}{2} + \frac{2}{\pi} V \sum_{1}^{\infty} \frac{1}{m} \sin mV\right\}\right] \text{ where } m \text{ is odd only.}$$

Ignoring the term $n_0 A_1' \cos \alpha_1$ here, since it is a d.c. component only,

$$-\frac{\pi}{2}\left(\frac{{}_0V_B}{n_0 A'_1} + \frac{V}{2}\right) = V \sum \frac{1}{m} \sin mV = VW, \text{ say.}$$

If it is remembered that the important terms in VW are those involving the circular functions of ωt, $2\omega t$ and $3\omega t$, and that C_2 and C_3 are small, W can be written as

$$\sum_{1}^{\infty} \left[\left\{\frac{x_m}{m} - y_m (C_2 \sin 2\omega t - C_3 \cos \omega t)\right\} \cos \{m \sin (\omega t + \phi_1)\} - \left\{x_m (C_2 \sin 2\omega t - C_3 \cos 3\omega t) + \frac{y_m}{m}\right\} \sin \{m \sin (\omega t + \phi_1)\}\right]$$

where $x_m = \sin (m \cos \alpha_1)$, $y_m = \cos (m \cos \alpha_1)$ and m is odd.

Hence $VW =$

$$\sum_{1}^{\infty} \left[\frac{x_m}{m}\left\{\cos \alpha_1 - \sin (\omega t + \phi_1) - C_2 \sin 2\omega t + C_3 \cos 3\omega t\right\} - y_m \cos \alpha_1 (C_2 \sin 2\omega t - C_3 \cos 3\omega t) + \frac{y_m C_2}{2}\left\{\cos (\omega t - \phi_1) - \cos (3\omega t + \phi_1)\right\} - \frac{y_m C_3}{2}\left\{\sin (4\omega t + \phi_1) - \sin (2\omega t - \phi_1)\right\}\right]\left[J_0(m) + 2J_2(m) \cos 2(\omega t + \phi_1) + 2J_4(m) \,.\, \cos 4(\omega t + \phi_1) \ldots\right]$$

$$- \sum_{1}^{\infty} \left[x_m \cos \alpha_1 (C_2 \sin 2\omega t - C_3 \cos 3\omega t) - \frac{x_m C_2}{2}\left\{\cos (\omega t - \phi_1) - \cos (3\omega t + \phi_1)\right\} + \frac{x_m C_3}{2}\left\{\sin (4\omega t + \phi_1) - \sin (2\omega t - \phi_1)\right\} + \frac{y_m}{m}\left\{\cos \alpha_1 - \sin (\omega t + \phi_1) - C_2 \sin 2\omega t + C_3 \cos 3\omega t\right\}\right]\left[2J_1(m) \,.\, \sin (\omega t + \phi_1) + 2J_3(m) \,.\, \sin 3(\omega t + \phi_1) + 2J_5(m) \sin 5(\omega t + \phi_1) \ldots\right]$$

where $J_n(m)$ are Bessel functions of the first kind of order n.

$\dfrac{{}_0V_B'}{n_0 A_1}$ then reduces to the following important terms

$$\tfrac{1}{2} + \frac{2}{\pi}\left[\sum_{1}^{\infty}\left\{\frac{x_m}{m}\Big(J_0(m) - J_2(m)\Big) + 2\frac{y_m}{m} \cos \alpha_1 \,.\, J_1(m)\right\}\right] \sin (\omega t + \phi_1) \quad \ldots \quad (4),$$

terms in $\cos (\omega t \pm p\phi_1)$, p being an integer 1–4, which terms may be written with sufficient accuracy, because $\sin \phi_1$ is small, as

$$-\frac{2}{\pi}\left[\sum_1^\infty C_2\left\{\frac{y_m}{2}\Big(J_0(m)-J_4(m)\Big)-\Big(x_m\cos\alpha_1-\frac{y_m}{m}\Big)\Big(J_1(m)+J_3(m)\Big)\right\}\right.$$
$$\left.+C_3\left\{\Big(\frac{x_m}{m}+y_m\cos\alpha_1\Big)\Big(J_2(m)+J_4(m)\Big)+\frac{x_m}{2}\Big(J_1(m)-J_5(m)\Big)\right\}\right]\cos\omega t \quad .. \quad .. \quad (5)$$

$$-\frac{2}{\pi}\left[\sum_1^\infty\left\{\Big(2\frac{x_m}{m}\cos\alpha_1 . J_2(m)-\frac{y_m}{m}\Big(J_1(m)-J_3(m)\Big)\right\}\right]\cos(2\omega t+2\phi_1) \quad .. \quad .. \quad (6)$$

and

$$\frac{2}{\pi}\left[\sum_1^\infty\left\{\frac{x_m}{m}\Big(J_2(m)-J_4(m)\Big)+2\frac{y_m}{m}\cos\alpha_1 . J_3(m)\right\}\right]\sin(3\omega t+3\phi_1) \quad .. \quad .. \quad .. \quad (7)$$

The terms (4), (6) and (7) contain neither C_2 nor C_3 and are identical with those which would be obtained by overloading the amplifier with a sinusoidal signal of the type $\sin(\omega t+\phi_1)$ of such a magnitude that overloading would occur at the angle α_1. Hence it follows that $\frac{1}{\pi}\Big(\pi-\alpha_1+\sin\alpha_1 . \cos\alpha_1\Big)=\frac{1}{2}$

$$+\frac{2}{\pi}\sum_1^\infty\left\{\frac{x_m}{m}\Big(J_0(m)-J_2(m)\Big)+\frac{2y_m}{m}\cos\alpha_1 . J_1(m)\right\},$$

where m is odd only, the L.H.S. having been derived from the Fourier coefficient A_1; this identity can be derived otherwise (see Appendix).

It is now necessary to reconcile ${}_0V_B$ with ${}_1V_B$, and if, as a first step, the respective amplitudes of the terms in ωt are to be made equal, α_1 must equal α (the term (5) has no significant influence on the magnitude of the resultant term in ωt). The relationship (2) follows and

$$\frac{n_0A_1'}{\pi}(\pi-\alpha+\sin\alpha\cos\alpha)=A_1.$$

It follows that the amplitude of term (6) is B_2 and that of (7) is A_3; thus

$$B_2=-\frac{2n_0A_1'}{\pi}\left[\sum_1^\infty\left\{2\frac{x_m}{m}\cos\alpha . J_2(m)-\frac{y_m}{m}\Big(J_1(m)-J_3(m)\Big)\right\}\right] \text{ and}$$

$$A_3=\frac{2n_0A_1'}{\pi}\left[\sum_1^\infty\left\{\frac{x_m}{m}\Big(J_2(m)-J_4(m)\Big)+\frac{2y_m}{m}\cos\alpha . J_3(m)\right\}\right] \text{ where } m \text{ is odd only.}$$

Term (5) was ignored as far as its effect on the amplitude of the net component in ωt was concerned. But it has an influence on the *phase* of this component of ${}_0V_B$ which can be written as $A_1\sin(\omega t+\phi_1-\theta)$ where, because θ is small,

$$\theta=\frac{2n_0A_1'}{\pi A_1}\left[\sum_1^\infty C_2\left\{\frac{y_m}{2}\Big(J_0(m)-J_4(m)\Big)-\Big(x_m\cos\alpha-\frac{y_m}{m}\Big)\Big(J_1(m)+J_3(m)\Big)\right\}+\right.$$
$$\left.C_3\left\{\Big(\frac{x_m}{m}+y_m\cos\alpha\Big)\Big(J_2(m)+J_4(m)\Big)+\frac{x_m}{2}\Big(J_1(m)-J_5(m)\Big)\right\}\right] \text{where } m \text{ is odd only.}$$

The coefficient of C_2 in this term is

$$\frac{2n_0A_1'}{\pi A_1}\sum_1^\infty\left\{\frac{y_m}{2}\Big(J_0(m)-J_4(m)\Big)-\Big(x_m\cos\alpha-\frac{y_m}{m}\Big)\Big(J_1(m)+J_3(m)\Big)\right\} \text{ which, remembering}$$

that $J_n(m)+J_{n+2}(m)=\dfrac{2(n+1)}{m}J_{n+1}(m)$, reduces to

$$\frac{4n_0A_1'}{\pi A_1}\sum_1^\infty\left\{\frac{y_m}{m}\Big(J_1(m)-J_3(m)\Big)-\frac{2x_m}{m}\cos\alpha . J_2(m)\right\}=\frac{2B_2}{A_1}.$$

Similarly the coefficient of C_3, $\dfrac{2n_0A_1'}{\pi A_1}\left[\sum_1^\infty\left\{\Big(\frac{x_m}{m}+y_m\cos\alpha\Big)\Big(J_2(m)+J_4(m)\Big)+\frac{x_m}{2}\Big(J_1(m)-J_5(m)\Big)\right\}\right]$ can be shown to be $\dfrac{3A_3}{A_1}$.

Hence $\theta=\dfrac{2B_2C_2+3A_3C_3}{A_1}$. If the phases of the fundamental components of ${}_0V_B$ and ${}_1V_B$

are to be identical, $\phi_1 = \theta$. This relationship immediately determines ω; for

$$\frac{\omega - \omega_0}{\omega_0} = -\frac{1}{2Q}\left(\frac{2B_2C_2 + 3A_3C_3}{A_1}\right).$$

Because $\dfrac{2B_2}{QA_1} = 3\dfrac{(z'-1)}{z'}\left(\dfrac{2B_2z'}{3(z'-1)QA_1}\right)$,

$$\frac{3A_3}{QA_1} = \frac{8(z'-1)}{z'}\left(\frac{3A_3z'}{8(z'-1)QA_1}\right)$$

and $(z'-1)/z'$ may be taken as unity,†

$$\frac{\omega - \omega_0}{\omega_0} = -\tfrac{1}{2}(3C_2^2 + 8C_3^2).$$

Moreover it is not difficult to show that if additional terms are included in the expression for ${}_1V_B$, the nth harmonic contributes a term $-\frac{1}{2}(n^2-1)C_n^2$ to $(\omega-\omega_0)/\omega_0$. The more general result is therefore

$$\frac{\omega - \omega_0}{\omega_0} = -\tfrac{1}{2}[3C_2 + 8C_3^2 + \ldots\ldots + (n^2-1)C_n^2 \ldots];$$

this is Groszkowski's relationship.

The phases of the harmonics present in ${}_0V_B$ and ${}_1V_B$ remain to be compared. The small discrepancy which is found is due mainly to the exclusion of certain small-valued terms from expressions (6) and (7) and to harmonics above the third having been ignored. No further consideration will be given to this less important feature.

3.2 *Other Characteristics*

Other characteristics of importance to a designer of an oscillator of this type are easily calculable from the analysis of Section 3.1. Assuming that n_0, L, Q and ω_0 are known, as is normal, Fig. 4 offers the designer most of these other properties in terms of n_0/z, which can be calculated from these primary quantities and R_1, a quantity at the designer's disposal. For this figure α [from Equ. (2)], B_2/A_1, A_3/A_1 and $\dfrac{\omega-\omega_0}{\omega_0}$ have been determined in turn. But $(\omega-\omega_0)/\omega_0$ itself is rarely of importance because (a) only a very exact knowledge of L, Q, C_0, the stray capacitances associated with the resonant circuit and with the leads to the amplifier, etc., will reduce the error in calculating ω_0 to less than $(\omega-\omega_0)$ and (b) some control of ω_0, if only in the form of a trimming capacitor shunted across C_0, is usually fitted. Whereas however the error in calculating ω_0 is not a function either of the power supplies (provided the inductor L is not iron-cored) or of any changes in the emissivity of the cathodes of V_1 and V_2 (except in each case so far as the input capacitance of A is

† If conditions are such that $(z'-1)/z'$ is thought to be significantly different from unity, allowance must then be made for ϕ_1, under these conditions, being slightly different from $-2\left(\frac{\omega-\omega_0}{\omega_0}\right)$. The final result for $\left(\frac{\omega-\omega_0}{\omega_0}\right)$ is unaffected.

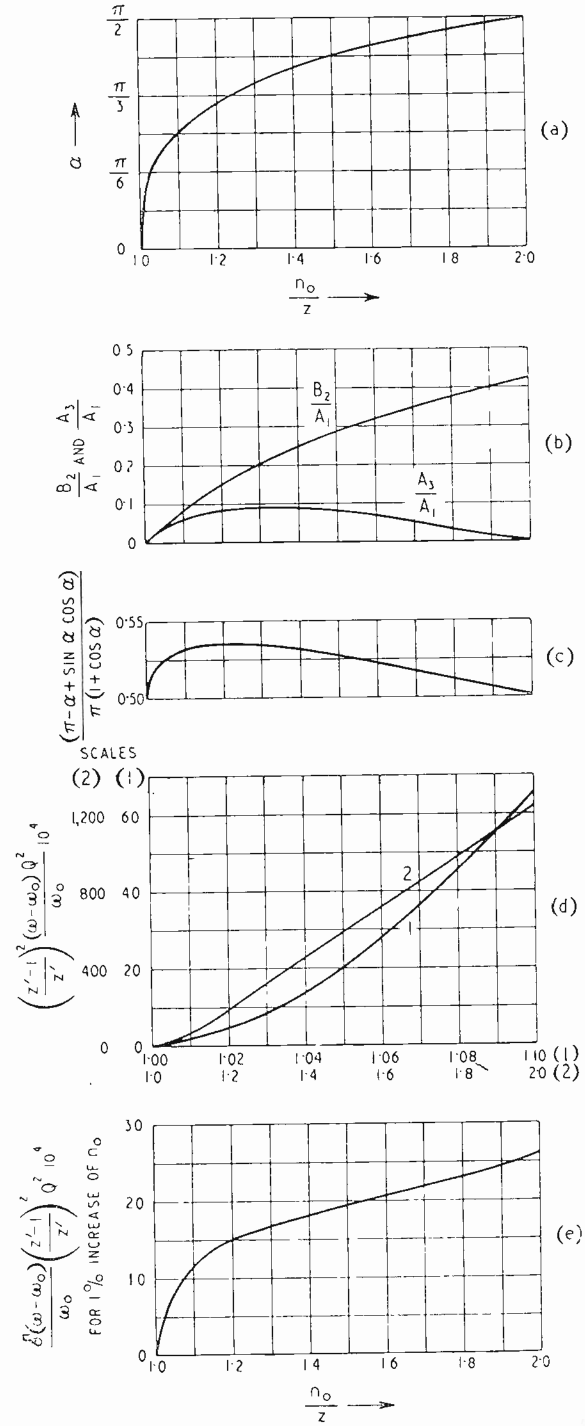


Fig. 4. *Design data.*

concerned), $(\omega - \omega_0)/\omega_0$, being a function of n_0, clearly is. The fractional change of n_0 accompanying any given fractional change of supply voltage will be a function of certain properties of the valves and of the extent of degeneration of A. Elsewhere the author[9] has suggested the following relationship for the change of mutual conductance, g, of an r.f. pentode used with cathode bias (suitably bypassed by a large value capacitor) and without a "dropping" resistor in the screen-grid circuit :— $\frac{\delta g}{g} \leqslant 0.5\frac{\delta V_{G2}}{V_{G2}} + 0.3\frac{\delta V_H}{V_H}$, V_{G2} and V_H being the screen-grid and heater voltages respectively. It is assumed here that any change in V_H persists for a time long compared with the thermal time constant of the cathode. If the screen grid receives its voltage from the h.t. supply, V_B, via a resistor, as is common, $\frac{\delta V_{G2}}{V_{G2}} < \frac{\delta V_B}{V_B}$. Now the amplifier A uses two such valves, in the cathode circuit of each of which the lack of bypassing capacitors produces about 6-db local feedback for each stage, and its overall gain has been degenerated n_1 times to n_0. Hence it can be shown that $\frac{\delta n_0}{n_0} < \frac{1}{n_1}\left(0.5\frac{\delta V_B}{V_B} + 0.3\frac{\delta V_H}{V_H}\right)$. If both V_B and V_H are derived rom a common supply, V_S, and $\frac{\delta V_B}{V_B} = \frac{\delta V_H}{V_H} = \frac{\delta V_S}{V_S}$, $\frac{\delta n_0}{n_0} < \frac{0.8}{n_1} \cdot \frac{\delta V_S}{V_S}$; i.e., a change of $\frac{n_1}{0.8}$ % of V_S causes less than a 1% change of n_0. The curve (*e*) has therefore been added to Fig. 4. It shows the changes of $\frac{\omega - \omega_0}{\omega_0}$, which are those of $\frac{\omega}{\omega_0}$, resulting from a 1% change of n_0. If $n_1 = 8$, $Q = 100$, $\frac{\rho}{z} = 1.2$ and $z (= z')$ is large a 1% change of V_S causes $< 1.5 \cdot 10^{-8}$ parts change in ω/ω_0, which represents good stability.

Little of a definite nature can be said of the short-period irregularities in cathode emission of modern valves except that they rarely result in changes of g greater than those accompanying a 2% change of heater voltage.

The changes of interelectrode capacitances affect ω_0 and hence ω; in practice the input capacitance, C_A, of A is, in this respect, of far greater importance than the output capacitance. The important components of C_A are, that due to the dynamic capacitance, C_{g1-k}, between the control grid and cathode of V_1; that between the control grid and the screen grid, C_{g1-g2}, of V_1; and the capacirance, C_s, between this control grid and the heater and metallizing of V_1. C_{g1-k} is a function of cathode current[12]; hence it is a function of the supply voltage. For such valves as the SP41, EF50 and EF36 used as V_1 in Fig. 1 it would be safe to assume that a 10% change of V_S causes no more than a small fraction of 1pF change in the value of C_{g1-k}. But C_{g1-k} is clearly within the overall feedback path, and any change in it will appear appropriately reduced at the input of A. C_{g1-g2} is not so included, though by a simple modification of the circuit of V_1 it can be made so; it is however much less dependent on V_S than is C_{g1-k}. V_S has no effect on C_s other than that caused by change of the temperature and hence of the linear dimensions of the various grids, etc.

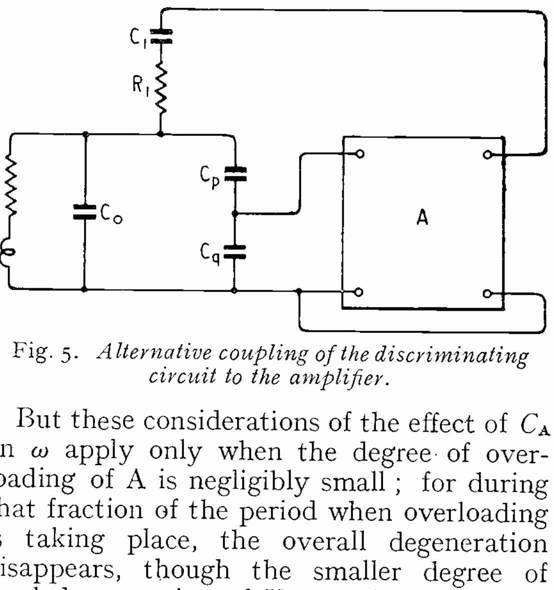


Fig. 5. *Alternative coupling of the discriminating circuit to the amplifier.*

But these considerations of the effect of C_A on ω apply only when the degree of overloading of A is negligibly small; for during that fraction of the period when overloading is taking place, the overall degeneration disappears, though the smaller degree of local degeneration of V_1 remains. If C_A is included in C_0, this larger capacitance clearly has two values, one during that part of the cycle when the main degeneration is operative and a second, greater, value, when it is not. However, there are methods of reducing the contribution which C_A makes to C_0 which ensure also that changes in this contribution occurring when the extent of overloading changes, as a result say of variations of the supply voltage, are made very small. The resonant circuit can be coupled to the input of A by means of a capacitive potential divider (C_p, C_q), attenuating all signals $n_c = \dfrac{C_p}{C_p + C_q}$ times, as shown in Fig. 5, C_0 being suitably reduced to maintain ω_0 unchanged. R_1 must be re-adjusted so that $\dfrac{R_1 + \omega_0 L'Q}{\omega_0 L'Q} = z' = \dfrac{z}{n_c}$. The influence of changes of C_A on the value of ω is then reduced n_c^2 times. Because a grid leak resistor for V_1 must be shunted across C_q, it may be necessary that C_p should be shunted by a resistor $(n_c - 1)$ times as great in order that this potential divider should introduce no phase shift. In practice, however, the phase shift resulting from the omission of this second resistor is usually so small that, although admittedly causing a change (usually very small) of ω, the effect on $\dfrac{\delta\omega}{\omega_0} \cdot \dfrac{V_S}{\delta V_S}$, the more important quantity for most purposes, is negligible. A resistance potential divider can sometimes be used in place of C_p and C_q; it makes a much smaller contribution to the tuning capacitance but degrades the Q of the resonant circuit. If either modification is made, the distinction between z and z' must be observed.

No calculation of the absolute magnitude of the signal at any point in the loop was necessary in the analysis of Section 3.1. But the designer of an oscillator may need information on this point. It can be obtained as follows. The excursion of the control grid of V_2 is from cut off or beyond to the onset of grid current, i_G; the anode current, therefore, varies from zero to the value, i_0, which it has at the onset‡ of i_G for the particular value of V_{G2}. From the appropriate expression for the output waveform, $E \sin \omega t$ limited at one extremity, it follows that $E + E \cos \alpha = i_0 R_{L2}$ where R_{L2} is the net anode load of V_2. Hence $E = i_0 R_{L2}/(1 + \cos\alpha)$ and $A_1 = \dfrac{i_0 R_{L2}(\pi - \alpha + \sin\alpha\cos\alpha)}{\pi(1 + \cos\alpha)}$. The signal which should be used, that at the control grid of V_1, has an amplitude A_1/z. Fig. 4 includes a curve of $\dfrac{(\pi - \alpha + \sin\alpha\cos\alpha)}{\pi(1 + \cos\alpha)}$ against $\dfrac{n_0}{z}$.

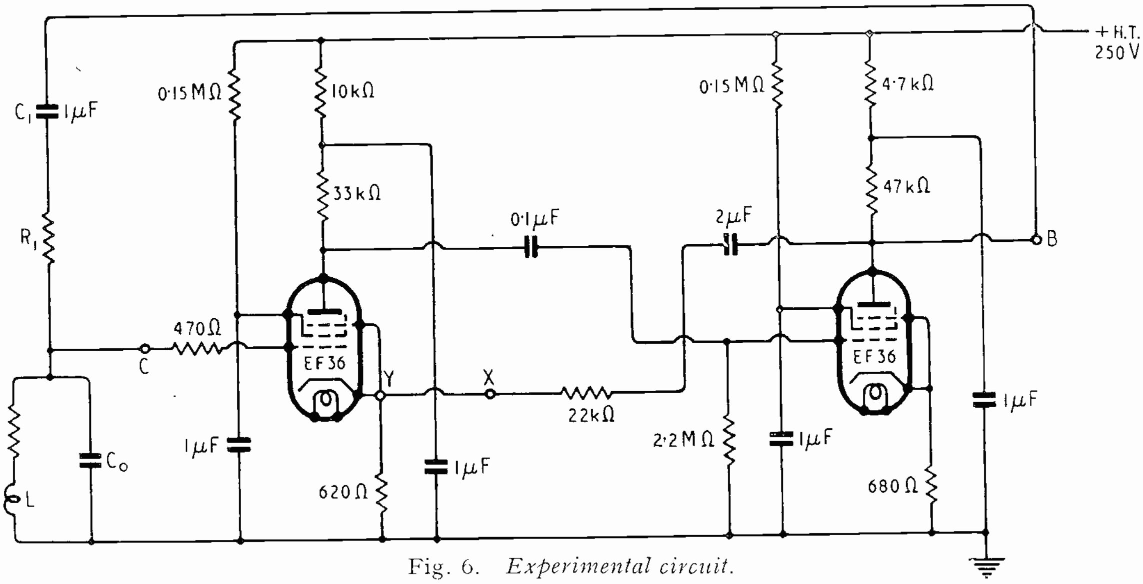


Fig. 6. *Experimental circuit.*

4. Experimental Confirmation

Confirmation of the results given by the preceding analysis was desirable. Many data could have been taken from the performance of several oscillators which had been constructed during the past six years using this circuit; but some desired data would have been missing or in unsuitable form. It was thought better therefore to concentrate on one new unit.

The circuit shown in Fig. 6 was set up. With X removed from Y and connected to earth the voltage gain of the amplifier from C to B, over the frequency range 1 — 10 kc/s,

‡ Because the control grid current increases very rapidly with small changes in the positive direction of the potential of this grid once the critical potential has been reached, the influence on i_0 of these small changes is negligible, and i_0 is assumed independent of $\dfrac{n_0}{z}$; e.g., in Fig. 2.

was 255; with the connection as shown (the condition to be assumed in all that follows) the gain was 29.8 ($= n_0$). The overall feedback was thus 8.5 times. The amplifier introduced negligible phase shift. L was an air-core inductor having a series inductance of 26.2 mH; its Q was artificially reduced to 10.0 ± 0.1 at the relevant frequency in order that $\frac{\omega - \omega_0}{\omega_0}$ should be the more easily observable. R_1 was controllable; hence z was calculable.

The measuring instruments used had input impedances sufficiently high to ensure that their connection to any point of the oscillator had negligible influence on the results obtained. The waveform of the signal at B is shown in Fig. 7. A condition of moderate overloading ($R_1 = 107$ kΩ, $n_0/z = 1.06$, $\alpha \approx \pi/6$) yielded (*a*), and one of severe overloading ($R_1 = 56.3$ kΩ, $n_0/z \approx 2$, $\alpha \approx \pi/2$) gave (*b*). The shape of (*a*) shows no measurable deviation from the waveform expected from the description, given in Section 2.22, of the mechanism of overloading; that of (*b*) shows a slight deviation from the constant limiting expected during the relevant half cycle and shows just perceptible distortion at the other extremity of the signal. The measurements of α, harmonic content at B and frequency of oscillation made for five values of R_1 are given in Table 1 together with values deduced, for the appropriate values of n_0/z, from Fig. 4.

thus 13.0 would read 13.3 and 2.6 would read 2.7. Agreement between the measured and calculated sets of values in Table 1 is good.

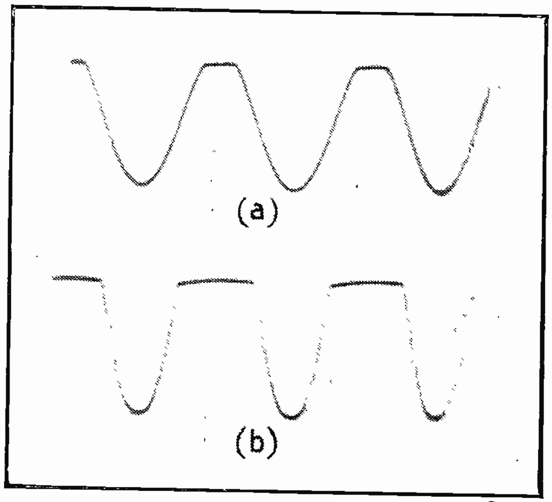


Fig. 7. *Waveforms obtained at the output of the drive circuit.*

The measured magnitude of the signal occurring at the output of the driving amplifier, when $R_1 = 56.3$ kΩ ($\alpha \approx \pi/2$) corresponded to an overall change of anode current of V_2 of 7.0 mA. Static characteristics of the valve showed that an anode current of 7.0 mA occurred for a control grid to cathode potential, V_{g1-k}, of − 0.4 V for the relevant value of the screen voltage; grid current was ≈ 1μA for $V_{g1-k} =$ − 0.7 V and ≈ 10μA for − 0.4 V.

