10

WIRELESS ENGINEER

MAY 1947

VOL XXIV TWO SHILLINGS AND SIXPENCE · · No. 284


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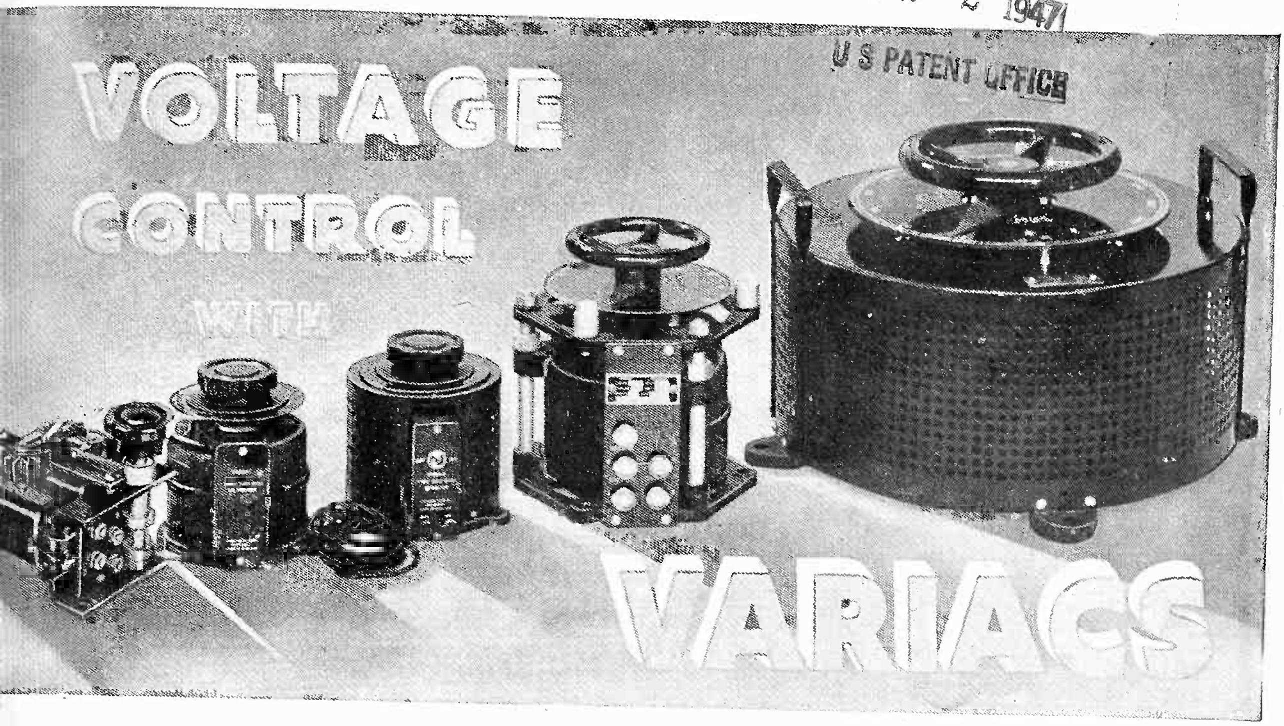
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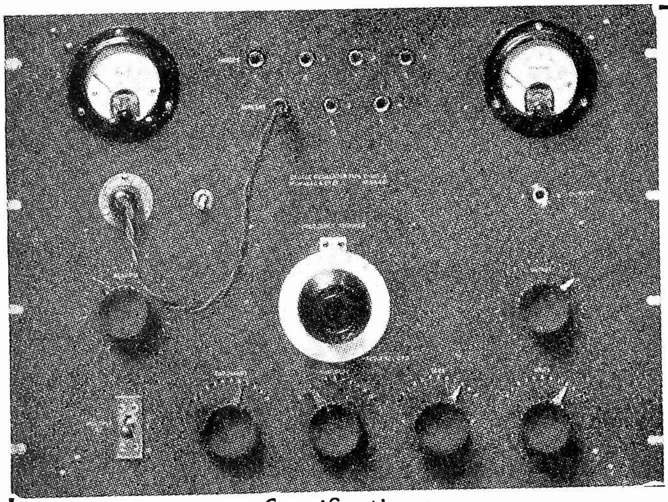

DECADE OSCILLATOR

Type D-105-A *"... as easy to use as a Resistance Box"*

The
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FREQUENCY IS DIRECT READING TO PRECISION ACCURACY ON FOUR DECADES. There are no troublesome calibration charts to refer to or engraved scales to adjust.

Write for Bulletin, B-528-B.

Specification :

FREQUENCY : *1 c/s to 111.1 kc/s on two ranges:*
1 c/s to 11.11 kc/s by 1 c/s steps.
10 c/s to 111.1 kc/s by 10 c/s steps.
ACCURACY : *± 0.2% or ± 2 c/s over the entire frequency range.* **OUTPUT :** *2 watts maximum.*
HARMONIC CONTENT : *2½% at 2 watts: 1.25% or less below 1 watt.*
POWER SUPPLY : *200 to 250 v. 50 c/s.*

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BECKENHAM, KENT
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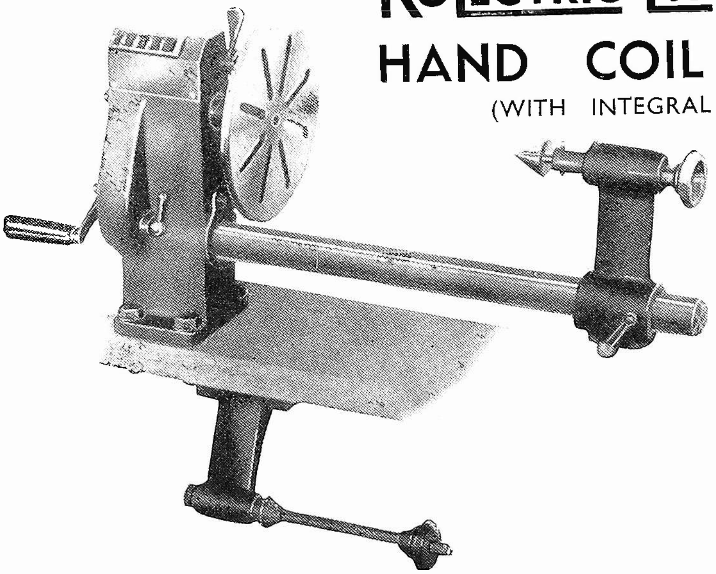

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