TABLE I

Measured								Calculated			
R_1 (kΩ)	z	n_0/z	α *	B_2/A_1	A_3/A_1	$\omega/2\pi$ (c/s)	$\frac{(\omega-\omega_0)}{\omega_0}.10^4$	α	B_2/A_1	A_3/A_1	$\frac{(\omega-\omega_0)}{\omega_0}.10^4$
4.6	29.7	1.00	0	<.005	0	$2404.5_0 \pm 0.0_3$	0	0	0	0	0
7.0	27.8	1.06	$\pi/6$	0.06	0.04	$2404.3_7 \pm 0.0_3$	0.5	37°	0.05_5	0.04	0.3
1.8	26.5	1.11	$\pi/4$	0.09	0.065	$2404.2_5 \pm 0.0_3$	1.0	46°	0.10	0.065	0.8
39.3	23.4	1.27	$\pi/3$	0.17	0.09	$2403.8_7 \pm 0.0_6$	2.6	62°	0.19	0.09	3.0
56.3	15.1	1.96	$\pi/2$	0.40	0.02	$2401.3_7 \pm 0.0_6$	13.0	89°	0.41	0.01	13.2

* Nominal value only.

Had C_1 been made infinitely large the values of $\omega/2\pi$ recorded would have been smaller by amounts varying from 0.07 ($R_1 = 114.6$) to 0.13 ($R_1 = 56.3$); the resulting changes to the measured values of $\frac{\omega - \omega_0}{\omega_0} . 10^4$ are hardly of any significance;

Measurements of $\frac{\delta\omega}{\omega_0} \Big/ \frac{\delta V_s}{V_s}$ were not possible; $\delta\omega$ was too small to be measurable with the equipment used for values of $\left|\frac{\delta V_s}{V_s}\right|$ up to 0.25 and little interest would attach to any measurements for which $\left|\frac{\delta V_s}{V_s}\right| > 0.25$.

A capacitor C_3, placed between the control grid and cathode of V_1 affected the frequency to the extent shown in Table 2. The calculated values also given in this table were obtained as follows. For $\alpha \approx 0$ allowance was made for the overall degeneration of 8.5 times. For $\alpha = \pi/2$ allowance was made for the feedback effective in reducing the influence of C_{g1-k} on the input capacitance of A during the period of each cycle when V_2 overloaded—the local feedback for V_1—being only 1/4.5 that effective elsewhere. Because when $\alpha = \pi/2$ overloading took place for one-half of each cycle, the mean value of input capacitance was therefore $(1 + 4.5)/2$ times that when $\alpha = 0$.

There is good agreement between the measured and calculated changes of frequency.

necessary to give that relationship practical significance. Recourse to measurements of harmonic content and change of such content with change of supply voltage are unnecessary.

The practical merits of this oscillator can now be briefly discussed. Only those properties of the valves used which are normally specified are of importance here; they do not involve the exact law of the curvature of the $I_A - V_{G1}$ characteristic, secondary emission, suppressor-grid characteristics or interelectrode capacitances (except in a secondary manner). Indeed it is for this reason that an estimation was possible of the behaviour to be expected from the oscillator when a small percentage change is made to the supply voltage. Even van der Pol[5], in his analysis of the regenerative triode oscillator, made no attempt to predict this behaviour; yet it is of much interest to

TABLE II

Condition	$0<\alpha<5°$		$\alpha = \pi/2$	
C_3	1,000 pF	10,000 pF	1,000 pF	10,000 pF
$\frac{\delta\omega}{\omega_0}$ measured	$-3.6 \cdot 10^{-4}$	$-3.7 \cdot 10^{-3}$	$-8.9 \cdot 10^{-4}$	$-8.5 \cdot 10^{-3}$
$\frac{\delta\omega}{\omega_0}$ calculated	$-3.5 \cdot 10^{-4}$	$-3.5 \cdot 10^{-3}$	$-9.5 \cdot 10^{-4}$	$-9.5 \cdot 10^{-3}$

5. Discussion

The present analysis, based on physical arguments derived from loop considerations, differs widely from earlier full analyses of oscillator circuits. The main feature is the calculation of the phase change introduced by the amplifier forming the driving circuit when both the input signal contains harmonic components and limiting occurs. This has some novelty in that although calculations of the output products of circuits exhibiting non-linearity when fed with non-sinusoidal signals are common, they usually deal only with the amplitudes of the intermodulation products.

Amongst the results obtained one, of much importance, is consistent with Groszkowski's general relationship connecting the frequency of oscillation and harmonic content. But the analysis is no mere substitute for Groszkowski's in respect of this particular oscillator. It provides, in addition, for the type of oscillator discussed the data not deducible from Groszkowski's relationship

the designer requiring high stability of frequency. There is great flexibility in the driving circuit; it is easily adapted for circuits with extreme values of L/C, and for frequencies up to several Mc/s and down to a few c/s. The resonant circuit is a simple type; mutual inductance is absent and the reactive component introduced by the driving circuit is easily made much smaller than is possible with some other oscillators. The harmonic content of the signal at C will normally be $<0.3\%$ if $Q \geqslant 50$, so that a buffer amplifier connected to receive some or all of the signal at this point will then provide anout put signal whose waveform will be substantially sinusoidal.

Pentodes are specified in preference to triodes for the amplifier A; the more so for oscillators designed for frequencies above about 10 kc/s. But the analysis would follow much the same lines even if triodes were substituted.

For fixed frequency oscillators $(n_0/z - 1)$ should be made small (e.g., $\leqslant 0.05$) because frequency stability and harmonic content mprove as $n_0/z \to 1$. But the risk of oscillations easing, should n_0 decrease slightly, accompanies a very close approach to the condition $_0/z = 1$. A more important use of the LC scillator is as a variable frequency oscillator; n which C or, in the case of multi-range nits, both C and L can be controlled. Because it is highly improbable that, with the imple resonating circuit, R' will remain onstant as C is varied, it is most desirable hat the properties of the oscillator should ot suffer unduly from the lack of a control f the driving circuit which maintains the scillating condition close to the critical ate (corresponding here to $(n_0/z - 1) \to 0$). ut designers rarely find it easy to include his control in the way usually preferred by e user, namely coupled to the control of equency.

With the present oscillator the increase of $\frac{\omega}{0}$ per 1% change of V_s, which quantity ll be denoted Δ, from say $n_0/z = 1.1$ to $/z = 2.0$ is 2.5 times if Q is assumed constant. his may be tolerable for most purposes, rticularly because the absolute values of Δ n normally be made very small; any ntrol of z or n_0 aimed at maintaining n_0/z nstant at, say, 1.1 is therefore unnecessary. it some change of A_1' must be expected er the range. Even if R' remains subntially constant—or the resonant circuit elaborated deliberately[13] with the view maintaining the equivalent R' constant—er the frequency range controlled by the riable capacitor C, the important properties l vary over the range, despite the constancy n_0/z, because Q must then vary roughly $1/\omega_0$; but once again the properties may ll be satisfactory.

At first sight there may seem considerable emblance between the present oscillator l the Franklin[14] type (see Fig. 8), in that wo-valve unit is used, the coupling is from anode of the second valve to the grid the first via high impedance(s) and the onant circuit is of the simple LC type. t analysis of the Franklin circuit involves ures which are foreign to or irrelevant he analysis of Sections 3.1 and 3.2.

or consider the Franklin oscillator to be the condition of just maintaining oscillans (i.e., the harmonic content small), and r the phases of all signals to that of the age between the control grid of V_1 and h, neglecting multiples of 2π. Now it can be assumed, as Ladner and Stoner[15] state, that the phase change introduced by V_1 is the conventional π. The phase of the current flowing into the resonant circuit will therefore lead the voltage at the anode of V_2 by $\pi/2$ because C_2 has an impedance very high compared with those of other

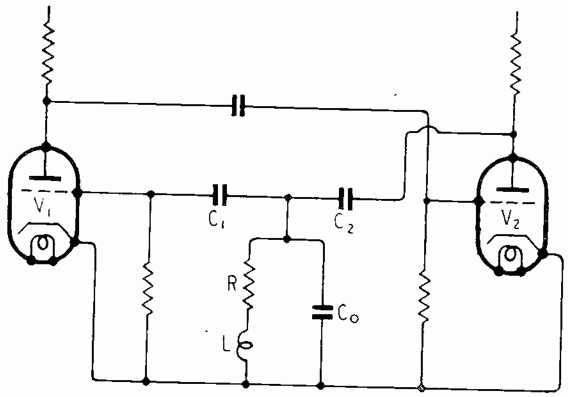


Fig. 8. *Basic circuit of Franklin oscillator.*

relevant components. If, therefore, the phase of this anode voltage is $3\pi/2$ (i.e., only $\pi/2$ ahead of that of the grid voltage of V_2), the current flowing into the resonant circuit will have zero phase angle. Provided the input impedance of V_1 is purely capacitive the phase of the voltage across the resonant circuit must coincide with that of the current producing it; i.e., the oscillation frequency $\omega/2\pi$ will be the resonant frequency, $\frac{\omega_0}{2\pi}$.

But the patent specification suggests that the anode load of V_2 is more nearly resistive than capacitive; and it seems doubtful whether the input of V_1 can be assumed purely capacitive. These two features demand that the phase of the voltage across the resonant circuit should lag behind the current producing it. Good designs of oscillator avoid any large difference of phase here, because it is detrimental to frequency stability and, of less importance, it causes $\omega/2\pi$ to differ from $\omega_0/2\pi$.

The fact that the impedance coupling the output of V_2 to the resonant circuit is capacitive rather than resistive may be seriously detrimental in that the harmonic currents fed to the resonant circuit will be relatively enhanced.

If the input capacitance of V_1 plays any substantial part in determining the input impedance of the amplifier, as seems most likely, the objection can be raised that gain or level considerations in this unit are dependent on a component that will vary with changes of supply voltage and ageing of the valve.

Franklin designed his oscillator before degeneration and its advantages were understood; the lack of this feature in the earlier oscillator represents a very important distinction between the two driving circuits. (Although this discussion of a sixteen-year old maintaining circuit contains some criticisms, they are not intended to reflect at all on the valuable contributions made by Franklin, which have resided in the tuning circuit rather than the driving circuit).

There are insufficient data for Δ for oscillators designed before 1938 with which to compare those of Section 3.2 in any detail; what there are indicate that the values obtained here are much to be preferred.

But in 1938 Meacham[16] introduced the bridge-stabilized oscillator. In it the non-linear resistance of a filament lamp forms one arm of a resistance bridge and controls the amplitude of oscillation. Correctly used, his circuit ensures that a very close approximation is made to the critical condition of exact neutralization, mentioned in Section 1 as being of little practical importance to the early investigators. Moreover, bridge stabilization maintains this condition of oscillation almost unchanged when valves age or supply voltages change. Extremely good stability of frequency is therefore expected and, in fact, obtained. Meacham shows that for an oscillator having his drive unit and a quartz crystal resonator ($Q = 100{,}000$) a 10 % change of gain (nominally 400 times) of his single valve amplifier gives $\Delta\omega/\omega = 2 \times 10^{-9}$ when the phase change through the amplifier is 0.1 radian. This figure for $\Delta\omega/\omega$ becomes 2×10^{-11} if a 1% change of gain (such as would be obtained with a change of ≈ 1 % of V_s) and a phase shift of 0.01, which despite the transformers involved need not necessarily be exceeded with good design at any one frequency, are substituted. Contrast this figure with that of 2×10^{-14}, which reference to Fig. 4(e) shows is possible for the same change of V_s with the present oscillator (having $n_1 = 8$) and like resonator. But it is only fair to add that the stability of the Meacham oscillator is proportional to Q and not to Q^2. If a value of Q of 100 is substituted for that of 100,000 each oscillator offers values of Δ of about 2×10^{-8}.

Meacham's work rightly attracted much attention and has been extended. Thus Clifford[17] has recently designed a bridge-stabilized resistance-capacitance oscillator having a drive circuit differing from that of Meacham but retaining a lamp as the non-linear device. He gives data from which a figure for Δ of 1.10^{-5} is deducible. Bearing in mind the very low Q associated with his discriminating circuit, this figure represents a high order of stability. Mention must be made also of an oscillator designed by Terman, Buss, Hewlett and Cahill[8]. This uses an RC discriminating circuit and a drive circuit which differs from A of Fig. 1. in one significant respect only. A lamp replaces R_K. Once again the resistance of the lamp, which is here a function of the signal level at B, controls that important factor of this drive circuit, the gain of A, in such a direction and to the extent that exact neutralization is approached. There can be little doubt that the substitution of a lamp for R_K still further improves the drive circuit from the point of view of stability of frequency with ageing of the valves and changes of supply voltage.

6. Conclusions

The aims of this article are to analyse a particular oscillator on the basis of loop considerations, a method not previously fully explored, and to demonstrate the advantages of the oscillator. The analysis extends to all the features normally of interest to the designer and the results obtained are of a simple form. Quantitative results are given in graphical form.

A detailed comparison between the stability of frequency with changes of supply voltages obtainable with this oscillator and those of oscillators designed before the introduction of the use of non-linear elements such as lamps to stabilize the amplitude of oscillation, thereby limiting the harmonic production, was considered unnecessary; this feature of the performance of earlier circuits of comparable simplicity never approaches that deduced here.

Sufficient comparison has been made with the bridge-stabilized type of oscillator to show that for use with resonant circuits having magnifications of 100 or more the present type holds its own or does even better in respect of stability. Any difference here is, at the moment, largely of academic interest because the limitations on stability for either type are far more likely to be found in the important temperature coefficients, and ageing effects, of the resonator than with any feature of the driving circuits.

APPENDIX

I am indebted to P. J. Hilton of Queens College, Oxford, for the following proof that

$$\frac{\pi}{2} - \alpha \pm \sin\alpha\cos\alpha = 2\sum_{1}^{\infty}\left[\frac{\sin(m\cos\alpha)}{m}\left\{J_0(m) - J_2(m)\right\} + 2\,\frac{\cos(m\cos\alpha)}{m},\ \cos\alpha\,.\,J_1(m)\right]$$

where m is odd only.

It is included here primarily because the method of attack is applicable to other problems involving periodic functions and Bessel coefficients.

Consider a function $f_1(t)$ defined by $f_1(t) = (1 - t^2)^{-\frac{1}{2}}$ when $-1 < t < 1$, $f_1(t) = 0$ when $-\pi \leqslant t \leqslant -1$ and $1 \leqslant t \leqslant \pi$ and $f_1(t) = f_1(t + 2\pi)$. Then $f_1(t)$ may be expanded in a Fourier series and, since $f_1(t) = f_1(-t)$,

$$f_1(t) = \tfrac{1}{2}a_0 + \sum_{1}^{\infty} a_m \cos mt$$

$$\text{where } a_m = \frac{1}{\pi}\int_{-\pi}^{\pi} f_1(t)\cos mt\,dt$$

$$= \frac{1}{\pi}\int_{-1}^{1}(1 - t^2)^{-\frac{1}{2}}\cos mt\,.\,dt$$

$$= \frac{1}{\pi}\int_{-\pi/2}^{\pi/2}\cos(m\sin\theta)\,d\theta.$$

Hence $a_m = J_0(m)$ and $a_0 = 1$. Therefore $f_1(t) = \frac{1}{2} + \sum_{1}^{\infty} J_0(m)\,.\cos mt$. Put $t = \sin\alpha$; then $-1 < t < 1$ and $f_1(\sin\alpha) = (1 - \sin^2\alpha)^{-\frac{1}{2}} = \sec\alpha$.

$$\text{Therefore } \sec\alpha = \tfrac{1}{2} + \sum_{1}^{\infty} J_0(m)\cos(m\sin\alpha) \quad \ldots \quad (1)$$

Put $t = \pi - \sin\alpha$; then if $\sin\alpha > 0$, $1 \leqslant t \leqslant \pi$ and if $\sin\alpha < 0$, $-\pi \leqslant t - 2\pi \leqslant -1$. Hence $f_1(\pi - \sin\alpha)$ must always be zero.

$$\therefore \tfrac{1}{2} + \sum_{1}^{\infty}(-1)^m J_0(m)\cos(m\sin\alpha) = 0 \quad \ldots \quad (2)$$

Subtracting (2) from (1) gives

$$\sec\alpha = 2\sum_{1}^{\infty} J_0(m)\cos(m\sin\alpha) \text{ where } m \text{ is odd only} \quad \ldots \quad (3)$$

Consider now the function $f_2(t)$ defined by $f_2(t) = t(1 - t^2)^{-\frac{1}{2}}$ when $-1 < t < 1$, $f_2(t) = 0$ when $-\pi \leqslant t \leqslant -1$ and $1 \leqslant t \leqslant \pi$ and $f_2(t) = f_2(t + 2\pi)$. Then $f_2(t)$ may be expanded in a Fourier series, and since $f_2(t) = -f_2(-t)$

$$f_2(t) = \sum_{1}^{\infty} b_m \sin mt \text{ where } b_m = \frac{1}{\pi}\int_{-\pi}^{\pi} f_2(t)\sin mt\,dt$$

$$= \frac{1}{\pi}\int_{-1}^{1} t(1 - t^2)^{-\frac{1}{2}}\sin mt\,dt$$

$$= \frac{1}{\pi}\int_{-\pi/2}^{\pi/2}\sin\theta\,.\,\sin(m\sin\theta)\,d\theta = J_1(m).$$

Therefore $f_2(t) = \sum_{1}^{\infty} J_1(m)\sin mt$. Then the expressions obtained first when $\sin\alpha$ and second when $(\pi - \sin\alpha)$ are substituted for t enable the equation

$$\sin\alpha\sec\alpha = 2\sum_{1}^{\infty} J_1(m)\sin(m\sin\alpha) \text{ where } m \text{ is odd only} \quad \ldots \quad (4)$$

to be obtained. Because $\cos\alpha = \sec\alpha - \sin^2\alpha\sec\alpha$ it follows from (3) and (4) that

$$\cos\alpha = 2\sum_{1}^{\infty}\left\{J_0(m).\cos(m\sin\alpha) - J_1(m)\sin\alpha\sin(m\sin\alpha)\right\} \text{ where } m \text{ is odd only} \quad \ldots \quad (5)$$

Because the series on the R.H.S. of (5) is uniformly convergent, it can be integrated term by term with respect to $\sin\alpha$.

$$\text{Now } \int_{0}^{\sin\alpha}\cos\alpha\,d(\sin\alpha) = \frac{\alpha + \sin\alpha\cos\alpha}{2}$$

$$\int_{0}^{\sin\alpha}\cos(m\sin\alpha)\,d(\sin\alpha) = \frac{\sin(m\sin\alpha)}{m} \text{ and}$$

$$\int_{0}^{\sin\alpha}\sin\alpha\,.\,\sin(m\sin\alpha)\,d(\sin\alpha) = -\frac{\sin\alpha\cos(m\sin\alpha)}{m} + \frac{\sin(m\sin\alpha)}{m^2}$$

$$\therefore \alpha + \sin\alpha\cos\alpha = 4\sum_{1}^{\infty}\left[\frac{\sin(m\sin\alpha)}{m}\left\{J_0(m) - \frac{J_1(m)}{m}\right\} + \frac{\cos(m\sin\alpha)}{m}\sin\alpha\,J_1(m)\right] \text{ where } m \text{ is odd only.}$$

$$\text{But } J_0(m) - \frac{J_1(m)}{m} = \tfrac{1}{2}\{J_0(m) - J_2(m)\}.$$

Hence $\alpha + \sin\alpha\cos\alpha$

$$= 2\sum_{1}^{\infty}\left[\frac{\sin(m\sin\alpha)}{m}\left\{J_0(m) - J_2(m)\right\} + 2\,\frac{\cos(m\sin\alpha)}{m}\sin\alpha\,.\,J_1(m)\right]$$

where m odd only $\quad \ldots \quad (6)$

If $\left(\frac{\pi}{2} - \alpha\right)$ is substituted for α the required identity is obtained.

REFERENCES

[1] Thomas, "Theory and Design of Valve Oscillators," 1939 (Chapman and Hall) gives a good account of many of them.
[2] Appleton and Greaves, *Phil. Mag.*, Vol. 45, p. 401 (1923).
[3] Moullin, *J. Instn Elect. Engrs*, Vol. 73, p. 186 (1933).
[4] Groszkowski, *Proc. Inst. Radio Engrs*, Vol. 21, p. 958 (1933).
[5] van der Pol, *Proc. Inst. Radio Engrs*, Vol. 22, p. 1051 (1934); includes a very full bibliography.
[6] Lynch and Tillman, *Electronic Engng*, Vol. 17, p. 382 and p. 414 (1945).
[7] Brunetti and Greenough, *Proc. Inst. Radio Engrs*, Vol. 30, p. 543 (1942).
[8] Terman, Buss, Hewlett and Cahill, *Proc. Inst. Radio Engrs*, Vol. 27, p. 649 (1939).
[9] Tillman, *Wireless Engr*, Vol. 22, p. 17 (1945).
[10] Nyquist, *Bell Syst. tech. J.*, Vol. 11, p. 126 (1932).
[11] Cooper, *Wireless Engr*, Vol. 21, p. 323 (1944).
[12] See, for instance, Freeman, *Proc. Inst. Radio Engrs*, Vol. 26, p. 1360 (1938).
[13] Lynch, Brit. Prov. Pat. No. 13189/45.
[14] Brit. Pat. No. 369,575.
[15] Ladner and Stoner, "Short Wave Wireless Communication," 4th Edition 1942 (Chapman and Hall).
[16] Meacham, *Proc. Inst. Radio Engrs*, Vol. 26, p. 1278 (1938).
[17] Clifford, *Electronic Engng*, Vol. 17, p. 560 (1945).

NEW BOOKS

Wireless Direction Finding

By R. KEEN. Pp. 1059+xii, with 633 illustrations. Iliffe & Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 45s.

This is the fourth edition of a book which first appeared soon after the First World War. It is no coincidence that the present revised volume is published after a war in which radio has played such a large part. The achievements of radar systems spring to mind; but steady advances have also been made in other location methods not involving the reflection of radio waves from a "target." These advances are perhaps not so spectacular—the refinement of a technique, for example, rather than the development of a brand-new one; a better understanding of the properties of older equipment, or of the medium between transmitter and receiver. It is with the principles, history and current practice of conventional direction finding that the book is mainly concerned. Although, in addition, hyperbolic-navigation systems are considered, and other chapters deal with landing aids for aircraft and beacons, the specialized techniques of radar, as such, and centimetre-wave utilization are deliberately excluded from detailed study.

The author has set out to write "a manual rather than a complete textbook but with a comprehensive bibliography . . . to be of value to students, radio operators and d.f. maintenance and construction personnel as well as to the non-specialist reader." His object has been very largely reached in this essentially practical book, in which the amount of theory is reduced to a bare minimum and in which explanation by word and diagram effectively replaces analysis by symbol.

An introductory chapter, in which the history of direction finding is reviewed in general terms and an estimate made of its likely future application, is followed by a treatment of the propagation of electromagnetic waves; particular attention is paid to the effects of the ionosphere. Succeeding chapters deal with the principles of direction finding and the directive properties of aerials; the Bellini-Tosi system is considered in detail. The polarization errors experienced with loop direction finders lead to a consideration of the advantages of Adcock aerial systems. Chapters which follow deal with practical direction finding at permanent land stations on frequencies up to 300 Mc/s; typical commercial equipments—including spaced loop apparatus—are described, and the problems encountered in their installation and application are discussed. A particularly interesting chapter is concerned with the organization of a direction-finding network and the statistical treatment of bearing data. Separate chapters deal with the awkward difficulties which arise when direction finders are mounted on board ship and on aircraft. It is unfortunate that the important chapter concerned with approach and landing aids for aircraft is divorced from that dealing with beacons; for the latter is largely concerned with the navigation of aircraft and is naturally complementary to a consideration of the landing problem. Modern equipments incorporating various forms of cathode-ray tube display are given a prominent place in the chapter dealing with special methods of bearing presentation. Another chapter is devoted to a description of radio navigation systems such as Gee, Loran, Decca and Consol; the properties of these are contrasted with the older systems already described. What appears to be a mis-statement is made at the bottom of page 943 concerning the phasing of the aerial currents to form the "Central Elektra Pattern"; the distribution described is not consistent with the formation of a course at right angles to the aerial base-line.

The preparation of special charts and maps is considered at various points in the text; improved continuity would probably have resulted if this information had been collected together and combined with the material of the final chapter dealing with field and nautical astronomy. For similar reasons it would have been preferable to relegate the somewhat extraneous matter, such as the Q code and certain air-traffic and communication regulations, to an appendix.

Attention must be drawn to deficiencies in an early chapter dealing with transmission lines. For example, the reader is confused by typesetting faults on page 96 in the expressions for the line constants; by a persistent error on page 98 in the sign of the distance-dependent phase terms for the component waves on an open-circuited line; and by an error in Fig. 73 on page 100. In this figure certain current, voltage and impedance graphs are shown as a function of the distance from the generator end of an open-circuited line; yet the impedance curve evidently relates to distances measured from the open end of the line.

Despite the drawbacks indicated, the book is to be recommended; the approach is comprehensive and practical. The well-arranged encyclopædic bibliography, to which very frequent references are made in the text, is particularly commendable.

H. G. H.

Radar System Engineering

Edited by L. N. RIDENOUR. Pp. 748 + xviii, wth 446 illustrations. McGraw-Hill Publishing Co. Ltd., Aldwych House, London, W.C.2. Price 37s. 6d.

American radar research and development during the war was centralized in the Radiation Laboratory, Massachusetts Institute of Technology. Instead of dispersing when their work ended with the war, the staff best qualified to write up the results in a form suitable for publication stayed on for another six months in order to do so. This book is No. 1 in a set of twenty-eight comprising the product of their labours. Its editor is also editor-in-chief of the series, and contributes the whole or part of several chapters. Most of the other books deal with specialized theory and techniques involved in radar but not necessarily confined to it; for example, magnetrons, waveguides, propagation of short waves, servo-mechanisms, etc. It was wisely planned that these subjects should be treated quite generally, because it was realized that radar might not even be the most important of their applications. As the preface to "Radar System Engineering" says, "this book specializes to radar the techniques reported more fully elsewhere in this series;" and "it is intended to serve as a general treatise and reference book on the design of radar systems."

The seventeen chapters deal with the theory, operation and design of the various elements, separately and in combination, that make up radar systems, not forgetting the target. Three of the chapter subjects—C. W. Radar Systems, Moving-Target Indication, and Radar Relay—have so far had little place in the literature.

As one would expect from such a source, there is in this book an abundance of authoritative information. It is perhaps only to be expected, too, that its outlook is backward rather than forward. The equipment discussed most fully belongs to a war that is over, while radar for present and future sea and air navigation is barely mentioned. Interesting though they are, the historical and tactical aspects of radar ought not to have been given so much space in what claims to be an engineering treatise. For example, while there is particular detail about the organization and routine procedure of U.S. and British tactical air Commands at various stages of the war, including even tabulated data of tracks reported by a particular Command, there are no appendices or collected tables of data useful in design.

Circuit technique is especially weak, only a portion of one chapter being devoted to it, in spite of the fact that the subject does not appear to be included in the titles of any of the more specialized volumes. The nearest approach to the design of time-base generators is a very superficial description of sawtooth generators extending to less than four pages. The influences of valve capacitances and other second order effects in pulse-generating circuits are ignored, and the old fallacy that the trailing edge of the pulse from a differentiating circuit is due to the *discharge* of the capacitor crops up once more. Fig. 13.18c, purporting to show the waveform of damped oscillations excited in the anode circuit of a triode, takes no account of the practically important extra damping during the conducting phase of the valve. Seeing that all this has been done so much better and more thoroughly by the Radar School staff of the M.I.T., the space would have been more appropriately devoted to applying the principles to practical quantitative design.

The reviewer was perhaps unlucky in his resort to the index, for he failed to find any reference therein to marine (or sea, or ship) radar, cheese aerials, bootstrap circuit, differentiating circuit, H.L., G.C.I., Rebecca, or Eureka, although they are all in the text, and might reasonably have been expected to be signposted in what claims to be a work of reference.

In brief, "Radar System Engineering" is a good book that could have been organized into a much better one.

M. G. S

Radio Aids to Navigation

By R. A. Smith, M.A., Ph.D., A.M.I.E.E. Pp. 114 + xi with 37 illustrations. Cambridge University Press, Bentley House, 200, Euston Rd., London, N.W.1. Price 9s.

The author was concerned with the development of radar methods of navigation during the war and the material in this book was originally prepared as a contribution to the Ministry of Supply (Air) Scientific War Records. Starting with pre-war systems of navigating aircraft, it goes on to describe the war-time systems. It covers d.f. methods, beacons and track guides, as well as radar and C.W. systems, including Gee, Loran, S. S. Loran, Sonne, P.O.P.I., Decca. Centimetre-wave systems, such as H_2S, are included, and there is a chapter on special radar applications covering G.H., Rebecca II, Shoran and Oboe.

Radio altimeters are dealt with and aids to instrument landing, notably S.B.A. and S.C.S.51, of the C.W. types, and B.A.B.S. among the radar methods.

The various systems are briefly described in general terms, sometimes with the aid of block diagrams, and their main characteristics are given. Nothing is said about the circuits adopted, and there is very little detailed information of methods or equipment. Although of a general nature, the book is not one for the non-technical, and it is certainly not a "popular" book.

W. T. C.

F.B.I. Register

The first post-war edition of the F.B.I. Register of Manufacturers is now available and provides the only complete guide to Members of the Federation of British Industries. It includes products and services, address, brands and trade marks sections, and there are reference facilities in French and Spanish. It is available from Kelly's Directories Ltd., 186, Strand, London, W.C.2. Price £2 2s.

Electronic Engineering Master Index

Edited by Frank A. Petralgia. Pp. 202 + x. Electronics Research Publishing Co., 2, West 46th St., New York 19, U.S.A. Price $14.50.

This book is a subject index of selections from over 85 periodicals and covers the period July 1945 to December 1946.

Indexes

As is our custom the Index to the Articles and Authors for the current volume is included in this issue.

The Index to the Abstracts and References published throughout the year is in course of preparation and will, it is hoped, be available in February, priced 2s. 8d. (including postage). As supplies will be limited our Publishers ask us to stress the need for early application for copies.

SIR EDWARD APPLETON

The 1947 Nobel Prize in Physics has been awarded to Sir Edward Appleton "for his work on atmospherical physics, and especially for his discovery of the Appleton layer." His important experiment to prove the existence of a reflecting layer in the upper atmosphere took place in December 1924.

The frequency of the B.B.C. transmitter at Bournemouth was varied over a small range and the strength of the signal received at Oxford was found to depend on the frequency. Artificial fading was thus produced, and not only proved that the received signal was composed of waves which had travelled by different paths, but enabled the height of the reflecting layer to be calculated.

Since 1939 Sir Edward has been Secretary of the Department of Scientific and Industrial Research.

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.

Comparison of A.M. and F.M.

Sir,—The comparison of the relative merits of a.m. and f.m. is not helped by Mr. A. A. McKenzie's quotation from a report on the subject in the *General Electric Review*, Vol. 42, 1939. The conclusions arrived at in that report were based on comparative tests in which the receiver was arranged with a switch to bring into circuit either an f.m. detector with noise limiter or an a.m. detector without limiter. In these circumstances, the statement that the signal-plus-noise to noise ratio was 20–25 db better with f.m. might, for all we know, merely mean that the noise limiter was working. Such tests are completely useless for enabling general conclusions to be drawn as to the relative merits of the two systems of modulation, yet it is on this sort of test that many of the claims for the vast superiority of f.m. have been founded.

Those who seek to maintain these claims also generally make their tests under laboratory conditions with the receiver exactly in tune, and do not stress the fact that unless an effective a.f.c. system is incorporated the signal/noise ratio expected of f.m. is not likely to be obtained, say, by the average broadcast listener.

In his tests, Mr. Nicholson evidently made a serious attempt to compare the two systems under equivalent conditions, and his critics cannot fairly do less. Though it may displease some to have the unqualified superiority of f.m. called into question, it appears that both systems must still be considered on their merits for any particular application. Thus although, as Mr. D. A. Bell has pointed out, f.m. has been approved for certain services by the B.B.C. and the G.P.O., practical experience of both systems has led the Home Office to adopt a.m. for the new county police networks, the first of which has recently been put into service.

Bromley, Kent M. G. Scroggie.

Sir,—The paper by Nicholson on this thorny subject, published in your July issue, serves the very valuable purpose of drawing attention to some of the many different problems which confront the engineer whose job it is to choose the best type of equipment to give a particular kind of service using the v.h.f. band. It is important to remember that the various factors weigh differently according to the type of service being considered and so it is not possible to come to a general conclusion, such as that given by Mr. D. A. Bell in the last paragraph of his letter in your September issue. In considering the two very diverse examples which he quotes, it should be borne in mind that in the majority of the reported B.B.C. tests, as in the various reported American tests, f.m. was compared with a.m. without noise limiters, while in the case of the use of f.m. by the Post Office for multichannel links one of the most important reasons for this is the great convenience of low-level modulation for multi-channel working.

In his remarks on the use of amplitude limiters for impulse-noise suppression on a.m. receivers Mr. Bell is somewhat misleading and I would like to correct the impression he gives on certain points. Taking in turn the three objections he raises to wide-band a.m. plus amplitude limiters :—

(i) Provided the transmitters operating on the same broad channel are on frequencies actually separated by 20 kc/s or more the interference effects using a.m. or f.m. will not be greatly different, as pointed out by Nicholson.

For mobile communication services (perhaps the most important users of the v.h.f. band) this point is not relevant as here receivers are normally run continuously and transmitters are only on when a message is being passed. Obviously in this case, using either a.m. or f.m., no transmitter sharing a channel should be within range of a receiver working with another transmitter or messages from the second transmitter could be received while the first is idle.

Thus for mobile services wide-band a.m. is certainly no more uneconomical in ether space than f.m. using the same bandwidth, while for broadcast and similar services there should be little difference.

(ii) Receivers nowadays almost invariably use diodes for detection and a.v.c. which, for efficient working, operate at levels of at least 10 volts. This is sufficient for the efficient operation of most noise limiters which are inserted between the detector and the first a.f. valve. There is no difficulty whatsoever in maintaining a bandwidth in excess of the half-bandwidth of the i.f. amplifier up to this point.

(iii) While certain noise-limiter circuits have been suggested which are undoubtedly complicated it can hardly be said that they are more complicated than the circuits met in an f.m. receiver. The simple carrier-controlled limiters give very good results. The series-diode circuit given in Fig. 7 of Nicholson's paper is good but the addition of a shunt diode (see for example *Wireless World*, Dec. 1946, p. 398) improves the noise suppression considerably. This carrier-controlled series-shunt circuit gives an excellent all round performance which is hard to improve on. According to my tests Nicholson's limiter (Fig. 8) can be made to yield an appreciable improvement in impulse-noise suppression (some 10 db) for a certain range of carrier levels (determined by the circuit constants used) but at other carrier levels it behaves little differently from the simpler series-shunt circuit. Hence, for a mobile-communication service at any rate, it is doubtful if the extra complication of this circuit is justified.

Concerning the operation of amplitude limiters they do not, as Mr. Bell suggests, suppress only higher-frequency components of the pulse. The carrier-controlled limiters limit the amplitude of a noise pulse to twice the mean carrier voltage corresponding to a signal with 100 per cent modulation (or at any other chosen percentage as determined by the circuit constants). This does not alter the frequency distribution of the various components of the pulse, it simply reduces their amplitude. As the bandwidth of the circuit at the limiter is considerably greater than the bandwidth of the audio amplifier which follows, the higher frequency components are removed in the latter with a consequent lengthening and reduction in peak amplitude of the pulse. In the idealized case the peak amplitude of the output noise pulse will be less than the 100 per cent modulation level in the ratio of the audio bandwidth to the i.f. half-bandwidth. The modulation-following limiters work in a similar manner except that the pulse is limited to the instantaneous modulation level and hence, in theory, should give considerably better results.

In an f.m. system impulse noise is not cut exactly at modulation level as Mr. Bell states and a noise output is obtained whether the carrier is being modulated or not. The latter case is always the more disturbing for impulse noise, as aural masking reduces its effects when modulation is present. The earlier treatments of impulse noise in f.m. were rather unsatisfactory but it has been shown by Landon (*Electronics*, Feb. 1941, Vol. 14, No. 2) that when in an ideal receiver the impulse adds to the carrier, at certain phase relationships which occur at random, rapid changes of instantaneous phase take place leading to large changes of instantaneous frequency. This produces a double impulse at the discriminator whose waveform is the differential of the pulse in the i.f. amplifier. The amplitude of this pulse depends on the bandwidth of the discriminator and the circuit immediately following, but assuming this to be at least equal to the i.f. half-bandwidth (to correspond to the a.m. case) the peak amplitude will correspond to that of a signal with 100 per cent modulation. This pulse will be lengthened and reduced in amplitude in its passage through the a.f. amplifier as in the a.m. case. The peak amplitude of the noise in the case of similar ideal f.m. and a.m. plus carrier-controlled limiter receivers should thus be approximately equal, and but for the different wave shape of the f.m. pulse (corresponding to the triangular spectrum) which gives it a somewhat less disturbing audible effect, the results would be similar.

In a practical f.m. receiver the alignment may not be perfect and the incoming carrier may not lie exactly in the centre of the receiver pass-band. This will cause an additional kind of impulse noise; viz., the "pop" noise discussed by Smith and Bradley (*Proc. Inst. Radio Engrs*, Nov. 1946, Vol. 34, No. 10). This noise does not have the triangular spectrum and sounds much louder than that occurring when the receiver is on tune, and so in this condition a f.m. receiver can be worse in respect of impulse noise than an a.m. receiver with carrier-controlled limiter.

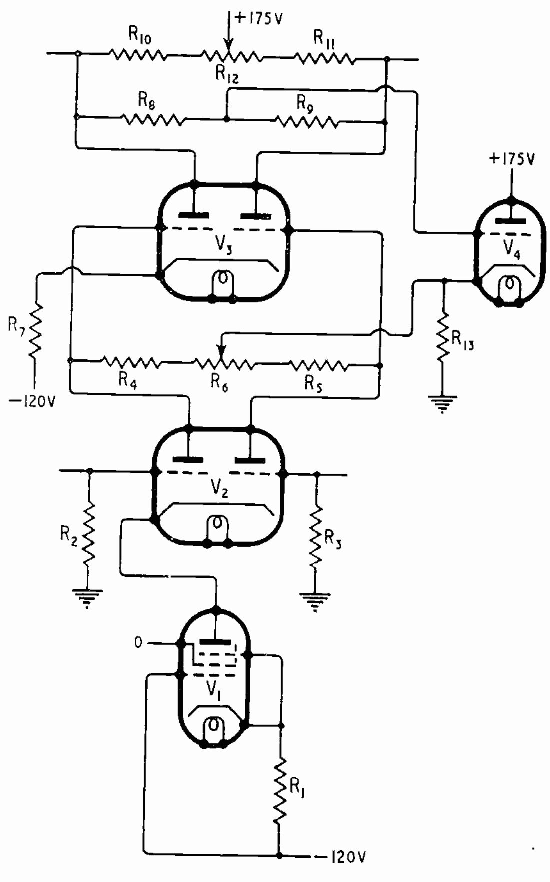
Tests which I have carried out on equipment designed for a mobile communication service confirm these expectations. They show that when a f.m. receiver is on tune there is little to choose between it and a similar a.m. receiver with a series-shunt limiter. In the case of the receiver tested (carrier about 100 Mc/s, i.f. bandwidth 35 kc/s, audio bandwidth 3.5 kc/s) a detuning of the carrier frequency by as little as 1 kc/s produced a marked deterioration of impulse noise performance. This is also the amount of the normal production tolerance in the crystals used for frequency control of such receivers. In practice, therefore, it is not an easy matter to maintain an impulse noise performance on a f.m. receiver which is as good as that given by an a.m. receiver with limiter.

I have not done any work on broadcast-quality f.m. receivers but it is of interest to note that in carrying out the aforementioned tests, I was unable to find any laboratory signal generator which would hold its frequency sufficiently accurately to give minimum impulse noise for more than a few minutes at a time. While the requirements of a broad-band broadcast receiver are less severe, I cannot think that the task of the designer of a reasonably priced broadcast f.m. receiver will be an enviable one.

I. F. MACDIARMID,
Dollis Hill, N.W.2.

Electro-encephalograph Amplifier

SIR,—By a simple modification to the circuit (Fig. 10) of the amplifier described by D. L. Johnston in your August issue, it is possible to increase the gain of the two stages by a factor of two. Use is made in the modified circuit shown below of a cathode follower to provide high tension for the first stage, the cathode follower being controlled by the mean potential of the anodes of the second stage. This method of applying feed-back from



$R_1 = 2.2\ k\Omega$; $R_2, R_3 = 3.3\ M\Omega$; $R_4, R_5 = 100\ k\Omega$; $R_6 = 10\ k\Omega$; $R_7 = 50 k\Omega$; $R_8, R_9 = 1.2\ M\Omega$; $R_{10}, R_{11} = 100\ k\Omega$; $R_{12} = 10\ k\Omega$; $R_{13} = 33\ k\Omega$; $V_1 = 6AG5$; $V_2, V_3 = 6J6$; $V_4 = 6SN7$ (*one half*).

one stage to the preceding stage can be of considerable value in the design of direct-current amplifiers. An amplifier is being made on these lines.

E. J. HARRIS.
P. O. BISHOP,
University College, London.

WIRELESS PATENTS

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

585 667.—Low-frequency power-amplifier with provision for maintaining a stabilized feed-back as the load varies.

Patel Hold Patentverwertungs &c. A.G. Convention date (Switzerland) 17th July, 1942.

586 102.—Method of clamping the needle of a gramophone pickup so that it is held firmly, relatively to the magnet-poles, whilst being free to follow the grooves in the record.

The British Thomson-Houston Co. Ltd. and G. H. Dyer. Application date 13th December, 1944.

AERIALS AND AERIAL SYSTEMS

586 085.—Construction of a shielded loop-aerial designed to radiate substantially plane-polarized waves.

Standard Telephones and Cables Ltd. (assignees of W. D. McGuignan). Convention date (U.S.A.) 15th November, 1943.

DIRECTIONAL AND NAVIGATIONAL SYSTEMS

585 826.—Radiolocation equipment in which the arrangement for blocking the receiver during the transmission of the exploring pulses includes a delay network.

Standard Telephones and Cables Ltd. and M. M. Levy. Application date 11th March, 1941.

585 871.—Driving and control means for causing the aerial system of a radiolocation set to scan the field of observation over a sector of adjustable width.

The British Thomson-Houston Co. Ltd. (communicated by the General Electric Co.). Application date 9th May, 1944.

585 906.—Push-pull amplifier circuit for intermittently feeding the echo-signals to the goniometer coils of a radiolocation set.

A. D. Blumlein. Application date 3rd November, 1939.

585 907.—Integrating circuit for reducing the effect of interference when receiving pulsed trains of signals, as in radiolocation.

A. D. Blumlein and E. L. C. White. Application date 1st December, 1939.

585 909.—Radiolocation equipment in which the scanning controls of the c.r. indicator are arranged to facilitate the identification of a selected echo-signal in the presence of others.

E. L. C. White. Application date 29th January, 1940.

585 986.—Radiolocation set utilizing horn-shaped receiving aerials, arranged symmetrically about the transmitter, and feeding the echo-signals to a common c.r. indicator.

D. I. Lawson, D. Weighton, and Pye Ltd. Application date 6th February, 1940.

586 033.—Construction of V-shaped d.f. aerial, with reflecting element, particularly for a portable blind-landing equipment.

Standard Telephones and Cables Ltd. (assignees of L. Himmel and M. Fuchs). Convention date (U.S.A.) 12th June, 1943.

586 116.—Phase-correcting arrangement for securing a high signal-to-noise ratio in a radiolocation set when the exploring pulses are of random phase and timing.

Standard Telephones and Cables Ltd. and C. W. Earp. Application date 11th March, 1941.

586 119.—Radiolocation system in which the frequency of the exploring pulse is automatically controlled by the echo signal until the distance of the target is indicated by a specific phase-difference.

Standard Telephones and Cables Ltd., P. K. Chatterjea, and L. W. Houghton. Application date 15th October, 1941.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

585 458.—Cathode-ray tube in which the usual fluorescent screen is replaced by one coated with an alkali halide on which the scanning-stream produces a transient discolouration.

P. G. R. King, P. W. Wells, and C. S. Wright. Application date 26th October, 1942.

586 034.—System in which one set of signals is transmitted during the periodic intervals between a different set of signals, applicable to television-and-sound systems.

Marconi's W. T. Co. Ltd. (assignees of G. L. Fredendall and A. C. Schroeder). Convention date (U.S.A.) 29th May, 1943.

TRANSMITTING CIRCUITS AND APPARATUS

See also under Television

585 471.—Probe-device, free from capacitance-variations, for measuring the energy flowing through a waveguide or concentric transmission-line.

G. E. F. Fertel, R. W. L. Batt, and C. S. Wright. Application date 7th June, 1944.

585 482.—Power amplifier designed to prevent excessive power-dissipation under off-tune conditions, particularly in portable transmitting sets.

A. C. Cossor Ltd. and A. H. A. Wynn. Application date 28th September, 1944.

585 672.—Two-valve oscillatory circuit of the so-called "butterfly" type designed to ensure optimum stability when generating centimetre waves.

The British Thomson-Houston Co. Ltd. and R. G. Hibberd. Application date 19th December, 1944.

ABSTRACTS AND REFERENCES

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

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

ACOUSTICS AND AUDIO FREQUENCIES

: 534 **3747**

eferences to Contemporary Papers on Acoustics. Taber Jones. (*J. acoust. Soc. Amer.*, July 1947, 19, No. 4, Part 1, pp. 706–713.) See also 2306 ugust.

3748

ogram of the Thirty-Third Meeting of the istical Society of America.—(*J. acoust. Soc.* ., July 1947, Vol. 19, No. 4, Part 1, pp. 738.) Titles and abstracts of 78 papers, with or index.

31.3 **3749**

oustical Impedance of Enclosures.—F. B. els. (*J. acoust. Soc. Amer.*, July 1947, Vol. 19, , Part 1, pp. 569–571.) Formulae are derived he acoustical impedance of three types of sures: a sphere, a cylinder and a narrow ngular box. The solutions are valid through- he entire range from adiabatic to isothermal tions.

32 : 621.396.67 **3750**

the Radiation Problem [of a vibrating cylinder] **igh Frequencies.**—L. Lax & H. Feshbach. *oust. Soc. Amer.*, July 1947, Vol. 19, No. 4, 1, pp. 682–690.) The polar diagram and impedance of an acoustically-vibrating cylinder of arbitrary cross-section, large compared with the wavelength, are considered for various pressure and velocity distributions. Rapidly converging series solutions are obtained to an integral equation. The method has applications to radiation from electromagnetic shells whose surface distributions are specified.

534.24 : 551.510.52 **3751**

Reflection of Sound Signals in the Troposphere.—G. W. Gilman, H. B. Coxhead & F. H. Willis. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, p. 390.) Summary of 330 of February.

534.321.9 **3752**

Ultrasonic Absorption [in liquids] **from 75 to 280 Mc/s.**—R. A. Rapuano. (*Phys. Rev.*, 1st July 1947, Vol. 72, No. 1, pp. 78–79.) A preliminary report. The pulse-echo method has been adapted by the use of an acoustic delay line consisting of a rod of fused quartz with polished parallel end faces.

534.321.9 **3753**

Ultrasonic Absorption in Liquids from 100 to 225 Mc/s.—R. A. Rapuano. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 184.) Summary of Amer. Phys. Soc. paper. Description of apparatus for examining the frequency dependence of the absorption, in order to investigate relaxation processes. Results for water are given.

534.321.9 **3754**

Ultra-Sound Waves made Visible.—G. W. Willard. (*Bell Lab. Rec.*, May 1947, Vol. 25, No. 5, pp. 194–200.) Supersonic waves in a liquid give a closely spaced system of compression and rarefaction regions with different optical refractive indices. Such a system behaves like an optical line grating, so that diffraction effects are obtained when a beam of light is passed at right angles through the supersonic beam in the liquid. Photographs exhibit many points of resemblance between supersonic and optical beams.

534.321.9 : 546.49 **3755**

Propagation of U.H.F. Sound in Mercury.—G. R. Ringo, J. W. Fitzgerald & B. G. Hurdle. (*Phys. Rev.*, 1st July 1947, Vol. 72, No. 1, pp. 87–88.) An outline of experiments in the frequency band 100–1 000 Mc/s. The results are compared with measurements made at lower frequencies by other experimenters. No significant change with frequency was observed in the speed of propagation or in the 'frequency-free' absorption coefficient.

534.321.9.001.8 3756

Opportunities in Ultrasonics.—S. Y. White. (*Audio Engng*, June 1947, Vol. 31, No. 5, pp. 30–32, 47.) Possible industrial applications of ultrasonic mechanical vibrations are briefly considered.

534.321.9.001.8 : 621.396.611.21 3757

Laboratory Supersonic Generators and Their Applications.—H. Tscherning. (*Rev. gén. Élect.*, Aug. 1947, Vol. 56, No. 8, pp. 319–327.) The principles of piezoelectric oscillators are briefly discussed and descriptions are given of practical apparatus of the piezoelectric and of the magnetostriction type suitable for the production of supersonic waves in liquids. Applications include the preparation of emulsions, many chemical and metallurgical processes, biological effects and the measurement of Young's modulus in metal rods.

534.417 : 534.88 3758

The German Use of Sonic Listening.—L. E. Holt. (*J. acoust. Soc. Amer.*, July 1947, Vol. 19, No. 4, Part 1, pp. 678–681.) "The most successful German sonic listening device, the GHG Gruppen Horch Gerät, is described in general terms. Reference is made to the types of ships using the equipment and to the arrangement and placement of the hydrophone arrays. A brief account is given of the steps taken by the Germans to improve the operation of the GHG by streamlining the array and by altering its position on the hull. The simple but efficient electrical training device is explained, and bearing accuracy and range data, as reported by the Germans, are presented. The paper is based on technical reports received from Germany and on subsequent investigations. The most important of the sources consulted is the Navy Technical Mission Report prepared by Mr. Laurence Batchelder."

534.43 : 621.395.61 3759

Moving Iron Pickups.—E. H. Francis. (*Wireless World*, Aug. 1947, Vol. 53, No. 8, pp. 285–286.) General discussion with special reference to the effect of inductance on frequency response, the impedance/frequency characteristic and frequency correction. A suggested preamplifier circuit with frequency correction is given.

534.43 : 621.395.67 3760

Transition Frequency Compensation.—C. G. McProud. (*Audio Engng*, July 1947, Vol. 31, No. 6, pp. 10–11.) RC equalizing networks compensate for recording loss which occurs at frequencies below 300, 500 or 800 c/s on various manufacturers' records. Networks are given for crystal and magnetic pickups.

534.771 3761

A Pulse-Tone Technique for Clinical Audiometric Threshold Measurements.—M. B. Gardner. (*J. acoust. Soc. Amer.*, July 1947, Vol. 19, No. 4, Part 1, pp. 592–599.) Description of a portable version of the equipment used for testing over 1 000 000 people at the 1939–40 World Fair in America (1403 of 1941). Operators and subjects both prefer the pulse-time to the standard manually interrupted tone method.

534.771 3762

Auditory Thresholds of Short Tones as a Function of Repetition Rates.—W. R. Garner. (*J. acoust. Soc. Amer.*, July 1947, Vol. 19, No. 4, Part 1, pp. 600–608.)

534.833.4 3763

Acoustical Properties of Homogeneous, Isotropic Rigid Tiles and Flexible Blankets.—L. L. Beranek. (*J. acoust. Soc. Amer.*, July 1947, Vol. 19, No. 4, Part 1, pp. 556–568.)

534.843 3764

The Effect of Non-Uniform Wall Distributions of Absorbing Material on the Acoustics of Rooms.—H. Feshbach & C. M. Harris. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, pp. 389–390.) Summary of 342 of February.

534.86 : 534.322.1 3765

Frequency Range Preference for Speech and Music.—H. F. Olson. (*J. acoust. Soc. Amer.*, July 1947, Vol. 19, No. 4, Part 1, pp. 549–555.) Tests with an acoustical 5 000-c/s low-pass filter placed between a light orchestra and the audience indicated that the full frequency range was preferred. The tests are part of a series designed to find out why most listeners prefer a restricted frequency range in monaural reproduced speech and music.

534.861.1 3766

The Acoustical Planning of Broadcasting Studios.—J. McLaren. (*B.B.C. Quart.*, Jan. 1947, Vol. 1, No. 4, pp. 194–208.) A brief survey of the basic problems of sound insulation and correction. Successful B.B.C. wartime improvisations are indicated. Acoustical correction experiments and methods are described. In particular, a pulse technique analogous to radar can be used for investigating the acoustic properties of large buildings.

621.395.61 : 534.6 3767

Application of the Methods of Automatic Regulation to Electroacoustic Apparatus. Method of obtaining the Response Curves of Microphones.—A. Moles. (*Ondē élect.*, July 1947, Vol. 27, No. 244, pp. 276–283.) Methods similar to the automatic gain control used in radio circuits can be applied to a microphone preamplifier to obtain a correction of the amplification proportional to the instantaneous value of the sound field. The correcting voltage may be derived from a standard microphone with uniform response characteristics. Details are given of a method for the direct recording of microphone or loudspeaker response curves, including particulars of the automatic regulation of the output of the sound source used. See also 1306 of May.

621.395.61/.62].089.6 : 534.417 3768

The Practical Application of the Reciprocity Theorem in the Calibration of Underwater Sound Transducers.—P. Ebaugh & R. E. Mueser. (*J. acoust. Soc. Amer.*, July 1947, Vol. 19, No. 4, Part 1, pp. 695–700.)

621.395.623 : 534.6 3769

Experiments on Artificial Ears.—I. Barducci. (*Alta Frequenza*, June/Aug. 1947, Vol. 16, Nos. 3/4, pp. 132–146. In Italian, with English, French and German summaries.) Determination of the dependence of the response curve of telephone receivers on cavity volume, coupling conditions and shape. Discussion of the results shows that it is possible to calculate the acoustic parameters of a telephone receiver and an artificial ear from the geometrical and physical data of the system.

21.395.623.7 **3770**
The Distribution of Acoustic Power.—L. Chrétien. *T.S.F. pour Tous*, June 1947, Vol. 23, No. 224, p. 137–138.) Various circuits for feeding loud-peakers. Continuation of 2317 of August.

21.395.625 **3771**
The Recording and Reproduction of Sound: arts 1-4.—O. Read. (*Radio News*, March–June 947, Vol. 37, Nos. 3–6, pp. 52–54, 50–52..153, 1–63..108 & 65–67..126.) The history, develop-ent and applications of all currently known ethods. Descriptions are given of (*a*) lateral disk cording, (*b*) basic methods for embossing sound n film or disk, (*c*) magnetic recording on tape, disk r wire, (*d*) optical film recording and (*e*) magnetic itters for home recording and for high-fidelity oadcast transcribing. Parts 5–7, 3772 below.

21.395.625 **3772**
The Recording and Reproduction of Sound: arts 5-7.—O. Read. (*Radio News*, July–Sept. 947, Vol. 38, Nos. 1–3, pp. 55–57..135, 57–59..148 62–64..147.) Description of the crystal cutter d its use for constant-amplitude and constant-locity recording, various methods of magnetic cording on wire, tape, and magnetically coated aterials, and various types of microphone used in cording. For parts 1–4 see 3771 above. To be ntinued.

1.395.625.3 : 621.396.97 **3773**
Adapting Paper Tape Recorders for Broadcasting. R. S. O'Brien. (*Audio Engng*, June 1947, Vol. 31, . 5, pp. 10–14, 48.)

1.395.667 **3774**
Response Equalization.—J. W. Straede. (*Radio aft*, Sept. 1947, Vol. 18, No. 12, pp. 34–35, 77.) simple system in which the bass attenuation may rt at any of 5 (or more) frequencies, or the lower quencies may be either kept constant or boosted. nilar arrangements can be made for the high quencies.

1.395.92 **3775**
Hearing Aid Miniature.—(*Wireless World*, June 17, Vol. 53, No. 6, p. 229.) The Multitone Type 3 is a deaf aid with a built-in crystal microphone. e unit is $3\frac{1}{4}$ inches × $1\frac{11}{16}$ inches × $\frac{1}{2}$ inch and with e lightest of a range of battery packs weighs oz.

AERIALS AND TRANSMISSION LINES

1.315.1 : 621.3.015.3 **3776**
Theory of the Propagation of Surge Waves on o Parallel Lines.—M. Cotte. (*Rev. gén. Élect.*, g. 1947, Vol. 56, No. 8, pp. 343–352.) Theory is en for the case of lines without resistance and h considerable coupling. On the induced line s shown that two voltage waves without current l two current waves without voltage may be pagated. The experimental results obtained Mauduit (3777 below) and Rogowski with surge ves are explained with the aid of symbolic culus.

.315.1 : 621.3.015.3 : 621.317.755 **3777**
scillographic Study of Surge Waves and Oscil-ons in an Experimental Overhead Line.—A. uduit. (*Rev. gén. Élect.*, Aug. 1947, Vol. 56, 8, pp. 331–343.) A surge wave, started by a capacitor discharge at one end of an aerial line whose other end is open, is successively reflected at the two ends and gives rise to a stationary damped oscillation, the line vibrating as a quarter-wave line. The damping obtained with various line terminations, and with return by earth or a parallel wire, is considered. When the far end is earthed through a resistance equal to the characteristic impedance Z of the line, there is no reflection and the surge wave dies away without oscillation, but a wave can be induced in a parallel return line. The cases in which this line is open at both ends or is earthed at the origin are considered. A remarkable result is that if the parallel return line is earthed at the origin through an impedance nearly equal to Z, no wave is induced in the parallel line by a surge wave in the original line.

621.315.21 : 621.395.822.1 **3778**
Splicing of Cables with Systematic Permutation.—G. Chardon. (*Câbles & Transmission, Paris*, April 1947, Vol. 1, No. 1, pp. 77–86. With English summary.)

621.315.21.011.2 **3779**
Maximum Tolerable Impedance Deviations in Repeatered Cable Sections.—R. Belus, P. Herreng & J. Ville. (*Câbles & Transmission, Paris*, April 1947, Vol. 1, No. 1, pp. 3–12. With English summary.) Discussion of the conditions to be fulfilled by mean-square values of impedance deviations of individual cable lengths, a number of which are connected in series between two successive repeaters.

621.315.212 + 621.392.029.64 **3780**
Transmission of Electromagnetic Guided Waves through a Series of Symmetrical and Equidistant Obstacles.—J. Lévy. (*Câbles & Transmission, Paris*, July 1947, Vol. 1, No. 2, pp. 103–113. With English summary.) When a waveguide or concentric cable has obstacles uniformly distributed along it, its transmission properties cease to vary uniformly with the frequency as soon as the distance between consecutive obstacles is comparable with the wavelength. When the number of obstacles is great enough, the cable or guide acquires the properties of a multiple band filter. Methods of calculating the limits of the pass and attenuating bands are given and applied to the case of a coaxial cable with a series of evenly distributed insulating disks.

621.315.212.029.6 : [621.317.333 + 621.317.37 **3781**
The Voltage Characteristics of Polythene Cables.—R. Davis, A. E. W. Austen & W. Jackson. (*J. Instn elect. Engrs*, Part I, June 1947, Vol. 94, No. 78, pp. 283–284.) Summary of 3179 of October.

621.315.212.011.2 **3782**
Note on the Statistical Study of Impedance Irregularities in Coaxial Pairs.—G. Fuchs. (*Câbles & Transmission, Paris*, April 1947, Vol. 1, No. 1, pp. 13–30. With English summary.) Previous mathematical results are reviewed and new statistical relations are established. A detailed study is made of the distribution of zeros and maxima or minima of the impedance-deviation curve as a function of the frequency interval between two successive measurements. Calculated and experimental results are in good agreement.

621.392 **3783**

Power Reflection.—P. M. Prache. (*Câbles & Transmission, Paris*, April 1947, Vol. 1, No. 1, pp. 31–37. With English summary.) The transmitted and reflected powers at an interconnection point between a generator or a transmission line and a receiving impedance are calculated as functions of the power which would theoretically be transmitted at the same point to an impedance equal to the characteristic impedance. A coefficient of reflection of available power is defined as the ratio of the power actually reflected to the maximum powei obtainable from the source. This coefficient remains unaltered when a non-dissipative quadripole is interposed.

621.392.029.64 **3784**

Receiving Vibrator in a Waveguide.—I. I. Volman. (*Radiotekhnika, Moscow*, Jan. 1947, Vol. 2, No. 1, pp. 27–35. In Russian with English summary.) The vibrator input resistance is computed taking account of the reflections at the load terminating the waveguide. The s.w.r. as well as the position of the electric field nodes relative to the receiving vibrator, arbitrarily loaded, are determined.

621.392.029.64 **3785**

The Effects of Curvature and Curvature Discontinuities on Wave Propagation in Guides of Rectangular Cross-Section.—M. Jouguet. (*Câbles & Transmission, Paris*, April 1947, Vol. 1, No. 1, pp. 39–60. With English summary.) A full mathematical treatment of the subject. Some of the results obtained have been reported previously in short non-mathematical papers. See also 1667 and 1668 of June and back references.

621.392.029.64 **3786**

The Effects of Curvature on the Propagation of Electromagnetic Waves in Guides of Circular Cross-Section.—M. Jouguet. (*Câbles & Transmission, Paris*, July 1947, Vol. 1, No. 2, pp. 133–153. With English summary.) A complete account of the work already noted in 2669 of September and back references.

621.392.029.64 : 534.11 **3787**

A Mechanical Analogy for Transverse Electric Waves in a Guide of Rectangular Section.—Makinson. (*See* 3844.)

621.392.029.64 : 621.317.3 **3788**

Definition and Measurement of the Coefficient of Reflection in Waveguides.—J. Ortusi. (*Ann. Radioélect.*, April 1947, Vol. 2, No. 8, pp. 173–194.) Definitions are given, for a type of guided wave, of the coefficients of reflection and transmission and of the apparent impedance. Two methods of measuring reflection coefficients are fully described, the first a direct method and the second a very accurate zero method. The results obtained are in perfect agreement with theory.

621.392.029.64 : 621.317.3 **3789**

Experimental Determination of Input Resistances of Vibrator in a Rectangular Waveguide.—I. I. Volman & A. I. Shpuntov. (*Radiotekhnika, Moscow*, Jan. 1947, Vol. 2, No. 1, pp. 36–48. In Russian with English summary.) Comparison of the experimental results with theory shows that the current distribution along the vibrator is not sinusoidal. The results support theoretical conclusions as to the effect of waveguide walls and of reflections at the terminating load.

621.392.2 : 621.315.212.2 **3790**

Concentric Line.—H. Bondi & S. Kuhn. (*Wireless Engr*, Aug. 1947, Vol. 24, No. 287, pp. 222–223.) Curves of critical wavelength and wave-impedance of $H_{n,1}$ modes in terms of the conductor diameters are given. The critical wavelength of the H_{11} mode is approximately equal to the mean of the circumferences of the inner and outer conductors.

3791

621.392.4.029.58 — 621.396.67.029.58] : 621.317.3

The Testing of High-Frequency Aerial Systems and Transmission Lines.—E. J. Wilkinson. (*Proc. Instn Radio Engrs, Aust.*, May 1947, Vol. 8, No. 5, pp. 17–18.) Comment on and amplification of 2672 of September.

621.392.43 **3792**

An Exponential Transmission Line employing Straight Conductors.—W. N. Christiansen. (*AWA tech. Rev.*, April 1947, Vol. 7, No. 3, pp. 229–240.) Reprint of 3023 of October.

621.392.43 **3793**

An Eight-Wire Transmission Line for Impedance-Transformation.—W. N. Christiansen & J. A. Guy. (*AWA tech. Rev.*, April 1947, Vol. 7, No. 3, pp. 241–249.) The characteristic impedance Z_0 of an 8-wire line comprising two identical 4-wire transmission lines arranged about a common axis is given by a simple expression involving cot θ, where θ is the angle through which one set of four wires is turned with respect to the other set. An approximately exponential variation of Z_0 can be obtained by varying θ and the wire spacing in linear steps. The design and construction of such a line transforming from 131 to 262 Ω is described. See also 3023 of October.

621.396.67 **3794**

The Radiation Patterns of Dielectric Rods — Experiment and Theory.—R. B. Watson & C. W. Horton. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 159.) Summary of Amer. Phys. Soc. paper. The radiation pattern for a dielectric rod, obtained theoretically by considering an equivalent surface distribution of electric and magnetic currents, has been measured for polystyrene rods of rectangular cross-section and of length 3λ–10λ. The widths of the major lobes and the positions of the first two minor lobes agree well with theory for rod lengths up to 5λ, but the heights of the first minor lobes show poorer agreement.

621.396.67 : 534.232 **3795**

On the Radiation Problem [of a vibrating cylinder] **at High Frequencies.**—Lax & Feshbach. (*See* 3750.)

621.396.67 : 621.396.96 **3796**

Radar Antennas.—H. T. Friis & W. D. Lewis. (*Bell. Syst. tech. J.*, April 1947, Vol. 26, No. 2, pp. 219–317.) A comprehensive survey paper divided into three parts. Part 1 defines gain, effective area, free-space transmission loss, etc., and develops radiation-patterns of various basic ideal and amplitude-tapered apertures of uniform phase, large compared with the wavelength, by the Huyghens source method. The effects of square and cubic aperture phase variations, representing common practical illumination distortion, are also considered. Part 2 deals with methods of aerial construction; possible methods are classified and basic designs formulated. Parabolic aerials, metal plate lenses, cosecant aerials, and lobing and scanning techniques are considered in some detail. Part 3 details shipborne, airborne and ground radar aerials developed by the Bell Laboratories.

621.396.67 : [621.396.97 + 621.397.5 **3797**

Triplex Antenna for Television and F.M.—L. J. Wolf. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 88–91.) Details of a single four-bay super-turnstile aerial used for simultaneous operation of a f.m. transmitter and the visual and aural transmitters of a television station, with negligible coupling between transmitters. The power gain is 6.4 for f.m. and 5 for television.

621.396.67 : 621.396.97 **3798**

F.M. [broadcast] **Antenna uses Waveguide Principle.**—G. G. Greene. (*FM & Televis.*, July 1947, Vol. 7, No. 7, p. 38.) A new design requiring only two short waveguide sections arranged at right angles and fed 90° out of phase. High gain and freedom from icing are claimed.

621.396.67 : 621.397.5 **3799**

Television Aerials.—N. M. Best & R. D. Beebe. (*Wireless World*, Aug. 1947, Vol. 53, No. 8, pp. 293–295.) Design considerations are discussed in detail with special reference to the reflector array with $\lambda/8$ spacing. Curves indicate the comparison between $\lambda/4$ and $\lambda/8$ reflector spacing. The close-spaced array has a more even gain over the transmitting band and better signal/noise ratio in the sound channel.

621.396.671 **3800**

Partially-Screened Open Aerials.—A. Colino. (*Wireless Engr*, Aug. 1947, Vol. 24, No. 287, p. 248.) Comment on 2681 of September (Burgess).

621.396.671 : 621.317.79.083.7 **3801**

Theoretical and Experimental Study of a Feeder Reflectometer.—A. R. Volpert. (*Radiotekhnika, Moscow*, Feb. 1947, Vol. 2, No. 2, pp. 3–23. In Russian, with English summary.) Construction and operation of an instrument for remote measurement of the standing wave ratio in aerial feeders.

621.396.677 **3802**

Metal-Lens Antennas.—W. E. Kock. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, p. 391.) Summary of 1013 of April.

CIRCUITS AND CIRCUIT ELEMENTS

621.318.371.011.2/.4 **3803**

Q of Solenoid Coils.—R. G. Medhurst. (*Wireless Engr*, Sept. 1947, Vol. 24, No. 288, p. 281.) Author's reply to comment on 1694 of June by Callendar (3046 of October).

621.318.572 **3804**

Scale of N Counting Circuits.—B. Howland. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 138..178.) A generalized Eccles-Jordan circuit having N states of stable equilibrium can be obtained by interconnecting N valves symmetrically so that conduction in one valve cuts off current in all the others. This can be done with multigrid valves since conduction in any one valve will make the voltage of one grid in each of the others negative. The small number of sensitive grids in most valves sets an upper limit to N.

A diode-triode circuit avoids this limitation but requires too many valves to be practical. A simplification requiring relatively few valves and interconnections is obtained if each valve, when conducting, cuts off two valves opposite it in the circuit.

Decade counters can best be constructed by combining scale-of-5 and scale-of-2 counters.

621.318.572 **3805**

A Fast Coincidence Circuit with Pulse Height Selection.—P. R. Bell, S. DeBenedetti & J. E. Francis, Jr. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 160.) Summary of Amer. Phys. Soc. paper. A system using two channels: a pulse height selector and a differentiation and delay circuit, so enabling simultaneous or delayed coincidences between pulses (within specified height limits) to be determined to about 0.3 μs.

621.318.572 **3806**

A Diode Coincidence Circuit.—J. D. Shipman, Jr., B. Howland & C. A. Schroeder. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 181.) Summary of Amer. Phys. Soc. paper.

621.318.572 **3807**

Frequency Meter for Random or Uniformly Spaced Pulses.—H. L. Schultz. (*Rev. sci. Instrum.*, April 1947, Vol. 18, No. 4, pp. 223–225.) An electronic instrument "capable of operating at random rates of about 5 000 pulses per second on the average with less than 2% error caused by resolving time." A resolving time in the vicinity of 1 μs can be achieved. Provision is made for the operation of a counter at low rates.

621.318.572 **3808**

Tone Burst Generator.—R. G. Roush. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 92–96.) Four single-cycle multivibrators controlled by a free-running multivibrator serve as an adjustable electronic switch. Two circuits can be switched at the same adjustable repetition rate but with independently controllable duration and spacing times.

621.319.4 **3809**

Capacitor Manufacture.—(*Elect. Rev., Lond.*, 30th May 1947, Vol. 140, No. 3627, pp. 911–912.) Use of pilot plant for small-scale manufacture of new types, to ensure the highest possible quality in quantity production.

621.319.4 **3810**

Hermetic Low-Voltage Paper Capacitors.—I. I. Morozov. (*Radiotekhnika, Moscow*, Feb. 1947, Vol. 2, No. 2, pp. 51–62. In Russian with English summary.) Various methods are described for vacuum-tight seals and the electrical characteristics are given for various types of liquid and solid impregnants. Aging effects are discussed and accelerated life tests are described.

621.319.4 : 621.315.614.6 **3811**

Paper Capacitors containing Chlorinated Impregnants — Effects of Sulfur.—D. A. McLean, L. Egerton & C. C. Houtz. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, p. 392.) Summary of 655 of March. *Note*. U.D.C. of 655 should read as above.

621.38/.39] (084.2) **3812**

Graphical Symbols for Electronic Diagrams.—(*Electronics, Buyers' Guide Issue*, June 1947, Vol. 20, No. 6B, pp. 122–123.) A chart including new symbols proposed by the I.R.E.

621.392 **3813**

Response of Linear Resonant System to Excitation of a Frequency varying Linearly with Time.—G. Hok. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 159.) Summary of Amer. Phys. Soc. paper. Calculation by means of Laplace transforms yields a result in terms of Fresnel integrals of a complex variable.

The significant parameter in the result is logarithmic decrement/(rate of change of frequency)$^{\frac{1}{2}}$.

621.392 : 517.93 **3814**

A Note on Van Der Pol's Equation.—N. G. de Bruijn. (*Philips Res. Rep.*, Dec. 1946, Vol. 1, No. 6, pp. 401–406.) A criticism and extension of Shohat's work (3656 of 1944). A new theorem concerning the analytical behaviour of periodic solutions of the equation is proved. It is shown that the agreement between Shohat's work and earlier experimental and theoretical results is accidental.

621.392.4 **3815**

Cathode Phase Inverter Design.—C. W. Vadersen. (*Audio Engng*, June & July 1947, Vol. 31, Nos. 5 & 6, pp. 18–19..47 & 20–22, 47.) An analysis of unbalance caused by variation of circuit parameters. Practical examples of the intermediate and output stages of the inverter are given.

621.392.41 : 621.395.623.7 **3816**

Design and Construction of Practical Dividing Networks.—C. G. McProud. (*Audio Engng*, June 1947, Vol. 31, No. 5, pp. 15–17..46.) Simple details for a particular type of loudspeaker dividing network.

621.392.5 **3817**

Study of the Properties of Quadripoles by Impulse Response. General Method for the Realization of Electric Filters. Filters with Linear or 90° Phase Shift.—M. Lévy. (*Onde élect.*, July 1947, Vol. 27, No. 244, pp. 261–275.) A function, termed the impulse response, which completely defines a quadripole, can be deduced from the reciprocal integrals of Fourier. It gives the quadripole response to a pulse of infinitely short duration; the laws of variation with frequency of phase and of attenuation can be deduced from it, and conversely. A general study of this function is presented. In particular, if the impulse response has a vertical axis of symmetry, either the phase change of the quadripole is proportional to the frequency or the phase is equal to $\pi/2$ at all frequencies, according as the curve is even or odd with respect to this axis. From the fact that the impulse response can be produced by the addition of a multitude of reflections of the initial pulse in the quadripole, a general method is derived for the design of a quadripole having a pulse response of any form whatever. The theory is applied to the construction of filters; a low-pass filter with rigorously linear phase shift is described which gives an attenuation of about 30 db in the pass band. The following types of filters producing a phase shift of 90° at all frequencies can be constructed: (*a*) high-pass filters with satisfactory characteristics up to frequencies 10 to 20 times the cut-off frequency; (*b*) band-pass filters, if the bandwidth is not too small; (*c*) low-pass filters, if the lower frequency limit to be transmitted is not too low.

621.392.52 **3818**

Extension of Norton's Method of Impedance Transformation to Band-Pass Filters.—V. Belevitch. (*Elect. Commun.*, March 1947, Vol. 24, No. 1, pp. 59–65.) Some applications of a method of network analysis first discovered by E. L. Norton (U.S. Patent 1 681 554), and sometimes used in the design of band-pass filters, are considered. Norton's method can be extended in different ways, and in certain cases indicates the design of new and more economical structures for composite band-pass filters.

621.392.52 **3819**

Filter Design Tables based on Preferred Numbers.—H. Jefferson. (*Wireless Engr*, Aug. 1947, Vol. 24, No. 287, pp. 242–245.) For the design of constant-*k* band-pass filters having preferred values of capacitance. See also 2503 or 1946 and back references.

621.392.52.011.2 **3820**

The Direct Setting-Up of $Z_{\alpha\beta}$ for Closed-Mesh Networks from the Network Diagram: Part 2.—S. A. Stigant. (*Beama J.*, Feb. 1947, Vol. 54, No. 116, pp. 65–69.) Branch current axes are considered. Rules are given for setting up $Z_{\alpha\beta}$ for loop and branch currents, with or without mutual impedance. For part 1 see 2033 of July.

621.392.6 **3821**

The Constants of a Passive Network.—P. Satche. (*Rev. gén. Élect.*, June 1947, Vol. 56, No. 6, pp. 267–270.) The inequality relations which should be satisfied by the constants of an *n*-pole passive network are established. The equation giving the active power of a passive network is put into a simple form and the inequalities existing between the real parts of the impedances of the network, measured between terminals, are determined. The analogy is demonstrated between this problem and that of the existence of a polyhedron of *n* vertices in a space of (*n*-1) dimensions.

621.396.611.39 **3822**

Link Coupling.—(*Wireless World*, Aug. 1947, Vol. 53, No. 8, pp. 291–292.) An equivalent circuit is derived and the formula for optimum coupling deduced. It is stressed that the correct method of adjusting the link coupling between two coils is by altering the physical separation at one end of the link rather than the number of turns at both ends.

621.396.611.4 **3823**

Graphical-Numerical Method for the Calculation of Resonator Cavities.—M. Abele. (*Alta Frequenza*, June/Aug. 1947, Vol. 16, Nos. 3/4, pp. 174–191. In Italian, with English, French and German summaries.) For cavities bounded by a surface of revolution, the method gives the configuration of the electric field and enables the fundamental resonance frequency and the damping factor to be calculated. Two examples are given: (*a*) a cylinder of circular cross-section, (*b*) two coaxial cylinders, the inner one being the shorter.

621.396.611.4 : 537.533 **3824**
Cavity Resonators and Electron Beams.—A. H. Beck : J. H. Owen Harries. (*Wireless Engr*, Sept. 1947, Vol. 24, No. 288, pp. 280–281.) Comment on 2706 of September (Owen Harries) and the author's reply.

621.396.615 **3825**
Amplitude Control in RC Oscillators.—E. J. B. Willey. (*Wireless World*, June 1947, Vol. 53, No. 6, pp. 219–220.) An alternative to the use of a non-linear lamp resistance, as proposed by Terman and others (64 of 1940) consists in balancing two negative feedback networks which vary the feedback in opposite senses with frequency.

621.396.615 **3826**
Principles of Addition of Powers in Valve Oscillators.—Z. I. Model. (*Radiotekhnika, Moscow*, Jan. 1947, Vol. 2, No. 1, pp. 3–26. In Russian, with English summary.)

621.396.615.029.5 **3827**
Improvements in the H.F. Beat-Frequency Oscillator.—R. Aschen & M. Lafargue. (*T.S.F. pour Tous*, June 1947, Vol. 23, No. 224, pp. 127–131.) These comprise (*a*) suppression of parasitic f.m. when using a.m., (*b*) introduction of a f.m. stage, (*c*) reduction of the harmonics of the fixed oscillator and (*d*) improved output arrangements. For a description of the oscillator see 2358 of August or 1709 of June.

621.396.615.12 **3828**
A Bandswitching V.F.O. Exciter.—C. Hays. (*Radio News*, Sept. 1947, Vol. 38, No. 3, pp. 49–51, 183.) Covers the 10-, 20-, 40- and 80-m bands and uses a two-section ceramic wafer type switch. Both sections are of the single-pole 4-position type; the output section is non-shorting.

621.396.615.17 : 621.317.755 : 621.396.96 **3829**
Radial Time Bases.—G. W. A. Dummer & E. Franklin. (*Wireless World*, Aug. 1947, Vol. 53, No. 8, pp. 287–290.) Wartime development of the p.p.i. is described in some detail. The circuit diagram of an early type of timebase for electrostatically deflected tubes is given, together with the voltage waveforms in each stage. Difficulties encountered in the production of timebases for electromagnetic tubes are discussed.

621.396.621.54 **3830**
Superheterodyne Tracking Charts: Part 5.—A. L. Green. (*AWA tech. Rev.*, April 1947, Vol. 7, No. 3, pp. 295–325.) Methods of simplifying the computation of superheterodyne tracking errors are described. Much of the required design data is presented in the form of tracking charts. For parts 1–4 see 3830 of 1945 and back references.

621.396.622.63 : [546.28+546.289 **3831**
Silicon and Germanium Rectifiers.—(*Electronics, Buyers' Guide Issue*, June 1947, Vol. 20, No. 6B, pp. 140–147.) Lists of available types, with details of all necessary design characteristics except linear dimensions.

621.396.645 : 518.3 **3832**
Cathode Follower Impedance Nomograph.—M. B. Kline. (*Electronics*, July 1947, Vol. 20, No. 7, p. 130.) Relates output impedance, transconductance, and cathode load resistance. See also 3455 of November and 2717 of September.

621.396.645 : 535.61-15 : 621.383.4 **3833**
Two Amplifiers for PbS Photo-Cells used in Recording Infra-Red Spectra.—W. R. Wilson. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 156.) Summary of Amer. Phys. Soc. paper. A method for providing good signal/noise ratio at slow scanning speeds by chopping the infra-red beam and also the light from a tungsten lamp and feeding the corresponding photocell outputs to a balanced modulator.

621.396.645 : 621.396.822 **3834**
Background Noise in Amplifiers.—W. Roos. (*Tech. Mitt. schweiz. Telegr.-Teleph Verw.*, 1st Aug. 1947, Vol. 25, No. 4, pp. 143–147. In German.) The various sources of noise in preamplifiers and power amplifiers are discussed and suggestions are made for noise reduction.

621.396.645.029.3 **3835**
High-Quality Audio Amplifier with Automatic Bias Control.—J. R. Edinger. (*Audio Engng*, June 1947, Vol. 31, No. 5, pp. 7–9, 41.) Exceptionally low distortion and uniform response from 20 to 20 000 c/s. Power triodes in push-pull, with automatic bias control, give an output of up to 30 W.

621.396.645.029.62 **3836**
A 15-W Amplifier for V.H.F.—L. Liot. (*Télévis. franç.*, Aug. 1947, No. 28, Supplement *Électronique*, pp. 29–32.) Circuit details of the voltage amplifier, frequency tripler and doubler stages and final power stage of apparatus covering the range 50–100 Mc/s, with input of 1 V from a master oscillator.

621.396.645.36 **3837**
Push-Pull Phase-Splitter.—E. Jeffery. (*Wireless World*, Aug. 1947, Vol. 53, No. 8, pp. 274–277.) A new high-gain circuit is described in which the high input impedance of a cathode follower is used as the anode load of the preceding a.f. stage. The circuit diagram is given of a complete 14.5-W amplifier with a measured response variation within ±1 db from 25 to 20 000 c/s.

621.396.662 **3838**
Attenuators with Linear Response.—C. Dreyfus-Pascal & R. Gondry. (*Toute la Radio*, June 1947, Vol. 14, No. 116, pp. 179–181.) Combinations of suitably chosen resistors and capacitors give an attenuator with response linear up to 1 Mc/s.

621.396.662.3 : [621.395.61 : 534.43 **3839**
Simple RC Filters for Phonograph Amplifiers.—G. L. Rogers. (*Audio Engng*, June 1947, Vol. 31, No. 5, pp. 28–29 . . 48.) Designed for improved reproduction with magnetic type pickups.

621.396.662.3.029.3 3840
Tuned A.F. Filters: Part 2.—H. E. Styles. (*Wireless World*, Aug. 1947, Vol. 53, No. 8, pp. 282–284.) Design of a correction filter for a crystal pickup. For part 1 see 3486 of November.

621.396.69 + 621.396.621 3841
Robot makes Radios.—Hallows. (*See* 4010.)

GENERAL PHYSICS

53.081 3842
On the Absolute Systems of Electrical Units.—É. Brylinski. (*Rev. gén. Élect.*, May 1947, Vol. 56, No. 5, pp. 235–236.) Discussion shows that certain systems, particularly that of Gauss, can be used with advantage in the domain of pure theory, but for practical purposes a system is required involving only four fundamental units. See also 2383 of August and 1392 of May (Dorgelo & Schouten).

530.12 : 538.3 3843
On the Kinematics of Uniformly Accelerated Motions and Classical Electromagnetic Theory.—E. L. Hill. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, pp. 143–149.) "A study is made of the 4-dimensional conformal group of transformations in space-time as the extension of the Lorentz group permitting the introduction of uniformly accelerated reference frames into relativity theory. The problem of the motion of a particle is discussed, as well as the implications for the classical-type electron theory developed by Dirac."

534.11 : 621.392.092.64 3844
A Mechanical Analogy for Transverse Electric Waves in a Guide of Rectangular Section.—R. E. B. Makinson. (*J. sci. Instrum.*, July 1947, Vol. 24, No. 7, pp. 189–190.) If a stretched rubber strip is clamped at the edges and excited transversely at one end, its vertical displacement and slope at any point correspond to the electric and magnetic vectors respectively. Such a model can be used to predict the effects of various waveguide configurations on H_{0m} waves.

535.338 3845
The Molecular Beam Magnetic Resonance Method. The Radiofrequency Spectra of Atoms and Molecules.—J. B. M. Kellogg & S. Millman. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, p. 391.) Summary of 1731 of June.

535.343.31-31 : [546.212 + 546.212.02 3846
Inter-Molecular Vibration Spectrum of Water.—R. C. Johnson, R. C. Weidler & D. Williams. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 158.) Summary of Amer. Phys. Soc. paper. Studies of the spectra of liquid H_2O and D_2O between 1.5 μ and 24 μ. The observed absorption extends from 10 μ to 21 μ for H_2O, and from 12 μ to 22 μ for D_2O.

536.48 3847
Low-Temperature Physics and the Theory of Metals.—E. B. Mendoza. (*Metal Treatm.*, Spring 1947, Vol. 14, No. 49, pp. 20–28.) A description of the techniques used, including that for obtaining temperatures below 1°K by adiabatic demagnetization of a paramagnetic salt, together with an account of the impact of these techniques on the theory of atomic structure.

537.228.1 : 621.396.611.21 3848
Thermal Voltage of a Quartz Crystal.—R. K. Cook, M. Greenspan & P. G. Weissler. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 175.) Summary of Amer. Phys. Soc. paper. The mean-square noise voltage is given by C_1kT/C_0^2, where C_1 is the crystal capacitance and C_0 is the input capacitance of the amplifier plus the shunt capacitance of the crystal. The noise spectrum is concentrated in the region of the resonant frequency of the crystal. At 0.01°K the peak charge would be about 1 electron.

537.291 3849
Control of Electron-Beam Dispersion at High Vacuum by Ions.—L. M. Field, K. Spangenberg & R. Helm. (*Elect. Comm.*, March 1947, Vol. 24, No. 1, pp. 108–121.) Based on the book referred to in 4071 below. When a high-density electron beam is passed through a field-free drift space, a dispersion of the beam occurs at much higher gas pressures than was expected from previous theories. A new approximate theory of positive ion removal (i.e., from the beam) is given which has had considerable success in predicting the effects observed. Further, as a result of the new theory, an 'ion trap' has been invented which prevents such dispersion.

537.291 : 621.385.1.032.21 3850
Cathode-Design Procedure for Electron-Beam Tubes.—Helm, Spangenberg & Field. (*See* 4071.)

537.312.62 3851
The Practical Possibilities of Superconductivity.—K. M. Koch. (*Elektrotech. u. Maschinenb.*, July/Aug. 1947, Vol. 64, Nos. 7/8, pp. 125–130.) A review of present knowledge, including experimental results of many investigators, and a discussion of applications to magnetic screening, photocells and h.f. circuits. The importance of developing improved refrigeration technique is stressed. A new theory appears to be necessary to account for all the phenomena.

537.312.62 3852
The Magnetic Threshold Curves of Superconductors.—J. G. Daunt. (*Phys. Rev.*, 1st July 1947, Vol. 72, No. 1, pp. 89–90.) Discussion of experimental results favours the view that the threshold curves are approximately parabolic functions of temperature. The 3/2-power function suggested by Sienko and Ogg (*Phys. Rev.*, Vol. 71, p. 319) is not supported by known magnetic or calorimetric data.

537.312.62 : 621.396.622 3853
Radio Frequency Detection by Superconductivity.—D. H. Andrews & C. W. Clark. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 161.) Summary of Amer. Phys. Soc. paper. A r.f. voltage modulated at 400 c/s is detected by a strip of superconducting CbN. There are several temperature zones of detection which increase with applied d.c. but are independent of frequency. The intensity of detection varies widely with frequency.

537.5 3854
The Kelvin Lecture. Electrical Discharge through Gases.—L. B. Loeb. (*Electrician*, 2nd May 1947, Vol. 138, No. 3594, pp. 1162–1164.) A historical review of the subject.

537.523.3 3855
Notes on Impulse Corona Studies in Air.—H. J. Hall. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 185.) Summary of Amer. Phys. Soc. paper. Results obtained with positive and negative pulses up to 60 kV, of duration 1–2 μs and repetition rates 50–2 000 per sec.

537.525 : 621.385.18 3856
The Effect of a Direct Current Potential on the Initiation of a Radiofrequency Discharge.—F. Kirchner. (*Phys. Rev.*, 15th Aug. 1947, Vol. 72, No. 4, p. 348.) The effect discussed by Varela (2397 of August) was described by the author in 1925 (*Ann. Phys., Lpz.*, Vol. 77, p. 287) and a satisfactory explanation given.

537.531 : 535.341 3857
Contribution to the Study of the Measurement of the Absorption of X Rays by Matter.—J. Devaux. (*Ann. Radioélect.*, April 1947, Vol. 2, No. 8, pp. 109–132.) A complete account of the author's method (2069 of July) with practical apparatus details and applications to organic liquids, H, C, O, N and to the point-to-point study of the composition of a binary alloy.

537.56 : 535.61-31 3858
Ion-Content of Air irradiated by Ultraviolet Light.—G. R. Wait. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 158.) Summary of Amer. Phys. Soc. paper. The number and mobility of various types of ions were examined. The results suggest an explanation for the coincidence of radio fade-outs and solar flares.

537.583 : 621.385.1.032.216 3859
Variations in the Constants of Richardson's Equation as a Function of Life for the Case of Oxide Coated Cathodes on Nickel.—H. Jacobs & G. Hees. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 174.) Summary of Amer. Phys. Soc. paper.

538.11 3860
The Mechanism of Magnetic Attraction.—G.W.O.H. (*Wireless Engr*, Sept. 1947, Vol. 24, No. 288, pp. 253–254.) The observed effects are explained by considering the forces acting on orbital electrons in a non-uniform magnetic field.

538.221 3861
Ferromagnetic Resonance at Microwave Frequencies.—W. A. Yager & R. M. Bozorth. (*Phys. Rev.*, 1st July 1947, Vol. 72, No. 1, pp. 80–81.) 'Supermalloy' foils were used as the narrow walls of a resonant cavity formed from a section of rectangular guide. The cavity was connected through a standing wave detector to a 1.25-cm wavelength source; measurements were made of the apparent permeability as a function of the strength of a static magnetic field applied in the plane of the foils. From the characteristics of the sharp resonance phenomenon observed at H = 4920 oersteds, a value of 2.17 for the Landé splitting factor was derived. The experimental results were also consistent with a relaxation time of 1.2×10^{-9} sec, using a damping term of the form suggested by Frenkel. See also 747 of March (Griffiths).

538.3 3862
On the Electromagnetic Energy of an Isolated System.—L. Bloch. (*Rev. gén. Élect.*, June 1947, Vol. 56, No. 6, pp. 270–275.) Various classical expressions for electromagnetic energy are cited, including the case where the medium is the seat not only of charges and currents, but also of electric and magnetic moments. It is shown that the Maxwell-Lorentz theory includes a term of simple form for the interaction between the ether and matter. The possible use of a similar term is suggested when the electromagnetic field is replaced by a meson field and the electrons by neutrons. This would help in understanding the passage from electromagnetic physics to nuclear physics.

538.3 3863
Electromagnetic Field of Multipoles.—V. Berestetski. (*Zh. eksp. teor. Fiz.*, 1947, Vol. 17, No. 1, pp. 12–18. In Russian.)

538.56 3864
Electromagnetic Waves in a Vacuum: Relative Directions of the Electric and Magnetic Vectors.—G.W.O.H. (*Wireless Engr*, Sept. 1947, Vol. 24, No. 288, p. 277.) Comment on 3503 of November (Japolsky).

538.566 3865
Calculation of the Reflecting Power of an Arbitrarily Stratified System.—A. Herpin. (*C. R. Acad. Sci., Paris*, 21st July 1947, Vol. 225, No. 3, pp. 182–183.) A method using a matrix characteristic of each medium, such that the corresponding matrix for passage from the first to the last medium is simply the non-commutative product of the partial matrices. Reflection and transmission formulae are given. The method can be extended to isotropic layers for any incidence, double-refracting layers, etc.

538.569.4.029.64 3866
Paramagnetic Resonance Absorption at 9 000 Mc/s for Five Salts of the Iron Group.—R. L. Cummerow, D. Halliday & G. E. Moore. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 173.) Summary of Amer. Phys. Soc. paper.

538.569.4.029.64 3867
Stark and Zeeman Effects in Microwave Spectroscopy.—D. K. Coles & W. E. Good. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 157.) Summary of Amer. Phys. Soc. paper.

538.569.4.029.64 : 546.171.1 3868
Precision Frequency Measurements of Microwave Absorption Lines and Their Fine Structure.—W. E. Good & D. K. Coles. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 157.) Summary of Amer. Phys. Soc. paper. The absorption frequencies of ammonia and other gases have been measured with accuracy better than 1 in 10^6. Frequency markers 0.008 cm^{-1} apart are provided in the 1.25-cm region by harmonics from a 240-Mc/s crystal-controlled oscillator. When frequencies are plotted against rotational quantum numbers, the results show deviations from a smooth curve, which are interpreted as a K-type doubling for which only one component of the doublet exists. See also 3097 of October.

538.569.4.029.64 : 546.171.1 3869
Hyperfine Structure in the Microwave Spectrum of Ammonia.—R. J. Watts & D. Williams. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 157.) Summary of Amer. Phys. Soc. paper. Recent studies are discussed and the observed spacings and relative intensities of the satellite lines are compared with the theoretically predicted values.

538.569.4.029.64 : 546.171.1 **3870**

Collision Broadening of the Inversion Spectrum of Ammonia at Centimetre Wave-Lengths : Part 1 — Self-Broadening at High Pressure.—B. Bleaney & R. P. Penrose. (*Proc. phys. Soc.*, 1st May 1947, Vol. 59, No. 333, pp. 418–428.) Experiments on the absorption spectrum of ammonia between 0.6 and 0.9 cm^{-1} are described, and the absorptions at pressures of 10 and 60 cm Hg are compared with those computed from the measurements on individual lines at a pressure of 0.5 mm Hg (3507 of November) assuming that line widths are proportional to pressure. At 60 cm pressure the observed attenuation at the lower frequencies is greater than that computed ; reasons for this are discussed.

538.569.4.029.64 : 546.171.1 **3871**

[Suggested explanation of] **Anomalous Values of Certain of the Fine Structure Lines in the Ammonia Microwave Spectrum.**—H. H. Nielsen & D. M. Dennison. (*Phys. Rev.*, 1st July 1947, Vol. 72, No. 1, pp. 86–87.)

538.569.4.029.64 : 546.265.2 **3872**

The Microwave Absorption Spectrum of Carbonyl Sulfide.—R. E. Hillger, M. W. P. Strandberg, T. Wentink & R. L. Kyhl. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 157.) Summary of Amer. Phys. Soc. paper.

538.632 **3873**

On the Sign of the Hall Effect.—A. Carrelli. (*Nuovo Cim.*, 1st Feb. 1946, Vol. 3, No. 1, pp. 40–49. In Italian, with English summary.) A modern interpretation of the effect is considered and applied to Bi. Measurements of the Hall constants for Bi-Sb alloys are given and discussed.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.53 : 621.396.82 **3874**

The Radio Detection of Meteor Trails and Allied Phenomena.—E. V. Appleton & R. Naismith. (*Proc. phys. Soc.*, 1st May 1947, Vol. 59, No. 333, pp. 461–472. Discussion, pp. 472–473.) The results of observations of (*a*) transient bursts of atmospheric ionization and (*b*) abnormal or sporadic E-layer ionization, are described ; these effects are explained as due largely to sporadic meteors.

523.53 : 621.396.82 **3875**

Whistling Meteors.—D. W. Heightman : T. W. Bennington. (*Wireless World*, June 1947, Vol. 53, No. 6, p. 219.) Comment on 2407 of August (Garratt).

523.7 + 550.385]"1947.01/.03" **3876**

Solar and Magnetic Data, January to March, 1947, Mount Wilson Observatory.—S. B. Nicholson. (*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, p. 268.)

523.74 : 550.38 **3877**

A Slow Corpuscular Radiation from the Sun.—K. O. Kiepenheuer. (*Astrophys. J.*, May 1947, Vol. 105, No. 3, pp. 408–423.) Experimental data are presented showing that the solar filaments are sources of a slow corpuscular radiation having a mean speed of about 500 km/sec. Sunspots and coronal patches in the neighbourhood of the filaments destroy the correlation between the received corpuscular radiation and the filaments. The phenomena are also discussed from a theoretical standpoint ; the calculated corpuscular speed is in agreement with the observed value.

523.746 : 550.385 **3878**

Sunspots and Telegraphy.—C. H. Cramer. (*Elect. Engng, N.Y.*, June 1947, Vol. 66, No. 6, pp. 557–560.)

523.746"1947.01/.03" **3879**

Provisional Sunspot-Numbers for January to March, 1947.—M. Waldmeier. (*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, p. 174.)

523.75 : 550.385 **3880**

Magnetic Effects of Visible Solar Eruptions.—P. Bernard. (*C. R. Acad. Sci., Paris*, 30th June 1947, Vol. 224, No. 26, pp. 1811–1813.) Several instances are quoted where observed solar eruptions have been accompanied by sharp variations of one or more of the magnetic elements (H, V and D). A possible explanation is given of time discrepancies between eruptions and corresponding magnetic variations.

523.75 : 550.385 : 621.396.11 **388**

Solar Limb Flare and Associated Radio Fade-Out April 15, 1947.—E. T. Pierce. (*Nature, Lond.*, 12th July 1947, Vol. 160, No. 4054, p. 59.) Sever magnetic disturbances on April 17–18 and a majo radio fade-out on April 15 are correlated with th appearance of a flare on the south-west edge c the sun's disk on April 15.

537.591 **388**

Various Papers on Cosmic Rays.—(*Phys. Rev*, 15th July 1947, Vol. 72, No. 2, pp. 171–173 Summaries of the following papers at the Washing ton Meeting of the American Physical Society, Ma 1947 : The Latitude Effect of the Mesotron Con ponent up to Elevations of 35 000 Feet, by M Schein, P. S. Gill & V. Yngve. Discussion of Possible Method for Measuring Masses of Cosmic Ray Mesotrons, by W. H. Furry. Positive Exce of Slow Mesotrons at an Altitude of 11 500 Feet, b M. Correll. Theoretical Considerations on Larg Air Showers, by H. A. Bethe. Interpretation Cosmic-Ray Ionization Bursts in Cylindrica Chambers by Pulse Shapes, by H. Bridge. Study of the Structure of Air Showers 11 500 Feet, by R. W. Williams & B. Ros Cosmic-Ray Induced Nuclear Disintegrations 11 500 Feet, by B. Rossi & R. W. Williams. Hig Energy Cosmic-Ray Air Showers, by P. J. Ovrebo H. L. Kraybill. Atmospheric Showers of Cosm Rays, by C. G. Montgomery & D. D. Montgomer A V-2 Cosmic-Ray Experiment, by G. J. Perlo Further Cosmic-Ray Experiments Above t Atmosphere, by E. H. Krause & S. E. Golia Methods in Cosmic-Ray Measurement in Rocke by L. W. Fraser, R. P. Petersen, H. E. Tatel & J. Van Allen.

537.591 **38**

On the Measurement of the Intensity of Cosm Radiation by the Telescope Method.—S. A. Azimo V. I. Veksler, N. A. Dobrotin, G. B. Zhdanov A. L. Liubimov. (*Zh. eksp. teor. Fiz.*, 1947, Vol. 1 No. 1, pp. 79–86. In Russian.)

537.591 3884
Measurements of Cosmic Ray Intensity at 3 860 m and 5 000 m above Sea Level.—S. A. Azimov, V. I. Veksler, G. B. Zhdanov & A. L. Liubimov. (*Zh. eksp. teor. Fiz.*, 1947, Vol. 17, No. 1, pp. 87–91. In Russian.)

537.591 3885
On the Absorption and Disintegration of Mesons when Stopped.—M. Conversi, E. Pancini & O. Piccioni. (*Nuovo Cim.*, 1st Dec. 1946, Vol. 3, No. 6. pp. 372–390.)

537.591 3886
On the [cosmic ray] **Electron Component of the Lower Atmosphere.**—G. Bernardini, B. N. Cacciapuoti & B. Querzoli. (*Nuovo Cim.*, 1st Dec. 1946, Vol. 3, No. 6, pp. 349–371. In Italian, with English summary.)

537.591 3887
Measurement of the Slow Meson Intensity at Several Altitudes.—B. Rossi, M. Sands & R. F. Sard. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, pp. 120–125.)

537.591 : 5 3888
The Place of Cosmic Ray Research in the Physical Sciences.—P. M. S. Blackett. (*Sci. Culture*, May 1947, Vol. 12, No. 11, pp. 514–519.) The particles composing cosmic radiation are of fundamental importance because of their extremely high energy. Cosmic-ray research has also provided experimental confirmation of the existence of atomic particles predicted by nuclear theory, and has important connections with cosmology, geomagnetism and meteorology.

537.591.15 3889
Experimental and Theoretical Evaluation of the Density Spectra of Extensive Showers.—G. Cocconi, A. Loverdo & V. Tongiorgi. (*Nuovo Cim.*, 1st Feb. 1946, Vol. 3, No. 1, pp. 50–56. In Italian, with English summary.)

537.591.15 3890
The Transition Effect for Large Bursts of Cosmic-Ray Ionization: Part 2.—C. G. Montgomery & D. D. Montgomery. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, pp. 131–134.) For part 1 see *Phys. Rev.*, 1939, Vol. 56, p. 640.

538.12 : 521.15 3891
Magnetic Fields of Astronomical Bodies.—H. W. Babcock. (*Phys. Rev.*, 1st July 1947, Vol. 72, No. 1, p. 83.). " . . . within the uncertainties of the observations, the magnetic dipole moments of the earth, sun, and 78 Virginis . . . are proportional to their angular momenta. . ." On the assumption that this proportionality has universal application, numerical deductions are made concerning the magnetic moment of the Andromeda Nebula (M31). See also 3112 of October (Blackett) and 3892 below.

538.12 : 521.15 3892
On the Magnetism of Masses in Rotation.—A. Gião. (*C. R. Acad. Sci., Paris*, 30th June 1947, Vol. 224, No. 26, pp. 1813–1815.) It is shown that Blackett's formula for the magnetic moment of a quasi-spherical rotating mass (3112 of October) can be deduced very easily from the author's unitary theory of gravitation and electromagnetism (*Portugaliae Physica*, Vol. 2, 1, 1946, pp. 1–98; *Portugaliae Mathematica*, Vol. 5, 3, 1946, pp. 145–192). See also 3891 above.

550.372 3893
A New Method for the Determination of the Electric Constants of the Earth's Surface.—K. F. Niessen. (*Philips Res. Rep.*, Dec. 1946, Vol. 1, No. 6, pp. 465–475.) Two vertical transmitting dipoles are used, one situated immediately above the other, and the upper dipole is rotated slowly in a vertical plane. The phase difference is measured between the signals received from the two dipoles in a very distant high-flying aircraft moving towards the dipoles along a line in the plane of rotation of the upper dipole. From a knowledge of the two positions of the rotating dipole at which the phase difference is (*a*) zero, and (*b*) changes discontinuously by π, it is possible to calulate the dielectric constant and conductivity of the ground.

550.38"1945" 3894
Mean Monthly Values of Magnetic Elements, Christchurch, New Zealand, All Days of 1945.—H. F. Baird. (*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, p. 188.)

550.38"1946.07/.12" 3895
Five International Quiet and Disturbed Days for July to December 1946.—W. E. Scott. (*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, p. 265.)

550.384.4 : 551.594 3896
Electric Current as a Probable Cause of Daily Magnetic Variation.—K. Terada. (*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, pp. 189–200.) Translation of a Japanese paper read in 1941 at a meeting of the Physico-Mathematical Society of Japan.

Simple formulae are derived for estimating, from observed magnetic data, the height of the ionospheric current sheet which could cause the daily variations of the earth's magnetic field. It is concluded that the height is about 100 km, and that the implications of this result are in agreement with ionospheric radio-exploration data.

550.385"1931/1940" 3897
Dual Laws of the Course of Magnetic Disturbances and the Nature of Mean Regular Variations.—A. P. Nikolsky. (*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, pp. 147–173.) An analysis of magnetic storm data obtained from high-latitude observatories of the U.S.S.R., particularly Tikhaya Bay, during 1931–1940.

550.385"1947.01/.03" 3898
Principal Magnetic Storms [Jan.–March 1947].—(*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, pp. 270–288.)

551.51 : 525.624 3899
Atmospheric Oscillations.—(*Observatory*, Aug. 1947, Vol. 67, No. 839, pp. 128–131.) Report of Royal Astronomical Society discussion, January 1947.

551.510.5 : 525.624 : 550.384 3900
Terrestrial Influences in the Lunar and Solar Tidal Motions of the Air.—O. R. Wulf & S. B. Nicholson. (*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, pp. 175–182.)

3901
551.510.53
Exploration of the Upper Atmosphere by means of Rockets.—H. E. Newell, Jr. (*Sci. Mon., N.Y.*, June 1947, Vol. 64, No. 6, pp. 453–463.) Details of some of the special equipment used in V-2 rocket experiments at White Sands, New Mexico, including spectroscopy and cosmic-ray apparatus, telemetering, etc. A full account of the contribution of the Naval Research Laboratory is given in Upper Atmosphere Reports No. 1 & No. 2 (*Naval Research Laboratory Reports* R-2955 & R-3030, 1st Oct. & 30th Dec. 1946.)

3902
551.510.535
The True Height of an Ionospheric Layer.—J. A. Pierce. (*Phys. Rev.*, 15th May 1947, Vol. 71, No. 10, pp. 698–706.) A method is described "for the analysis of ionospheric sweep-frequency records in terms of the scale height and true height of maximum of the layer of Chapman form which most closely fits the observed data. It is shown that the height of maximum determined by the method of Appleton [395 of 1938], Booker, and Seaton [2145 of 1940] is the height of a parabolic layer which is not coincident with the parabola that most closely fits the Chapman distribution.

3903
551.510.535
On the Evaluation of the Parameter σ_0 in Chapman's Formula for determining the Ionic Density of the E Layer.—M. M. Sengupta & S. K. Dutt. (*Indian J. Phys.*, Feb. 1947, Vol. 21, No. 1, pp. 1–6.) σ_0 has a diurnal and seasonal variation between the limits 0.1 and 0.02 for latitudes 24° to 30° N or S.

3904
551.593.9 + 551.594.5
Emission Spectra of the Night Sky and Aurorae.—A. H. (*Observatory*, Aug. 1947, Vol. 67, No. 839, pp. 121–127.) Report of an international conference in London in July 1947.

3905
551.594
Currents of Atmospheric Electricity.—J. A. Chalmers & E. W. R. Little. (*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, pp. 239–260.) Description of recordings of the charge brought to an electrically isolated area by conduction and precipitation, and of the apparatus used. Point-discharge is also considered. Some special phenomena are analysed.

3906
551.594 : 550.384.4
Diurnal Variations of Computed Electric Currents in the High Atmosphere.—E. Sucksdorff. (*Terr. Magn. atmos. Elect.*, June 1947, Vol. 52, No. 2, pp. 201–215.)

3907
551.594.21
Some Aspects and Recent Results of Electromagnetic Effects of Thunderstorms.—H. A. Norinder. (*J. Franklin Inst.*, Aug. & Sept. 1947, Vol. 244, Nos. 2 & 3, pp. 109–129 & 167–207.) "A comprehensive article concerning the electromagnetic properties and effects of lightning discharges obtained at the Institute [of High Tension Research in the University of Uppsala, Sweden] mainly during the war time and up to date." See also 3804 of 1945 and 1784 of June.

3908
551.594.21
Atmospheric Electricity and Lightning.—J. Frenkel. (*J. Franklin Inst.*, April 1947, Vol. 243, No. 4, pp. 287–307.) Author's translation of a Russian paper. See also 2186 of 1946.

LOCATION AND AIDS TO NAVIGATION

3909
534.88 : 534.417
The German Use of Sonic Listening.—Holt. (*See* 3758.)

3910
621.396.933
Radio Technique in the Service of Long-Range Navigation [Loran].—E. Ya. Shchegolev. (*Nauka i Zhizn*, 1947, No. 2, pp. 2–7. In Russian.)

3911
621.396.933 : 621.396.96 : 629.139.83
Landing Aircraft with Ground Radar.—J. S. Engel. (*Elect. Commun.*, March 1947, Vol. 24, No. 1, pp. 72–81.) Description of a mobile equipment for assisting the landing of aircraft under conditions of poor visibility. A 10-cm search radar, replaced for the last 10 miles by a 3-cm precision radar, is operated from the airfield and corrects the course of the aircraft; appropriate instructions to the pilot are transmitted by R/T on a frequency in the band 100–150 Mc/s. The pilot is thus brought to a position 50 ft above the runway, after which landing is accomplished without further assistance from the ground.

3912
621.396.933 : 629.13.052
Radio Sounder for Measurement of Aircraft Height above Ground.—P. Giroud & L. Couillard. (*Ann. Radioélect.*, April 1947, Vol. 2, No. 8, pp. 150–172.) A f.m. transmitter on the aircraft radiates vertically downwards. The wave reflected from the ground is picked up on a separate receiving aerial and superimposed upon a fraction of the transmitted wave, giving a beat frequency which is directly proportional to the aircraft height. In the case of the 'Aviasol' apparatus, the beat frequency is read directly on a dial instrument with two ranges, 0–300 m and 0–1 500 m. Details are given, with photographs and circuit diagrams, of transmitter, receiver, dipole aerials and indicator.

3913
621.396.96
Basic Equations in Radiolocation.—S. I. Tetelbaum. (*Radiotekhnika, Moscow*, Feb. 1947, Vol. 2, No. 2, pp. 24–34. In Russian with English summary.) Relations are derived between the transmitted power, receiver sensitivity and the maximum range for non-radiating objects.

3914
621.396.96 : 621.396.615.17 : 621.317.755
Radial Time Bases.—Dummer & Franklin. (*See* 3829.)

3915
621.396.96 : 621.396.67
Radar Antennas.—Friis & Lewis. (*See* 3796.)

MATERIALS AND SUBSIDIARY TECHNIQUES

3916
531.788.7
The Design of an Ionization Manometer Tube.—D. L. Hollway. (*Proc. Instn Radio Engrs, Aust.*, April & May 1947, Vol. 8, Nos. 4 & 5, pp. 14–19 & 4–10.) A recently developed ionization manometer tube is described having a high sensitivity substantially independent of electrode potential variations. Published measurements of ionization efficiency are compared and used to predict the sensitivity with different gases. Errors from various causes are considered. The curves used in the sensitivity calculation apply to any design.

533.5 : 621.3.032.53 3917

Metal-Ceramic Brazed Seals.—R. J. Bondley. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 97–99.) A new method involves applying titanium hydride to the ceramic, then brazing to metals or similarly prepared ceramics with silver or any other metal that melts at 1 000° C. The resulting seals are strong and ideal for microwave valves.

533.5 : 621.3.032.53 3918

Glass-to-Metal Seals.—N. S. Freedman. (*Metal Ind., Lond.*, 23rd May 1947, Vol. 70, No. 21, pp. 378–380.) A plating process for the electrodeposition of silver on steel to withstand the temperatures encountered in the manufacture of h.f. valves.

535.37 3919

The Short-Period Time Variation of the Luminescence of a Zinc Sulphide Phosphor under Ultraviolet Excitation.—M. P. Lord, A. L. G. Rees & I. E. Wise. (*Proc. phys. Soc.*, 1st May 1947, Vol. 59, No. 333, pp. 473–502.) A photographic method described which permits observations up to 400 ms from the end of irradiation. The results are interpreted in terms of a bimolecular law, assuming two types of activating centre.

535.37 : 621.385.832 3920

The Efficiency of Cathodoluminescence as a Function of Current Density.—S. Lasof. (*Phys. Rev.*, 15th July 1947, Vol. 72,. No. 2, p. 165.) Summary of Amer. Phys. Soc. paper.

535.37 : 621.385.832 3921

Performance Characteristics of Long-Persistence Screens, Their Measurement and Control.—R. E. Johnson & A. E. Hardy. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 165.) Summary of Amer. Phys. Soc. paper. The efficiency of the primary-layer (phosphorescent) phosphor bears no consistent relation to screen performance, unless a method of pulsed light excitation is used. Average curves are given which show the variation of performance with baking temperature and the construction of the phosphor.

535.37 : 621.397.5 : 621.385.832 3922

Application of the I.C.I. Color System to the Development of the All Sulfide Television White Screen.—A. E. Hardy. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 166.) Summary of Amer. Phys. Soc. paper.

538.213 3923

Complex Permeability of Permalloy.—M. H. Johnson, G. T. Rado & M. Maloof. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, pp. 173–174.) Summary of Amer. Phys. Soc. paper. The behaviour of 45-Permalloy and Mo-Permalloy is similar to that of magnetic iron. For method of measurement see 2852 of September and 3182 and 3183 of October.

[.41/.431].64 : 621.385.1.032.21 3924

The Methods of Manufacture of Carbonates for Valve Cathodes.—C. Biguenet & C. Mano. (*Le Vide, Paris*, July/Sept. 1946, Nos. 4/5, 6 pp. Reprint.) Methods for the carbonates of Ba, Sr and Ca. The crystalline structure depends on the method used and this may account for observed differences in the emissive properties.

.0 : 537 : 546.331.2 3925

Elastic, Piezoelectric, and Dielectric Properties of Sodium Chlorate and Sodium Bromate.—W. P. Mason. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, pp. 391–392.) Summary of 752 of March.

549.514.51 3926

Variations in Crystal Quartz.—C. P. Glover & K. S. Van Dyke. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 175.) Summary of Amer. Phys. Soc. paper.

620.197 : 669.58 3927

Zinc Plating for Corrosion Resistance and Decorative Finishing.—W. F. Coxon. (*Metal Treatm.*, Spring 1947, Vol. 14, No. 49, pp. 38–40.)

620.197 : 679.5 3928

Stabilizing Electrical and Mechanical Characteristics of Circuits [by embedding them in a casting resin].—(*Electronics*, July 1947, Vol. 20, No. 7, pp. 136, 138.) A suitable resin, developed by the National Bureau of Standards, has the required h.f. characteristics, quick polymerization with small volume change at low temperature and atmospheric pressure, and low viscosity and surface tension, so that it penetrates into small openings.

Rubber jackets fitted round valves protect them from thermal and mechanical shock.

621.315.611.011.5 + 537.226.3 3929

The Relation between the Power Factor and the Temperature Coefficient of the Dielectric Constant of Solid Dielectrics : Part 5.—M. Gevers. (*Philips Res. Rep.*, Dec. 1946, Vol. 1, No. 6, pp. 447–464.) Results are given of measurements of the power factor and of the temperature coefficient of the dielectric constant of a number of well-known materials as functions of temperature and frequency. Anomalous cases are discussed. It is shown that all the experimental results are in accordance with the theory advanced in part 4 (3572 of November).

621.315.612.4 : 546.431.823 : 538.662.13 3930

Curie Point of Barium Titanate.—M. G. Harwood, P. Popper & D. F. Rushman. (*Nature, Lond.*, 12th July 1947, Vol. 160, No. 4054, pp. 58–59.) A range of temperatures, 122°–129°C, is found in which the tetragonal and cubic forms of $BaTiO_3$ coexist, the cubic phase appearing at 122°C and the tetragonal disappearing at 129°C. A high permittivity maximum is observed at 125°C.

621.315.616 3931

Low-Loss Plastic Insulation Materials.—J. H. Parliman. (*Electronics, Buyers' Guide Issue*, June 1947, Vol. 20, No. 6B, pp. 116–121.) Electrical, mechanical and chemical properties of materials commercially available are tabulated and briefly discussed.

621.315.616 3932

The Current-Creep Problem with Artificial [insulating] **Materials.**—B. Frischmuth. (*Schweiz. Arch. angew. Wiss. Tech.*, May 1944, Vol. 10, No. 5, pp. 156–160.) Discusses the mechanism of current creep and tracking. The author considers an irregular distribution of surface conductivity necessary for the occurrence of current creep.

621.315.62 : 621.315.612.6 3933

Toughened Glass Insulators.—(*Elect. Rev., Lond.*, 26th Sept. 1947, Vol. 141, No. 3644, pp. 461–466.) Description of production processes for pin-type (6.6–33 kV) and disk-type insulators for power lines with mechanical strengths up to 60 000 lb. See also 875 of 1941 (Hogg : E.R.A.).

621.316.99 **3934**

Present-Day Technique of Earthing of Electrical Installations.—D. Petrocokino. (*Rev. gén. Élect.*, May 1947, Vol, 56, No. 5, pp. 193–217.) A comprehensive review, including discussion of methods for protection of apparatus and personnel and for lightning protection, earthing of neutral points of power systems, etc. Consideration of shock effects shows that many old types of earth connection are very inefficient. Earthing technique requires revision.

621.318.2 **3935**

Permanent Magnets.—J. L. Salpeter. (*Proc. Instn Radio Engrs, Aust.*, April–July 1947, Vol. 8, Nos. 4–7, pp. 8–14, 10–17, 4–8 & 4–17.) A comprehensive discussion of (*a*) the demagnetization curve and the figure of merit for a permanent magnet, (*b*) the nature of ferromagnetism and ferromagnetic alloys, and (*c*) magnetic anisotropy and magnetic hardness.

621.318.2 : 518.4 **3936**

Permanent Magnets.—"Cathode Ray". (*Wireless World*, Aug. 1947, Vol. 53, No. 8, pp. 300–306.) Methods for obtaining the data necessary for the design of a permanent magnet with given air-gap dimensions and flux density. General procedures, based on the relations between magnetic flux, reluctance and magnetomotive force, are deduced by analogy with Ohm's law. Approximate graphical methods are outlined, using data obtainable from the B-H curve, and are illustrated by practical examples.

621.318.22 **3937**

Modern Magnetic Materials.—H. E. Finke. (*Materials & Methods*, June 1947, Vol. 25, No. 6, pp. 72–76.) Comparison of the physical and mechanical properties of modern magnetic alloys including the alnicos, cunife, cunico, vectolite and silmanal.

621.318.323.2.042.15 **3938**

Permeability of Dust Cores.—P. R. Bardell. (*Wireless Engr*, Aug. 1947, Vol. 24, No. 287, p. 249.) Reply to 3163 of October (Friedlaender).

621.318.323.042.15 **3939**

Permeability of Dust Cores.—H. W. Lamson. (*Wireless Engr*, Sept. 1947, Vol. 24, No. 288, pp. 267–270.) Expressions are derived for the longitudinal and transverse permeabilities of dust cores in terms of the dimensions of the magnetic granules, and other parameters. The ratios of the longitudinal to the transverse permeabilities are functions of the elongation of the granules; measurements of these permeabilities, made on a molybdenum-permalloy dust core, confirm Bardell's hypothesis of granular elongation (1693 of June). See also 3555 of November and back references.

621.357.9 : 669.27-426 **3940**

An Electrolytic Method for pointing Tungsten Wires.—W. G. Pfann. (*Metals Technol.*, June 1947, Vol. 14, No. 4, TP2210, 4 pp.) For forming points on wires 0.002–0.01 inch in diameter such as are required in crystal rectifiers. An aqueous potassium hydroxide solution containing a certain amount of copper is used as the electrolyte. Summary in *Metal Ind., Lond.*, 8th Aug. 1947, Vol. 71, No. 6, pp. 110, 112.

621.775.7 : 016 **3941**

Powder Metallurgy: An Indexed Bibliography of the Literature: Part 1.—G. H. S. Price. (*Metal Treatm.*, Spring 1947, Vol. 14, No. 49, pp. 42–65.) Over 600 references are given.

621.775.7 : 669.337 **3942**

Electrolytic Copper Powder.—(*Metal Ind., Lond.*, 12th Sept. 1947, Vol. 71, No. 11, pp. 226–227.) Abstract of B.I.O.S. report on production methods in Germany.

621.791.353 : 669.018.21 **3943**

Metallic Joining of Light Alloys: Parts 5-7.—(*Light Metals*, May, June & July 1947, Vol. 10, Nos. 112, 113 & 114, pp. 214–223, 273–275 & 365–368.) Application of electrical fusion to the joining of Al wire and strip; survey of patent literature on typical apparatus; theory and techniques of flame welding of Al. For parts 1–4, see 2152 of July and 2467 of August. To be continued.

621.946.148.12 **3944**

New Diamond Die Drilling Method revolutionizes Industry.—(*J. Franklin Inst.*, May 1947, Vol. 243, No. 5, pp. 424–428.) A new method for small dies used in drawing and shaping extremely hard and fine wire has been developed at the National Bureau of Standards. The process is carried out in ten steps combining h.v. electrical, l.v. electrolytic, and mechanical drilling, requires no specially skilled operators, produces better dies and saves almost 100 man-hours compared with older processes. For a complete account see *Bur. Stand. J. Res.*, May 1947, Vol. 38, No. 5, pp. 449–464 (C. G. Peters et al.).

669.14 : 538.652 : 621.314.1/.2 **3945**

Magnetostriction of Transformer Steel subjected to Thermomagnetic Treatment.—Ya. S. Shur & A. S. Khokhlov. (*Zh. eksp. teor. Fiz.*, 1947, Vol. 17, No. 1, pp. 7–11. In Russian.)

669.152.5 **3946**

A New Magnetic Alloy.—(*Machinery, Lond.*, 8th May 1947, Vol. 70, No. 1802, p. 490.) 'Hiperco,' a new ductile alloy for motors and generators. For another account see 2820 of September.

678 : 016 **3947**

Advances in Rubber during 1946.—E. F. Riesing & J. O. Callouette. (*Mech. Engng, N.Y.*, May 1947, Vol. 69, No. 5, pp. 373–379.) A review of developments in synthetic and natural rubbers, vulcanization, etc., with a bibliography of 174 papers.

679.5 : 016 **3948**

Advances in Plastics during 1946.—H. M. Richardson. (*Mech. Engng. N.Y.*, May 1947, Vol. 69, No. 5, pp. 370–372, 382.) A short review of progress with a bibliography of 118 papers.

679.5 **3949**

British Catalogue of Plastics. [Book Review]—E. Molloy (Ed.). National Trade Press, London, 704 pp., 50s. (*Elect. Rev., Lond.*, 6th June 1947, Vol. 140, No. 3628, p. 930.) "This guide to selection, processing and uses is encyclopaedic in character and dimensions. . . . Specialist articles by thirty-five contributors are followed by makers' recommendations on moulding, fabricating and nishing. . . . A too-brief reference to uses in the lectrical industry is mainly illustrative, while nine ages are devoted to the radio industry."

MATHEMATICS

17.9 3950
Perturbations of Discontinuous Solutions of Non-inear Systems of Differential Equations.—N. evinson. (*Proc. nat. Acad. Sci., Wash.*, July 947, Vol. 33, No. 7, pp. 214–218.)

7.93 : 621.392 3951
A Note on Van Der Pol's Equation.—de Bruijn. *ee* 3814.)

18.5 3952
Recent Developments in Calculating Machines.— R. Hartree. (*J. Sci. Instrum.*, July 1947, ol. 24, No. 7, pp. 172–176.) Based on a lecture the Manchester and District Branch of the stitute of Physics, similar to the account noted 2480 of August. Photographs of parts of recent S. machines are here included.

8.5 3953
High-Speed Electronic Digital Computers.—(*J. anklin Inst.*, April 1947, Vol. 243, No. 4, pp. 3–326.) A short account of developments con-nplated in connection with the production by the tional Bureau of Standards of two electronic nputers for the Bureau of Census and the ice of Naval Research.

.5 3954
An Electronic Computer for Crystal Structure alyses.—R. Pepinsky. (*Phys. Rev.*, 15th July 7, Vol. 72, No. 2, p. 175.) Summary of Amer. ys. Soc. paper. For computation of two-dimen-ial Fourier series connected with electron sities in a crystal unit cell. The method is ed on that of Bragg for the summation of simu-d interference fringes.

MEASUREMENTS AND TEST GEAR

.7 3955
Modern Methods of Timekeeping.—(*Observatory*, . 1947, Vol. 67, No. 839, pp. 132–136.) Report Royal Astronomical Society discussion, March 7, when the relative merits of various methods, uding astronomical observation and pendulum quartz clocks, were considered.

317.081.3 — 53.081.3 3956
he Impending Change in the Electrical Units.— 3. Silsbee. (*Phys. Rev.*, 15th July 1947, Vol. 72, 2, p. 159.) Summary of Amer. Phys. Soc. er. See also 2833 and 2834 of September.

317.1.011.5 : 621.392 3957
rude's Second Method applied to the Measurement ielectric Permeabilities and to the Determination ipole Moments on the $\lambda = 10$ cm Wave.—A. P. ustin. (*Zh. eksp. teor. Fiz.*, 1947, Vol. 17, , pp. 30–40. In Russian, with English summary.) nagnetron with a ribbon circuit was used to sure the dielectric permeabilities of various ry systems and the dipole moments of molecules.

317.3 : 621.392.029.64 3958
efinition and Measurement of the Coefficient of ction in Waveguides.—Ortusi. (*See* 3788.)

621.317.333 + 621.317.37] : 621.315.212.029.6 3959
The Voltage Characteristics of Polythene Cables.—R. Davis, A. E. W. Austen & W. Jackson. (*J. Instn elect. Engrs*, Part I, June 1947, Vol. 94, No. 78, pp. 283–284.) Summary of 3179 of October.

621.317.336 + 621.317.733 3960
H.F. Impedance Measurements. [Impedance] Bridge for the Range 10 kc/s-6 Mc/s.—L. Katchat-ouroff & R. Delavenne. (*Câbles & Transmission, Paris*, April 1947, Vol. 1, No. 1, pp. 61–76. With English summary.) A discussion of the principal features of various types of impedance bridges and a description of a new bridge with equal ratio arms. Special attention was paid to the elimination of parasitic impedances. Results are given of tests made by the Laboratoire National de Radioélec-tricité.

621.317.336 3961
Impedance Measurements at V.H.F.—E. G. Hills. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 124–128.) In the region from 44 to 216 Mc/s the slotted transmission line is a simple device for measuring impedances. When used with a variable-reactance line that balances out reactive impedances, accuracy of measurement is increased and the apparatus can be readily adapted to measurements of aerial phasing and directivity. The method is suitable for large and rapid changes of frequency.

621.317.34 3962
Highly-Selective Transmission-Measuring Equip-ment for Communication Circuits.—D. G. Tucker. (*J. Instn elect. Engrs*, Part I, June 1947, Vol. 94, No. 78, p. 282.) Summary of 3181 of October. The full paper is also published in *J. Instn elect. Engrs*, Part II, June 1947, Vol. 94, No. 39, pp. 247–252.)

621.317.374 3963
A New Alternating Current Bridge for Precision Measurements.—J. W. L. Köhler & C. G. Koops. (*Philips Res. Rep.*, Dec. 1946, Vol. 1, No. 6, pp. 419–446.) A detailed description of a bridge permitting the use of ratios of 1, 10, 100 and 1 000 : 1. With any of these ratios phase differences may be measured with errors not exceeding 10^{-6} radian at frequencies between 1 and 100 kc/s. Using a variable air capacitor of 50 to 15 000 pF as a secondary standard, the losses of any capacitor between 50 pF and 1 μF can be measured.

The construction allows the ratio to be changed quickly and conveniently. The final design con-sists of a fixed centre part having four points to which the four branch impedances are connected. An exhaustive analysis of the various factors affecting the performance of the bridge is given.

621.317.39 : 531.765 3964
A Millisecond Chronoscope.—R. S. J. Spilsbury & A. Felton. (*J. Instn elect. Engrs*, Part I, June 1947, Vol. 94, No. 78, p. 284.) Summary of Measure-ments Section paper. A portable instrument of simple design. The range is 2.0–1 000 ms and accuracy is of the order of 0.5 ms for short intervals and 0.5% for long intervals. Another summary noted in 1137 of April.

621.317.726 3965
A Pulse Peak Kilovoltmeter.—L. U. Hibbard. (*J. sci. Instrum.*, July 1947, Vol. 24, No. 7, pp. 181–186.) The instrument measures pulses of

length greater than 0.25 μs, recurrence frequency not less tha 50 c/s, and maximum amplitude 30 kV, to an accuracy of 3%. The attenuator is of the capacitor type and incorporates guard rings, so that its characteristics can be calculated accurately. The effects of stray capacitance and of pulse characteristics on the accuracy are discussed.

621.317.738 : 621.385.1 3966
A Radio-Frequency Interelectrode-Capacitance Meter.—F. J. Lehany & W. S. McGuire. (*A.W.A. tech. Rev.*, April 1947, Vol. 7, No. 3, pp. 271–282.) The design and calibration of the instrument, which is direct reading in the range 0.000 1–2 pF. A system of interchangeable shielded panels enables it to be used for a wide variety of valves, with accuracy within 5%.

621.317.76 : 621.396.621.54 3967
Measurement of Superheterodyne Tracking Errors.—H. A. Ross & P. M. Miller. (*A.W.A. tech. Rev.*, April 1947, Vol. 7, No. 3, pp. 327–336.) The nominal i.f. of the receiver is heterodyned against a crystal oscillator adjusted to the exact value. The frequency of the resultant beat note is used as a measure of the tracking error over the tuning range.

621.317.79 : 621.315.212 3968
Theory and Design of the Reflectometer.—B. Parzen & A. Yalow. (*Elect. Commun.*, March 1947, Vol. 24, No. 1, pp. 94–100.) The 'reflectometer' has been designed for the measurement of standing wave ratios, reflection coefficient, and power transfer on coaxial lines operated at frequencies of 1 000 Mc/s and below.

621.317.79 : 621.396.615.12 3969
A Signal Generator for Frequency and Amplitude Modulation.—W. S. McGuire. (*A.W.A. tech. Rev.*, April 1947, Vol. 7, No. 3, pp. 283–293.) Output in the range 3–14 Mc/s is obtained by the beat-frequency method, using a variable-frequency oscillator tunable over the range 23–34 Mc/s and a constant-frequency 20-Mc/s oscillator, derived by multiplication from a 5-Mc/s oscillator to which f.m. is applied by a reactance valve, with a maximum deviation of ± 25 kc/s, giving a maximum deviation of ± 100 kc/s in the output. A 400-c/s modulation oscillator is included and provision made for a.m.

621.317.79 : 621.396.615.12 3970
The Standard Generator, 10 kc/s-55 Mc/s, of the Société Alsacienne de Constructions Mécaniques (S.A.C.M.).—G. Couanault & P. Herreng. (*Câbles & Transmissions, Paris*, July 1947, Vol. 1, No. 2, pp. 155–162. With English summary.) Full details of a generator for which amplitude modulation from 0 to 100% can be provided by a 400-c/s internal oscillator or by an external source of frequency (*a*) 30 c/s–15 kc/s, (*b*) 50 c/s–3 Mc/s, or by a telegraph relay.

3971
621.317.79 : 621.396.615.12] : 621.396.621.001.4
Central Signal Generator for [receiver] **Production Testing.**—F. Miller. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 100–105.) Modulated frequencies are supplied to 25 test stations. Coupling, impedance matching, attenuator design, radiation and leakage are discussed.

621.317.79.089.6 : 621.396.615.12/.14 3972
A Method of calibrating Standard-Signal Generators and Radio Frequency Attenuators.—G. F. Gainsborough. (*J. Instn elect. Engrs*, Part I, June 1947, Vol. 94, No. 78, pp. 280–281.) Summary of 3202 of October.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.321.7/.9].001.8 3973
Applications of Sonic and Ultrasonic Vibrations.—A. A. McKenzie & F. Rockett. (*Electronics, Buyers' Guide Issue*, June 1947, Vol. 20, No. 6B, pp. 140–141.) A list, arranged according to frequency, ranging from the killing of germ life in canned foods to submarine detection and the emulsification of immiscible liquids.

534.321.9.001.8 : 621.396.611.21 3974
Laboratory Supersonic Generators and Their Applications.—Tscherning. (*See* 3757.)

537.531 : 535.341 3975
Contribution to the Study of the Measurement of the Absorption of X Rays by Matter.—Devaux. (*See* 3857.)

537.533.8 3976
A Microwave Secondary Electron Multiplier.—M. H. Greenblatt & P. H. Miller, Jr. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 160.) Summary of Amer. Phys. Soc. paper. Electrons are accelerated between two flat plates by a 3 000-Mc/s field whose strength is such that the transit time is a half-period, and are finally drawn off, after secondary multiplication, by a positive collector.

539.16.08 3977
Portable Geiger-Müller Counters.—W. Hushley & K. Feldman. (*Canad. J. Res.*, May 1947, Vol. 25, Sec. F, No. 3, pp. 226–235.) A description of three types of portable G-M counter suitable for field use. The high voltage in each tube is supplied by means of a multivibrator circuit, and the pulse from the tube is fed to a trigger circuit which operates headphones. Details of circuit design and application are given.

539.16.08 3978
A General Method for determining Coincidence Corrections of Counting Instruments.—T. P. Kohman. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 181.) Summary of Amer. Phys. Soc. paper.

539.16.08 3979
Fluctuations for Proportional Counters.—H. S. Snyder. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 181.) Summary of Amer. Phys. Soc. paper.

539.16.08 398
Properties of Ion Counters operating at Low Potentials.—J. A. Simpson, Jr. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 181.) Summary of Amer. Phys. Soc. paper.

539.16.08 398
Low Voltage Self-Quenching Counters.—S. H. Liebson. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, pp. 181–182.) Summary of Amer. Phys. Soc. paper.

539.16.08 3982

The Discharge Mechanism of Self-Quenching G-M Counters.—S. H. Liebson. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 187.) Summary of Amer. Phys. Soc. paper.

539.16.08 : 537.525.3 : 621.316.722.078.3 3983

The Voltage Stabilization Properties of the Continuous Corona Discharge.—I. H. Blifford & H. Friedman. (*Phys. Rev.*, 15th July, 1947, Vol. 72, No. 2, p. 185.) Summary of Amer. Phys. Soc. paper. An electronic stabilizer using positive wire continuous corona discharge between coaxial cylinders provides regulation to 0.1% at 40 kV for loads up to 10 mA. See also 1596 of May.

551.508.1 3984

A Coding Radiosonde of Rational Design.—N. Gibbs, L. Gibbs & E. W. Pike. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 160.) Summary of Amer. Phys. Soc. paper. Meteorological data are converted into Morse letter groups, so that only a receiver is required on the ground. The sonde construction is simple and economical.

621.316.7 : 621.313.2/.3]-9 3985

Basic Procedures in Motor Control: Parts 2-4.—G. W. Heumann. (*Gen. elect. Rev.*, June–Aug. 1947, Vol. 50, Nos. 6–8, pp. 41–46, 41–48 & 40–51.) D.c. shunt and compound motors, amplidyne control circuits and a.c. induction motors. Part 1, 3212 of October.

621.316.726 : 621.313.333 3986

Adjustable Frequency Control of High-Speed Induction Motors.—G. W. Heumann. (*Elect. Engng, N.Y.*, June 1947, Vol. 66, No. 6, pp. 576–579.) Abridged version of A.I.E.E. paper. Details of amplidyne and thyratron control systems.

621.317.792 3987

A Lightning Warning Device.—B. F. J. Schonland & P. G. Gane. (*Trans. S. Afr. Inst. elect. Engrs*, April 1947, Vol. 38, Part 4, pp. 119–123. Discussion, pp. 123–125.) The device gives audible warning of the occurrence of flashes within about 5 or about 20 miles, according to the position of a switch. Corona current in the aerial is used to give warning of imminent nearby flashes to ground.

621.318.572 3988

Electronic Relays.—R. van Steenkiste. (*Bull. sci. Ass. Inst. Montefiore*, July 1947, Vol. 60, No. 7, pp. 193–199.) Describes the use of triodes, thyratrons, photoelectric cells and neon tubes as relays for d.c. or a.c. circuits.

621.318.572 3989

A Diode Coincidence Circuit.—J. D. Shipman, Jr., B. Howland & C. A. Schroeder. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 181.) Summary of Amer. Phys. Soc. paper.

621.318.572 : 531.76 3990

Interval Timer.—E. L. Deeter & W. K. Dau. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 86–87.) Timing periods in 0.1-second increments for the range 0.1 to 100 seconds can be set up on direct reading dials. The period depends upon reduction of control-tube bias by discharge of an RC circuit."

621.38 : 621.791.7 3991

Electronic Welding Equipment.—M. Félix. (*Bull. sci. Ass. Inst. Montefiore*, June 1947, Vol. 60, No. 6, pp. 163–175.) A general description of methods and apparatus for spot and seam welding, and butt resistance welding, including the use of thyratrons and ignitrons.

621.38.001.8 3992

Industrial Applications of Electronic Techniques.—H. A. Thomas. (*J. Instn elect. Engrs*, Part I, July 1947, Vol. 94, No. 79, pp. 309–331. Discussion, pp. 331–338.) Full paper. Summary noted in 2523 of August. A bibliogrophy of 81 papers is included.

621.38.001.8 3993

Electronics — A New Branch of Technics.—S. E. Teleshevski. (*Nauka i Zhizn*, 1947, No. 2, pp. 8–12. In Russian.) Short historical survey.

621.38.001.8 3994

Electronics in Measurement.—L. G. Gitzendanner. (*Gen. elect. Rev.*, Aug. 1947, Vol. 50, No. 8, pp. 24–29.) Descriptions of a photoelectric recorder, spectrophotometer, vibration-velocity meter and other devices.

621.383.001.8 : 535.247.4 3995

Sensitive Photoelectric Photometer.—F. T. Gucker, Jr. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 106–110.)

621.384 + 621.319.3 3996

The Palletron, a New Electron Resonator and Its Proposed Application to the Generation of Potentials in the Million-Volt Range.—A. M. Skellett. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 180.) Summary of Amer. Phys. Soc. paper. Design of a proposed megavolt voltage generator, with experimental results on a small model.

621.384 3997

The Electron Mechanics of Induction Acceleration.—J. A. Rajchman & W. H. Cherry. (*J. Franklin Inst.*, April & May 1947, Vol. 243, Nos. 4 & 5, pp. 261–285 & 345–364.) The equations of electron motion in the betatron are developed and, with the aid of a potential function, previously reported conditions of equilibrium, stability and oscillation damping are derived for the region of parabolic and of non-parabolic variation of the potential. The application of an auxiliary radial electric field is discussed in detail without materially complicating the analysis. Experimental work complementing the theory is described.

621.384 : 621.396.611.4 3998

Acceleration of Electrons by a Single Resonant Cavity.—F. L. Hereford, Jr. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, pp. 159–160.) Summary of Amer. Phys. Soc. paper. Energies of 0.75 MeV at 17 μA were obtained from a cavity resonant at λ 75 cm. using a pulse length of 4 μs and 60 pulses/sec. The energy spectrum is remarkably narrow, about 50 keV. See also 2997 of 1946 (Bowen, Pulley & Gooden).

621.384 : 621.396.611.4.029.62 3999

Cavity Accelerator for Electrons.—H. L. Schultz, R. Beringer, C. L. Clarke, J. A. Lockwood, R. L. McCarthy, C. G. Montgomery, P. J. Rice & W. W. Watson. (*Phys. Rev.*, 15th Aug. 1947, Vol. 72, No. 4, pp. 346–347.) A linear electron accelerator consisting of a series of cylindrical cavities, operating in the TM_{010} mode, which are not mutually coupled. Frequency and phase coherence in the separate cavities are provided by a master oscillator driving separate power amplifiers for the excitation of the various cavities. The system is designed for pulse operation at 580 Mc/s.

621.384.6 **4000**
Note on the 2.8 MeV Betatron.—W. B. Lasich & L. Riddiford. (*J. sci. Instrum.*, July 1947, Vol. 24, No. 7, pp. 177–179.) The construction and operation of a small laboratory betatron having a total ionization intensity equivalent to 1 gm of radium.

621.385.1.001.8 : 531.768.087 **4001**
A Vacuum Tube for Acceleration Measurement.—W. Ramberg. (*Elect. Engng, N.Y.*, June 1947, Vol. 66, No. 6, pp. 555–556.) For another account see 2528 of August.

621.385.833 **4002**
Experimental Determination of Astigmatism and of the Focal Surfaces in Electron Optics.—A. Cazalas. (*C. R. Acad. Sci., Paris*, 21st July 1947, Vol. 225, No. 3, pp. 178–180.)

621.385.833 **4003**
Limit of Resolution of the Decentred Electrostatic Objective.—H. Bruck. (*C. R. Acad. Sci., Paris*, 30th June 1947, Vol. 224, No. 26, pp. 1818–1820.) A formula is derived by considering the objective as made up of three independent elementary lenses, the two outer ones weakly divergent and the central one strongly convergent.

621.398+621.314.12 **4004**
Electric Positioning Systems of High Accuracy for Industrial Use.—D. E. Garr. (*Gen. elect. Rev.*, July 1947, Vol. 50, No. 7, pp. 17–24.) Description of a system using selsyns, valves, an amplidyne and a d.c. motor.

PROPAGATION OF WAVES

538.566.2 **4005**
Refraction of Plane Non-Uniform Electromagnetic Waves between Absorbing Media.—L. Pincherle. (*Phys. Rev.*, 1st Aug. 1947, Vol. 72, No. 3, pp. 232–235.) It is shown that after refraction there are two possible positions for the propagation vector in the second medium. Energy flow considerations show that each solution holds within a certain range of values of the (complex) angle of incidence, the transition between the two solutions being discontinuous. Polarizations perpendicular and parallel to the plane of incidence are considered.

621.396.11 **4006**
Observations on the Propagation of Ultra-Short Waves.—G. Latmiral & G. Barzilai. (*Alta Frequenza*, June/Aug. 1947, Vol. 16, Nos. 3/4, pp. 147–173. In Italian, with English, French and German summaries.) A critical discussion. It is pointed out that the phase diagram of aerials above the earth must be considered, that the radiation diagram may not be independent of distance and that reflection must not be supposed to occur at a single point. The finite dimensions of the reflecting zone, when the earth's surface is uneven, can produce notable variations in the signal strength of the reflected ray. U.s.w. fading may be reduced by the use of aerials connected together without phase synchronism.

621.396.11 **4007**
Radio-Wave Propagation and Electromagnetic Surface Waves.—P. S. Epstein. (*Proc. nat. Acad. Sci., Wash.*, June 1947, Vol. 33, No. 6, pp. 195–199.) A short critical account of the development of Sommerfeld's classical theory. Another interpretation of Sommerfeld's equations, hitherto overlooked, shows that the surface-wave is not generated by the aerial and can have an independent existence.

621.396.11.029.58 : 551.510.535 **4008**
Doppler Effect in Propagation.—R. E. Burgess: F. S. Atiya : L. Essen : H. V. Griffiths. (*Wireless Engr*, Aug. & Sept. 1947, Vol. 24, Nos. 287 & 288, pp. 248–249 & 279–280.) Criticism and correction of a statement by Griffiths (3254 of October) which implied that absolute velocity could be measured, thereby flouting the principles of relativity.

621.396.812.029.64 **4009**
Further Observations of the Angle of Arrival of Microwaves.—A. B. Crawford & W. M. Sharpless. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, p. 389.) Summary of 1183 of April.

RECEPTION

621.396.621 + 621.396.69 **4010**
Robot makes Radios.—R. W. Hallows. (*Radio Craft*, Sept. 1947, Vol. 18, No. 12, pp. 20–21, 81.) Another account of the E.C.M.E. (Electrical Circuit Making Equipment) described in 1913 of June (Sargrove).

621.396.621 **4011**
A New Approach to F.M./A.M. Receiver Design.—D.G.F. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 80–85.) Full description of a double superheterodyne receiver; the second local oscillator is crystal-controlled and good selectivity, sensitivity and signal/noise ratio are obtained with a minimum number of components.

621.396.621 **4012**
Clipping and Clamping Circuits.—N. W. Mather. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 111–113.) Basic circuits for removing that portion of a signal which exceeds a predetermined level or for passing only signals exceeding the clip level, and for restoring or changing average values of signals having level portions.

621.396.621 : 621.396.619.13 **4013**
Designing an F.M. Receiver: Part 2.—T. Roddam. (*Wireless World*, June 1947, Vol. 53, No. 6, pp. 203–206.) Limiter and discriminator circuits are considered in detail. For part 1 see 2365 of August; an omission from Fig. 3 of this article is corrected.

621.396.621.029.5 **4014**
Universal Receiver RU95.—G. de Champs. (*Ann. Radioélect.*, April 1947, Vol. 2, No. 8, pp. 137–149.) The frequency range is 50 kc/s to 30 Mc/s. The general electrical design is discussed, the various stages being considered separately, and practical constructional details are given. Examination of all the factors involved in the calculation of the signal/noise ratio shows that the sensitivity approximates to the theoretical maximum. The construction and operation of the crystal filter is described and typical performance results of the receiver are given.

621.396.621.029.62 4015
BC-624 on Two Meters.—L. W. May, Jr. (*Radio Craft*, Sept. 1947, Vol. 18, No. 12, pp. 24–35..63.) Details of the modifications necessary for 2-m reception.

621.396.621.029.62 4016
Designing a 2 Meter Communication Receiver.—R. B. Tomer. (*Radio News*, Sept. 1947, Vol. 38, No. 3, pp. 57–59..146.) Full constructional details of a 144–148-Mc/s superheterodyne, incorporating an S-meter and a noise limiter. Special features include the use of separate assemblies in the more critical sections such as the i.f. channel, local oscillator, mixer, and r.f. amplifier.

621.396.621.52 4017
The Application of Super-Regeneration in Frequency-Modulation Receiver Design.—C. E. Tapp. (*Proc. Instn Radio Engrs, Aust.*, April 1947, Vol. 8, No. 4, pp. 4–7.) The principles of f.m. and super-regeneration are outlined and their combination in f.m. receivers suggested. A relatively small number of valves and tuned circuits would be required.

621.396.622 : 537.312.62 4018
Radio Frequency Detection by Superconductivity.—Andrews & Clark. (*See* 3853.)

621.396.813.015.3 : 621.396.645 4019
Analysis of Nonlinear Distortions owing to Transients in High-Power Class B Amplifiers.—...M. Pesarevsky. (*Radiotekhnika, Moscow*, Feb. 1947, Vol. 2, No. 2, pp. 35–50. In Russian with English summary.) A study of the distortion due to transients in the anode and grid circuits and of the effect on this distortion of the complex character of the amplifier load.

...21.396.823 4020
Interference from Industrial R.F. Heating Equipment.—A. Turney. (*British Electrical & Allied Industries Research Association Technical Report ...T88.*) The investigation is confined to four ...ts of apparatus of powers ranging from 2.5 to ... kW operating on frequencies from 600 kc/s ... 20 Mc/s. Both frequency and amplitude modulations were observed. An unscreened 25-kW equipment operating at 15 Mc/s produced fields greater than 100 μV/m over an area of half a square mile. Enclosing the apparatus in simple perforated steel cabinets gives considerable reduction in interference. Summary in *Wireless World*, Sept. 1947, Vol. 53, No. 9, p. 326. See also *Electronic Engng*, Aug. 1947, Vol. 19, No. 234, pp. 251–255.

...1.396.828.029.62 4021
Reflector Antenna solves "Skip" Problem.—... L. Campbell. (*Elect. World, N.Y.*, 2nd Aug. 1947, Vol. 128, No. 5, pp. 88, 90.) Serious interference with reception in Portland, Oregon, from ...stern f.m. stations was very much reduced by ...ng a 3-element beam aerial for reception only. ...e aerial has two parasitic elements, one a re...ctor and the other a director, giving a front-to-back ratio of 30 db. Addition of further reflectors ... proposed to eliminate the slight residual interference.

...ATIONS AND COMMUNICATION SYSTEMS

...1.391.63 : 621.397.5 4022
Photovision.—A.Z. (*Toute la Radio*, June 1947, Vol. 14, No. 116, p. 175.) A short account of the ...len B. Du Mont system and possible applications ... such systems.

621.391.64 : 621.327.44 4023
Modulation of the Resonance Lines in a Cesium Arc.—J. M. Frank, W. S. Huxford & W. R. Wilson. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, pp. 156–157.) Summary of Amer. Phys. Soc. paper. The light from a Cs arc Type CL2 is modulated by applying an alternating potential across the electrodes. The radiation is received by a photocell and displayed on an oscillograph together with the arc current and potential. The ratio of light to current modulation is about 0.8 for modulating frequencies below 1 kc/s and varies inversely as the square root of the frequency between 1 kc/s and 1 Mc/s. See also 3241 of October.

621.394/.395]"1939/1945" 4024
Progress in Telephony and Telegraphy.—(*Engineering, Lond.*, 16th & 23rd May 1947, Vol. 163, Nos. 4242 & 4243, pp. 402–403 & 441.) Summary of 1206 of April (Radley).

621.395.44 4025
The Basic Principles of Carrier-Current Telephony.—H. Jacot. (*Tech. Mitt. schweiz. Telegr.-Teleph-Verw.*, 1st April & 1st June 1947, Vol. 25, Nos. 2 & 3, pp. 47–58 & 97–105.) A general account, with discussion of modulation methods, filters, including bridge-type crystal filters, h.f. generators for carrier currents, and the principal features of the System-U, developed by Siemens in Germany before the war, and of the Bell Laboratories' System-K.

621.396.1 4026
Channels of Communication : Why and How they require Bands of Frequency.—"Cathode Ray". (*Wireless World*, June 1947, Vol. 53, No. 6, pp. 223–226.)

621.396.44 : 621.315.052.63 4027
A New Single-Side-Band Carrier System.—B. E. Lenehan. (*Elect. Engng, N.Y.*, June 1947, Vol. 66, No. 6, pp. 549–552.) Two-phase currents, of the signal and carrier frequencies, are produced by phase-splitting circuits, and the outputs are multiplied together by two copper-oxide ring modulators. The carrier frequency is suppressed by passing d.c. through the signal paths.

621.396.619 4028
Modulation Types and Characteristics.—Rockett. (*See* 4061.)

621.396.619 : 621.396.822 4029
Noise Reduction and Bandwidth in the Principal Modulation Systems.—W. Nowotny. (*Elektrotech. u. Maschinenb.*, July/Aug. 1947, Vol. 64, Nos. 7/8, pp. 116–125.) A comparison of characteristic signal/noise ratios, with particular reference to pulse modulation, including both pulse time and pulse phase modulation. The relative ratios are given in a table and a diagram.

621.396.619.11/.13 4030
Comparison of A.M. and F.M.—D. A. Bell. (*Wireless Engr*, Sept. 1947, Vol. 24, No. 288, p. 279.) Comments on Nicholson's paper (3660 of November) emphasizing the advantages of f.m. over a.m.

621.396.619.16 : 621.396.5 4031
Methods and Equipment used in Multiplex Pulse Transmission.—G. Potier. (*Onde élect.*, June & July 1947, Vol. 27, Nos. 243 & 244, pp. 215–230 &

separate cavities are provided by a master oscillator driving separate power amplifiers for the excitation of the various cavities. The system is designed for pulse operation at 580 Mc/s.

621.384.6 **4000**
Note on the 2.8 MeV Betatron.—W. B. Lasich & L. Riddiford. (*J. sci. Instrum.*, July 1947, Vol. 24, No. 7, pp. 177–179.) The construction and operation of a small laboratory betatron having a total ionization intensity equivalent to 1 gm of radium.

621.385.1.001.8 : 531.768.087 **4001**
A Vacuum Tube for Acceleration Measurement.—W. Ramberg. (*Elect. Engng, N.Y.*, June 1947, Vol. 66, No. 6, pp. 555–556.) For another account see 2528 of August.

621.385.833 **4002**
Experimental Determination of Astigmatism and of the Focal Surfaces in Electron Optics.—A. Cazalas. (*C. R. Acad. Sci., Paris*, 21st July 1947, Vol. 225, No. 3, pp. 178–180.)

621.385.833 **4003**
Limit of Resolution of the Decentred Electrostatic Objective.—H. Bruck. (*C. R. Acad. Sci., Paris*, 30th June 1947, Vol. 224, No. 26, pp. 1818–1820.) A formula is derived by considering the objective as made up of three independent elementary lenses, the two outer ones weakly divergent and the central one strongly convergent.

621.398+621.314.12 **4004**
Electric Positioning Systems of High Accuracy for Industrial Use.—D. E. Garr. (*Gen. elect. Rev.*, July 1947, Vol. 50, No. 7, pp. 17–24.) Description of a system using selsyns, valves, an amplidyne and a d.c. motor.

PROPAGATION OF WAVES

538.566.2 **4005**
Refraction of Plane Non-Uniform Electromagnetic Waves between Absorbing Media.—L. Pincherle. (*Phys. Rev.*, 1st Aug. 1947, Vol. 72, No. 3, pp. 232–235.) It is shown that after refraction there are two possible positions for the propagation vector in the second medium. Energy flow considerations show that each solution holds within a certain range of values of the (complex) angle of incidence, the transition between the two solutions being discontinuous. Polarizations perpendicular and parallel to the plane of incidence are considered.

621.396.11 **4006**
Observations on the Propagation of Ultra-Short Waves.—G. Latmiral & G. Barzilai. (*Alta Frequenza*, June/Aug. 1947, Vol. 16, Nos. 3/4, pp. 147–173. In Italian, with English, French and German summaries.) A critical discussion. It is pointed out that the phase diagram of aerials above the earth must be considered, that the radiation diagram may not be independent of distance and that reflection must not be supposed to occur at a single point. The finite dimensions of the reflecting zone, when the earth's surface is uneven, can produce notable variations in the signal strength of the reflected ray. U.s.w. fading may be reduced by the use of aerials connected together without phase synchronism.

621.396.11 **4007**
Radio-Wave Propagation and Electromagnetic Surface Waves.—P. S. Epstein. (*Proc. nat. Acad. Sci., Wash.*, June 1947, Vol. 33, No. 6, pp. 195–199.) A short critical account of the development of Sommerfeld's classical theory. Another interpretation of Sommerfeld's equations, hitherto overlooked, shows that the surface-wave is not generated by the aerial and can have an independent existence.

621.396.11.029.58 : 551.510.535 **4008**
Doppler Effect in Propagation.—R. E. Burgess: F. S. Atiya: L. Essen: H. V. Griffiths. (*Wireless Engr*, Aug. & Sept. 1947, Vol. 24, Nos. 287 & 288, pp. 248–249 & 279–280.) Criticism and correction of a statement by Griffiths (3254 of October) which implied that absolute velocity could be measured, thereby flouting the principles of relativity.

621.396.812.029.64 **4009**
Further Observations of the Angle of Arrival of Microwaves.—A. B. Crawford & W. M. Sharpless. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, p. 389.) Summary of 1183 of April.

RECEPTION

621.396.621 + 621.396.69 **4010**
Robot makes Radios.—R. W. Hallows. (*Radio Craft*, Sept. 1947, Vol. 18, No. 12, pp. 20–21, 81.) Another account of the E.C.M.E. (Electrical Circuit Making Equipment) described in 1913 of June (Sargrove).

621.396.621 **4011**
A New Approach to F.M./A.M. Receiver Design.—D.G.F. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 80–85.) Full description of a double superheterodyne receiver; the second local oscillator is crystal-controlled and good selectivity, sensitivity and signal/noise ratio are obtained with a minimum number of components.

621.396.621 **4012**
Clipping and Clamping Circuits.—N. W. Mather. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 111–113.) Basic circuits for removing that portion of a signal which exceeds a predetermined level or for passing only signals exceeding the clip level, and for restoring or changing average values of signals having level portions.

621.396.621 : 621.396.619.13 **4013**
Designing an F.M. Receiver: Part 2.—T. Roddam. (*Wireless World*, June 1947, Vol. 53, No. 6, pp. 203–206.) Limiter and discriminator circuits are considered in detail. For part 1 see 2365 of August; an omission from Fig. 3 of this article is corrected.

621.396.621.029.5 **4014**
Universal Receiver RU95.—G. de Champs. (*Ann. Radioélect.*, April 1947, Vol. 2, No. 8, pp. 137–149.) The frequency range is 50 kc/s to 30 Mc/s. The general electrical design is discussed, the various stages being considered separately, and practical constructional details are given. Examination of all the factors involved in the calculation of the signal/noise ratio shows that the sensitivity approximates to the theoretical maximum. The construction and operation of the crystal filter is described and typical performance results of the receiver are given.

621.396.621.029.62 4015
BC-624 on Two Meters.—L. W. May, Jr. (*Radio Craft*, Sept. 1947, Vol. 18, No. 12, pp. 24–35..63.) Details of the modifications necessary for 2-m reception.

621.396.621.029.62 4016
Designing a 2 Meter Communication Receiver.—R. B. Tomer. (*Radio News*, Sept. 1947, Vol. 38, No. 3, pp. 57–59..146.) Full constructional details of a 144–148-Mc/s superheterodyne, incorporating an S-meter and a noise limiter. Special features include the use of separate assemblies in the more critical sections such as the i.f. channel, local oscillator, mixer, and r.f. amplifier.

621.396.621.52 4017
The Application of Super-Regeneration in Frequency-Modulation Receiver Design.—C. E. Tapp. (*Proc. Instn Radio Engrs, Aust.*, April 1947, Vol. 8, No. 4, pp. 4–7.) The principles of f.m. and super-regeneration are outlined and their combination in f.m. receivers suggested. A relatively small number of valves and tuned circuits would be required.

621.396.622 : 537.312.62 4018
Radio Frequency Detection by Superconductivity.—Andrews & Clark. (*See* 3853.)

621.396.813.015.3 : 621.396.645 4019
Analysis of Nonlinear Distortions owing to Transients in High-Power Class B Amplifiers.—A. M. Pesarevsky. (*Radiotekhnika, Moscow*, Feb. 1947, Vol. 2, No. 2, pp. 35–50. In Russian with English summary.) A study of the distortion due to transients in the anode and grid circuits and of the effect on this distortion of the complex character of the amplifier load.

621.396.823 4020
Interference from Industrial R.F. Heating Equipment.—A. Turney. (*British Electrical & Allied Industries Research Association Technical Report M/T88.*) The investigation is confined to four sets of apparatus of powers ranging from 2.5 to ? kW operating on frequencies from 600 kc/s to 20 Mc/s. Both frequency and amplitude modulations were observed. An unscreened 25-kW equipment operating at 15 Mc/s produced fields greater than 100 μV/m over an area of half a square mile. Enclosing the apparatus in simple perforated steel cabinets gives considerable reduction in interference. Summary in *Wireless World*, Sept. 1947, Vol. 53, No. 9, p. 326. See also *Electronic Engng*, Aug. 1947, Vol. 19, No. 234, pp. 251–255.

621.396.828.029.62 4021
Reflector Antenna solves "Skip" Problem.—. L. Campbell. (*Elect. World, N.Y.*, 2nd Aug. 1947, Vol. 128, No. 5, pp. 88, 90.) Serious interference with reception in Portland, Oregon, from eastern f.m. stations was very much reduced by using a 3-element beam aerial for reception only. The aerial has two parasitic elements, one a reflector and the other a director, giving a front-to-back ratio of 30 db. Addition of further reflectors is proposed to eliminate the slight residual interference.

STATIONS AND COMMUNICATION SYSTEMS

621.391.63 : 621.397.5 4022
Photovision.—A.Z. (*Toute la Radio*, June 1947, Vol. 14, No. 116, p. 175.) A short account of the Allen B. Du Mont system and possible applications of such systems.

621.391.64 : 621.327.44 4023
Modulation of the Resonance Lines in a Cesium Arc.—J. M. Frank, W. S. Huxford & W. R. Wilson. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, pp. 156–157.) Summary of Amer. Phys. Soc. paper. The light from a Cs arc Type CL2 is modulated by applying an alternating potential across the electrodes. The radiation is received by a photocell and displayed on an oscillograph together with the arc current and potential. The ratio of light to current modulation is about 0.8 for modulating frequencies below 1 kc/s and varies inversely as the square root of the frequency between 1 kc/s and 1 Mc/s. See also 3241 of October.

621.394/.395]"1939/1945" 4024
Progress in Telephony and Telegraphy.—(*Engineering, Lond.*, 16th & 23rd May 1947, Vol. 163, Nos. 4242 & 4243, pp. 402–403 & 441.) Summary of 1206 of April (Radley).

621.395.44 4025
The Basic Principles of Carrier-Current Telephony.—H. Jacot. (*Tech. Mitt. schweiz. Telegr.-Teleph-Verw.*, 1st April & 1st June 1947, Vol. 25, Nos. 2 & 3, pp. 47–58 & 97–105.) A general account, with discussion of modulation methods, filters, including bridge-type crystal filters, h.f. generators for carrier currents, and the principal features of the System-U, developed by Siemens in Germany before the war, and of the Bell Laboratories' System-K.

621.396.1 4026
Channels of Communication : Why and How they require Bands of Frequency.—" Cathode Ray ". (*Wireless World*, June 1947, Vol. 53, No. 6, pp. 223–226.)

621.396.44 : 621.315.052.63 4027
A New Single-Side-Band Carrier System.—B. E. Lenehan. (*Elect. Engng, N.Y.*, June 1947, Vol. 66, No. 6, pp. 549–552.) Two-phase currents, of the signal and carrier frequencies, are produced by phase-splitting circuits, and the outputs are multiplied together by two copper-oxide ring modulators. The carrier frequency is suppressed by passing d.c. through the signal paths.

621.396.619 4028
Modulation Types and Characteristics.—Rockett. (*See* 4061.)

621.396.619 : 621.396.822 4029
Noise Reduction and Bandwidth in the Principal Modulation Systems.—W. Nowotny. (*Elektrotech. u. Maschinenb.*, July/Aug. 1947, Vol. 64, Nos. 7/8, pp. 116–125.) A comparison of characteristic signal/noise ratios, with particular reference to pulse modulation, including both pulse time and pulse phase modulation. The relative ratios are given in a table and a diagram.

621.396.619.11/.13 4030
Comparison of A.M. and F.M.—D. A. Bell. (*Wireless Engr*, Sept. 1947, Vol. 24, No. 288, p. 279.) Comments on Nicholson's paper (3660 of November) emphasizing the advantages of f.m. over a.m.

621.396.619.16 : 621.396.5 4031
Methods and Equipment used in Multiplex Pulse Transmission.—G. Potier. (*Onde élect.*, June & July 1947, Vol. 27, Nos. 243 & 244, pp. 215–230 &

284–291.) The general principles of pulse modulation are outlined and the various methods hitherto used for modulation of pulse amplitude, duration or position are described. Methods of selecting the pilot pulses in receiving equipment are discussed and also the selection and detection of the signal pulses. Illustrative examples are given.

621.396.65.029.62/.64 : 621.396.619.16 **4032**
A Multichannel Microwave Radio Relay System.—H. S. Black, J. W. Beyer, T. J. Grieser, & F. A. Polkinghorn. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, pp. 388–389.) Summary of 1219 of April.

621.396.712 **4033**
Continuity Working.—R. T. B. Wynn. (*B.B.C. Quart.*, Jan. 1947, Vol. 1, No. 4, pp. 184–193.) A new method of presenting broadcast programmes allowing complete co-operation between programme staff and engineers even during the broadcast. The programme is controlled by an announcer from the continuity studio, sound-insulated from but connected to the continuity room, where two operators are responsible for the technical presentation. The technical facilities are described and the duties of those responsible for both technical and artistic presentation are discussed.

621.396.712.3 **4034**
Planning a Studio Installation : Part 1.—J. D. Colvin. (*Audio Engng*, July 1947, Vol. 31, No. 6, pp. 7–9, 41.) Concerned only with the audio equipment, wiring, etc. Each step in the planning is treated separately, then the steps are combined and the whole scheme completed.

621.396.931 **4035**
Mobile Radio-Telephone Service links Nation.—F. E. Butler. (*Radio News*, May 1947, Vol. 37, No. 5, pp. 45–47..118.) Fixed and mobile stations operate in the bands 152–162 Mc/s and 30–44 Mc/s respectively. A selective signalling device provides 2 030 combinations. Crystal control and phase modulation are the main features in the 30-W transmitters.

621.396.931 **4036**
F.M. Communications at CP's [Canadian Pacific] **Toronto Yard.**—(*Telegr. Teleph. Age*, May 1947, Vol. 65, No. 5, p. 6.) Shunting engines have been fitted with two-way f.m. radio communication equipment. The system has a possible range of 15 miles.

621.396.931 : 621.396.81.029.62 **4037**
153-Mc/s F.M. for Forestry Service.—R. L. Atkinson. (*F.M. & Televis.*, July 1947, Vol. 7, No. 7, pp. 23–26, 61.) A survey of results in the State of Florida with 15-W and 30-W transmitters shows that 20-mile communication ranges were consistently obtained.

621.396.932 **4038**
Modern Marine Radio.—D. F. Bowers & E. F. Cranston. (*Wireless World*, June 1947, Vol. 53, No. 6, pp. 221–222.) Two alternative standardized installations made by the Marconi Company for merchant ships are described, one for medium frequencies and the other for medium and high frequencies. Each consists of a transmitter, communication receiver, automatic alarm device and d.f. receiver. The transmitter frequency can be changed rapidly to predetermined values, and the equipment may be removed and serviced with the power on.

SUBSIDIARY APPARATUS

621-526 **4039**
The Development of Servo Mechanisms.—(*Elect. Times*, 22nd May 1947, Vol. 111, No. 2898, pp. 579–584.) Summary of the following papers read at the recent I.E.E. Convention on Servomechanisms. Fundamental Principles of Automatic Regulators and Servo Mechanisms, by A. L. Whiteley. Elements of Position Control, by K. A. Hayes. The Use of Servos in the Army during the Past War, by E. J. Douch. The Nature of the Operator's Response in Manual Control and Its Implications in Controller Design, by A. Tustin. Some Servo Mechanisms used by the Royal Navy, by J. O. H. Gairdner. Some Naval Applications of Electrical Remote-Positional Controllers, by W. E. C. Lampert. The Use of Servo Mechanisms in Aircraft, by A. A. Hall. The Theoretical Foundations of Process Control, by G. H. Farrington. Automatic Voltage Control of Generators, by C. Stewart. Amplidyne Regulating Systems, by B. Adkins. Automatic Control in the Chemical Industry, by J. W. Broadhurst, F. C. Broderick, A. W. Foster & G. E. Wheeldon, with four appendices. Some Industrial Electronic Servo and Regulator Systems by E. W. Forster & L. C. Ludbrook. Electronic Servo Simulators, by F. C. Williams & F. J. V. Ritson.

621.318.5 : 621.398 : 621.396.621 **4040**
Receiver Remote Control.—J. F. O. Vaughan. (*Wireless World*, June 1947, Vol. 53, No. 6, pp. 212–214.) A system using isolating capacitors and two relays enables a receiver to be switched on and off from an extension speaker by a push button without using additional connecting wires.

621.319.3.027.89 **4041**
Aluminium and Magnesium in the Electrical Industries. [Electrostatic generators.]—B. J. Brajnikoff. (*Light Metals*, July 1947, Vol. 10, No. 114, pp. 325–332.) An account of the principles and construction of h.v. electrostatic generators, giving voltages up to 25 MV. Al is used largely in the construction of these generators.

621.319.33 **4042**
New Electrostatic Influence Generator.—P. Jolivet. (*C. R. Acad. Sci., Paris*, 21st July 1947, Vol. 225, No. 3, pp. 177–178.) Similar in construction to that previously described (1934 Abstracts, p. 53) but with no moving connections. The combs are connected through resistors to the corresponding armatures.

621.319.33 **4043**
Electrostatic Influence Machines and the Modernizing of Their Technique.—P. Jolivet. (*Rev. gén. Élect.*, June 1947, Vol. 56, No. 6, pp. 243–255.) A short historical review is given, with a new classification of such machines. The operation of generators with a new method of inductor mounting is described and also research on generators operating in compressed air. Technical details are given of machines actually constructed for use in com

pressed gas, which enables much higher output voltages to be reached. The design of generators of this type for still higher voltages is discussed. An output of 15 mA at 150 kV appears practicable.

621.319.33 **4044**

Electrostatic Sources of Electric Power.—J. G. Trump. (*Elect. Engng, N.Y.*, June 1947, Vol. 66, No. 6, pp. 525–534.) A general article on their production and use. The Van de Graaff belt generator is described, with details of modern generators of this type. Modifications include the control of the electric field round the upper terminal by means of intermediate metallic equipotential shields, and confining the charge on each belt by spaced conducting rods connected to the column sections and mounted close and parallel to each side of the belt. The insulation for these generators is either compressed gas or high vacuum, and the properties of some typical gases are given. The proposed use of vacuum-insulated electrostatic machinery, an a.c. synchronous motor and a d.c. generator for operation in a high vacuum, and the direct use of atomic power by means of a vacuum-insulated motor of the type described, are also discussed.

621.396.682 : 621.316.722.076.7 **4045**

Stabilizing Direct-Voltage Supplies.—J. W. Hughes. (*Wireless Engr*, Aug. 1947, Vol. 24, No. 287, pp. 224–230.) "A graphical method of assessing the performance of the gas-discharge tube stabilizer circuit is described, and a means of ensuring that the tube 'strikes' with low supply voltages is indicated."

621.396.682 : 621.316.722.1 **4046**

Voltage-Regulated Power Supplies.—P. Koontz & E. Dilatush. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 119–123.) A simplified design theory. Actual values of circuit elements necessary to build a power pack and electronic regulator are calculated. Practical suggestions are given for physical layout and elimination of ripple.

621.396.682 : 621.397.62 **4047**

Television E.H.T. [extra-high voltage] **Supply.**—W. T. Cocking. (*Wireless World*, June 1947, Vol. 53, No. 6, pp. 207–211.) The design of rectifier systems for supplying high voltage for television receiver c.r. tubes using the voltage developed across the line amplifier output transformer at flyback. Equations and experimental data are given showing the effect of stray capacitance across the transformer primary and the use of a tapped primary to step up the flyback voltage. A voltage-doubling rectifier system using components rated at half the output voltage is described.

TELEVISION AND PHOTOTELEGRAPHY

621.397.335 **4048**

Television Synchronization.—A. W. Keen. (*Wireless World*, June 1947, Vol. 53, No. 6, p. 220.) Comment on 2261 of July (Cocking).

621.397.335 **4049**

Investigation of the Range of Stable Synchronization of a Synchronizing Generator.—V. N. Gorshunov. (*Radiotekhnika, Moscow*, Jan. 1947, Vol. 2, No. 1, pp. 62–72. In Russian with English summary.) The results obtained are shown graphically and a stability criterion is derived.

621.397.5 **4050**

Television.—V. K. Zworykin. (*J. Franklin Inst.*, Aug. 1947, Vol. 244, No. 2, pp. 131–145.) A general description of modern television apparatus including the R.C.A. simultaneous colour system.

621.397.5 : 535.37 : 621.385.832 **4051**

Application of the I.C.I. Color System to the Development of the All Sulfide Television White Screen.—A. E. Hardy. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 166.) Summary of Amer. Phys. Soc. paper.

621.397.5 : 535.88 **4052**

Projection Television.—(*Wireless World*, June 1947, Vol. 53, No. 6, pp. 227–228.) With plastic lenses, non-spherical surfaces can be produced cheaply, so that large-aperture systems combining high optical efficiency with freedom from spherical aberration become possible.

621.397.5 : 535.88 **4053**

The Projection of Images on a Screen.—R. Aschen. (*Télévis. franç.*, Aug. 1947, No. 28, pp. 11–12, 34.) Describes various types of optical systems and discusses briefly the production of moulded correction lenses of plexiglass.

621.397.5 : 535.88 **4054**

Reflective Optical System for Projection Television.—V. K. Zworykin. (*Radio News*, Sept. 1947, Vol. 38, No. 3, pp. 54–56..155.) A description of the R.C.A. system using a high-current sharp-focus kinescope operated at 27 kV, a spherical mirror and a moulded plastic correction lens to give a 20-inch × 15-inch picture.

621.397.5(73) **4055**

Progress in Television.—G. R. Town. (*Elect. Engng, N.Y.*, June 1947, Vol. 66, No. 6, pp. 580–590.) A general discussion on the latest position in the U.S.A., dealing with the immediate future and its commercial problems. Monochrome television will not be ousted rapidly by colour television, as the F.C.C. have stopped the commercialization of colour television until it has reached a satisfactory state of development.

621.397.62 **4056**

Television Receiver Construction : Parts 6 & 7.—(*Wireless World*, Aug. & Sept. 1947, Vol. 53, Nos. 8 & 9, pp. 278–281 & 330–334.) Part 6: Discussion of c.r. tube mounting. Part 7: Description of the complete receiver unit, with list of components. For previous parts see 3687 of November and back references.

621.397.62 **4057**

Learn as You Build — Television.—A. Liebscher. (*Radio News*, Sept. 1947, Vol. 38, No. 3, pp. 39–42..141.) Complete construction details for a television receiver using a 3-inch tube.

621.397.62 **4058**

Study of the Detection and Video-Frequency Amplification Stages for 455-Line Television Receivers.—J. Barthon. (*Télévis. franç.*, Aug. 1947, No. 28, pp. 18–21.) An explanation of the particular features of these stages and the functions of the various circuits and components, to enable service men, etc., to understand the operation of the apparatus they have to handle.

621.397.62 : 621.396.682 **4059**
Television E.H.T. [extra-high voltage] **Supply.**—Cocking. (*See* 4047.)

TRANSMISSION

621.396.61.029.62 : 621.396.712 **4060**
Frequency-Modulated Broadcast Transmitters for 88-108 Megacycles.—L. Everett. (*Elect. Commun.* March 1947, Vol. 24, No. 1, pp. 82-93.) A detailed description of a series of transmitters having r.f. outputs of 1, 3, 10, 20 and 50 kW respectively. The transmitters are crystal controlled and the radiated centre frequency is maintained to within ±1 kc/s. A 75-μs pre-emphasis circuit is provided at the a.f. input.

621.396.619 **4061**
Modulation Types and Characteristics.—F. Rockett. (*Electronics, Buyers' Guide Issue,* June 1947, Vol. 20, No. 6B, pp. 124-125.)

621.396.619.16 **4062**
Spectrum Analysis of Pulse Modulated Waves.—J. C. Lozier. (*Bell. Syst. tech. J.*, April 1947, Vol. 26, No. 2, pp. 360-387.) The elementary theory of spectrum analysis is reviewed and discussed. A complex pulse is resolved into a series of rectangular pulses, the spectra of which are known and can be combined vectorially. The spectra of pulse-position and pulse-width modulation are thus determined; as the pulse repetition rate is increased pulse position modulation approximates to a form of phase modulation, while pulse-width modulation approximates to amplitude modulation of the pulse repetition frequency and of its harmonics present in the unmodulated pulse.

621.396.645 : 621.396.822 : 621.396.97 **4063**
Preamplifier Noise in F.M. Broadcasting.—A. E. Richmond. (*Audio Engng,* July 1947, Vol. 31, No. 6, pp. 15-16, 45.) Methods of testing and improving the signal/noise ratio are discussed.

VALVES AND THERMIONICS

621.383.4 + 546.28 **4064**
A New Bridge Photo-Cell employing a Photo-Conductive Effect in Silicon. Some Properties of High Purity Silicon.—G. K. Teal, J. R. Fisher & A. W. Treptow. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, pp. 392-393.) Summary of 1961 of June.

621.385.029.63/.64 **4065**
The Travelling-Wave Tube.—R. Kompfner. (*Wireless Engr,* Sept. 1947, Vol. 24, No. 288, pp. 255-266.) Expressions are derived for the amplification and noise factor of the travelling-wave valve. The modulation of the beam by the wave is first considered neglecting any reaction of such modulation on the wave; similarly the wave produced by a modulated beam is investigated neglecting the effect of the wave on the modulation. The reaction of the modulated beam on the modulating wave is then determined and by repeating this process for an infinite number of actions and reactions, the complete interaction is calculated.

A coaxial line with a helical inner conductor is suitable for providing a wave having a velocity to which electrons can be accelerated easily. The development of such valves up to 1944 is described. See also 2286 of July.

621.385.029.63/.64 **4066**
Tentative Theory of the Travelling-Wave Valve.—J. Bernier. (*Onde élect.*, June 1947, Vol. 27, No. 243, pp. 231-243.) Reprint of 2974 of September, with correction of a slight error in that paper.

621.385.029.63/.64 **4067**
Tentative Theory of the Travelling-Wave Valve.—J. Bernier. (*Ann. Radioélect.*, April 1947, Vol. 2, No. 8, p. 195.) Correction to 2974 of September.

621.385.1 + 621.396.694 **4068**
New Receiving Valves.—(*Wireless World,* June 1947, Vol. 53, No. 6, pp. 228-229.) Details of British valves with B8A base. See also 3717 of November.

621.385.1 + 621.396.694 **4069**
Contemporary Receiving Tubes.—J. D. Askew. (*Electronics, Buyers' Guide Issue,* June 1947, Vol. 20, No. 6B, pp. 126-129.) Valves classified according to their functions for comparison with other types. See also 2976 of September.

621.385.1 . 621.317.738 **4070**
A Radio-Frequency Interelectrode-Capacitance Meter.—Lehany & McGuire. (*See* 3966.)

621.385.1.032.21 : 537.291 **4071**
Cathode-Design Procedure for Electron-Beam Tubes.—R. Helm, K. Spangenberg & L. M. Field. (*Elect. Commun.*, March 1947, Vol. 24, No. 1, pp. 101-107.) Based on a book entitled "The Production and Control of Electron Beams," published as secret material during the war and now out of print. The design procedure is an extension of the work of J. R. Pierce (4275 of 1940). Charts are given from which a cathode structure can readily be determined for any current and voltage and at any angle of beam convergence, over a wide range of these variables.

621.385.1.032.21 : 546.41[.431].64 **4072**
The Methods of Manufacture of Carbonates for Valve Cathodes.—Biguenet & Mano. (*See* 3924.)

621.385.1.032.216 : 537.583 **4073**
Variations in the Constants of Richardson's Equation as a Function of Life for the Case of Oxide Coated Cathodes on Nickel.—H. Jacobs & G. Hees. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 174.) Summary of Amer. Phys. Soc. paper.

621.385.2 **4074**
The High Frequency Response of Thermionic Diodes.—E. H. Gamble. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 160.) Summary of Amer. Phys. Soc. paper. The temperature-limited and space-charge-limited operations of planar and cylindrical diodes are analysed. The transient build-up of current in a planar diode on the sudden application of an external voltage is determined.

621.385.3/.5 **4075**
Study of Grid Current.—U. Zelbstein. (*Toute la Radio,* June 1947, Vol. 14, No. 116, pp. 168-172.) Discussion of: (*a*) the complex nature and the consequences of grid current, (*b*) the possibilities of using modern valves with the minimum of grid current, and (*c*) the photoelectric effect in electrometer tubes.

621.385.83.032.29 4076

High Current Electron Guns.—L. M. Field. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, p. 390.) Summary of 1967 of June.

621.385.832 4077

A Cathode-Ray Tube for viewing Continuous Patterns.—J. B. Johnson. (*Bell Syst. tech. J.*, April 1947, Vol. 26, No. 2, p. 390.) Summary of 1640 of May.

621.385.832 : 535.37 4078

Performance Characteristics of Long-Persistence Screens, Their Measurement and Control.—Johnson & Hardy. (*See* 3921.)

621.385.832 : 535.37 4079

The Efficiency of Cathodoluminescence as a Function of Current Density.—S. Lasof. (*Phys. Rev.*, 15th July 1947, Vol. 72, No. 2, p. 165.) Summary of Amer. Phys. Soc. paper.

621.396.615.14 4080

Possibility of Oscillation at Ultra-High Frequency of Conventional Valves.—F. Cappuccini. (*Alta Frequenza*, June/Aug. 1947, Vol. 16, Nos. 3/4, pp. 196–200. In Italian, with English, French and German summaries.)

621.396.615.142.2 4081

On the Theory of the Klystron.—Ya Z. Tsipkin. (*Radiotekhnika, Moscow*, Jan. 1947, Vol. 2, No. 1, pp. 49–61. In Russian with English summary.) From the author's criterion for the stability of systems with retarded feedback the self-excitation conditions of transit and reflection klystrons are determined. From these conditions the relation between self-excitation regions and parameters determining the klystron operation is deduced simply.

621.396.615.142.2 4082

External Cavity Klystron.—P. G. Bohlke & F. G. Freeden. (*Electronics*, July 1947, Vol. 20, No. 7, pp. 114–118.) Development and characteristics of a 10-cm klystron with an external cavity. Output about 100 mW. With a coaxial cavity the klystron covers the wavelength range 7–14 cm in single-mode operation; with a radial cavity the range is 6.5–8.1 cm.

621.396.615.142.2 4083

A Relatively High Power Klystron Oscillator using a Circuit resembling the Hartley.—Yu. A. Katsman. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1946, Vol. 10, No. 1, pp. 87–92. In Russian.) A modification of Lüdi's klystron (57 of 1942) is discussed (Fig. 1), in which a resonant coaxial line is used, whose ends are loaded with different capacitances. By suitably choosing these capacitances the required ratio of the standing wave voltages at the ends of the line can be obtained. One of these voltages can be used as the buncher voltage; the other will then represent the output voltage of the klystron. The system is thus divided into two parts and is similar to the well known Hartley circuit.

The operation of the system is discussed and the necessary conditions are established for the balancing of the phases and amplitudes.

621.396.615.17 4084

The Application of the Radiotron Type 807 Valve as a Frequency Doubler.—G. L. Edgecombe & J. G. Downes. (*A.W.A. tech. Rev.*, April 1947, Vol. 7, No. 3, pp. 251–269.) It is shown that 26 W output with an anode efficiency of 50% is both theoretically and practically realizable.

621.396.622.6 : 546.28 4085

Development of Silicon Crystal Rectifiers for Microwave Radar Receivers.—J. H. Scaff & R. S. Ohl. (*Bell Syst. tech. J.*, Jan. 1947, Vol. 26, No. 1, pp. 1–30.) Characteristic curves of early types are given. The need for a stable, easily replaceable type brought about the ceramic cartridge rectifier and later the shielded rectifier, the construction of which is discussed in some detail. The applications and performance of various types are given and improved modern production methods are indicated. See also 771 of 1946 (Cornelius).

621.396.622.63 : [546.28 + 546.289 4086

Silicon and Germanium Rectifiers.—(*See* 3831.)

621.396.822 4087

A Theory of Flicker Noise in Valves and Impurity Semi-Conductors.—G. G. Macfarlane. (*Proc. phys. Soc.*, 1st May 1947, Vol. 59, No. 333, pp. 366–375. Discussion, pp. 403–408.) A theory of contact noise at low frequencies assuming diffusion of mobile impurity centres on to the contact surface. A formula is derived for the flicker noise which is applicable to emission from oxide-coated filaments and to contacts in photo-conductive cells and rectifiers. "The spectral power density of the noise is found to depend on current j and frequency f as j^{x+1}/f^x where $1 < x < 2$."

621.396.822 4088

Spontaneous Fluctuations of Electricity in Thermionic Valves under Retarding Field Conditions.—D. K. C. MacDonald & R. Fürth. (*Proc. phys. Soc.*, 1st May 1947, Vol. 59, No. 333, pp. 375–388. Discussion, pp. 403–408.) The measured fluctuations are compared with those generated by a diode operating under saturation conditions. Under certain conditions of current and differential resistance of the valve, the classical Schottky formula is obeyed. The necessary limiting current can be calculated. Measurements of this type can be used for determining cathode temperatures in diodes.

621.396.822 : 519.24 4089

Statistical Analysis of Spontaneous Electrical Fluctuations.—R. Fürth & D. K. C. MacDonald. (*Proc. phys. Soc.*, 1st May 1947, Vol. 59, No. 333, pp. 388–403. Discussion, pp. 403–408.) Fluctuations were produced in a receiver of high natural frequency (0.1–1.0 Mc/s) and narrow bandwidth (1–6 kc/s) and recorded by means of a single-stroke c.r.o. The fluctuations were thus displayed as rapid oscillations, with the natural frequency of the receiver, whose amplitude R varied slowly and irregularly in time. The distribution function of R within a statistically stationary series of observations and the correlation between values of R separated by a finite time interval were found to be in good agreement with statistical theory.

MISCELLANEOUS

371.3 : 621.396 4090

Technical Educational Requirements of the Modern Radio Industry.—P. L. Gerhart. (*RCA Rev.*, March 1947, Vol. 8, No. 1, pp. 186–191.)

5+6] : 05(43) : 778.1 4091

Photostat Copies of German Scientific and Technical Papers.—(*Nature, Lond.*, 27th Sept. 1947, Vol. 160, No. 4065, p. 427.) A photostat service to provide workers in Great Britain with the full text of papers appearing in current German scientific journals, of which a very full list is sent regularly to the Bureau of Abstracts, 9-10 Savile Row, London, W.1. Any scientist requiring the full text of a German article referred to in a British Abstract publication should write direct to Research Branch E.C.O.S.C. (Photostat Service) 77 H.Q. C.C.G. (B.E.) A.V.A.-Göttingen, B.A.O.R. Payment is made in sterling to the Director of Accounts, Photostat Service, Foreign Office (German Section), Norfolk House, St. James' Square, London, S.W.1, at the rate of one guinea for the first 10 pages and 2s. 6d. for each additional page.

621.3.016.25 4092

The Sign of Reactive Power.—(*Elect. Engng, N.Y.*, June 1947, Vol. 66, No. 6, pp. 627–628.) Further comment on 971 of March; see also 2642 of August and back references.

621.38/.39](083.72) 4093

Wartime Words and Their Meanings.—C. DeVore. (*Electronics, Buyers' Guide Issue*, June 1947, Vol. 20, No. 6B, pp. 108–113.) Concise definitions of nearly 600 code names, abbreviations, slang and technical terms added to the language of electronics during the war years.

621.39"1939/1945" 4094

Telecommunications in War.—A. S. Angwin. (*Engineering, Lond.*, 2nd May 1947, Vol. 163, No. 4240, pp. 367–368.) Summary of I.E.E. Radiocommunication Convention speech. See also 2644 of August.

621.395 : 061.24 C.C.I.F. 4095

Short Account of the Work of the 14th Plenary Assembly of the C.C.I.F. [Comité Consultatif International Téléphonique] **at Montreux.**—R. Sueur. (*Câbles & Transmission, Paris*, July 1947, Vol. 1, No. 2, pp. 115–119. With English summary.) The principal recommendations are given and briefly analysed. See also 3373 of October (Schiess).

621.396 4096

Future Trends in Radio Communication.—C. C. Paterson. (*Engineering, Lond.*, 9th May 1947, Vol. 163, No. 4241, p. 379.) Summary of I.E.E. Radiocommunication Convention speech. See also 2649 of August.

621.396/.397 : 06.064 Paris 4097

Radio and Television at the Paris Fair, 1947.—G. Giniaux. (*T.S.F. pour Tous*, June 1947, Vol. 23, No. 224, pp. 123–126.)

621.396(494) 4098

The 25th Anniversary of Radio-Suisse.—A. Ch. (*Tech. Mitt. schweiz. Telegr.-Teleph Verw.*, 1st Aug. 1947, Vol. 25, No. 4, pp. 154–158. In French.) A review of the development of the society and of present radio communication facilities.

621.396 Marconi Company 4099

Marconi Company's Jubilee.—(*Engineer, Lond.*, 2nd May 1947, Vol. 183, No. 4762, pp. 386–387.) Marked by an exhibition, showing the development of Marconi's invention from the first crude apparatus with a range of a few miles, to the most modern apparatus in world-wide use to-day.

621.396.67 4100

Who Invented the Aerial — Marconi or Popov?—(*Wireless World*, Sept. 1947, Vol. 53, No. 9, p. 338.) Translation of some passages of an article by Marquis Luigi Solari on the April/May number of the Italian paper *L'Antenna*, confirming that Marconi was the inventor.

621.396.69 4101

[1947] **Chicago** [radio] **Parts Show.**—(*Radio Craft*, May 1947, Vol. 18, No. 8, pp. 41–46.) List of exhibitors, with brief descriptions of a few of the exhibits.

015(73) 4102

United States Government Publications. [Book Notice]—United States Government Printing Office, Washington. A monthly catalogue, price $2.25 per annum ($2.85 abroad), issued by the Superintendent of Documents and including titles of a large number of papers issued by the Scientific Research and Development Office.

43-3=2 4103

German-English Dictionary for Electronics Engineers and Physicists. [Book Review]—B. R. Regen & R. R. Regen. J. W. Edwards, Ann Arbor, Mich., 1946, 358 pp., $6.00. (*Electronics*, Sept. 1947, Vol. 20, No. 9, pp. 260, 262.) Nearly 21 000 German technical terms in the fields of electronics and physics are listed alphabetically with English equivalents. Brief explanatory definitions are sometimes added.

621.3 4104

Principles of Electrical Engineering. [Book Review]—T. F. Wall. George Newnes Ltd., London, 40s. (*Electronic Engng*, Aug. 1947, Vol. 19, No. 234, p. 269.) Unusual emphasis is given to fundamental aspects common to heavy and light current engineering. The mathematical treatment is always elegant and within the capacity of the undergraduate, who " will do well to build upon Dr. Wall's book as a foundation ".

ABSTRACTS AND REFERENCES INDEX

The Index to the Abstracts and References published throughout the year is in course of preparation and will, it is hoped, be available in February, price 2s. 8d. (including postage). As supplies are limited our Publishers ask us to stress the need for early application for copies.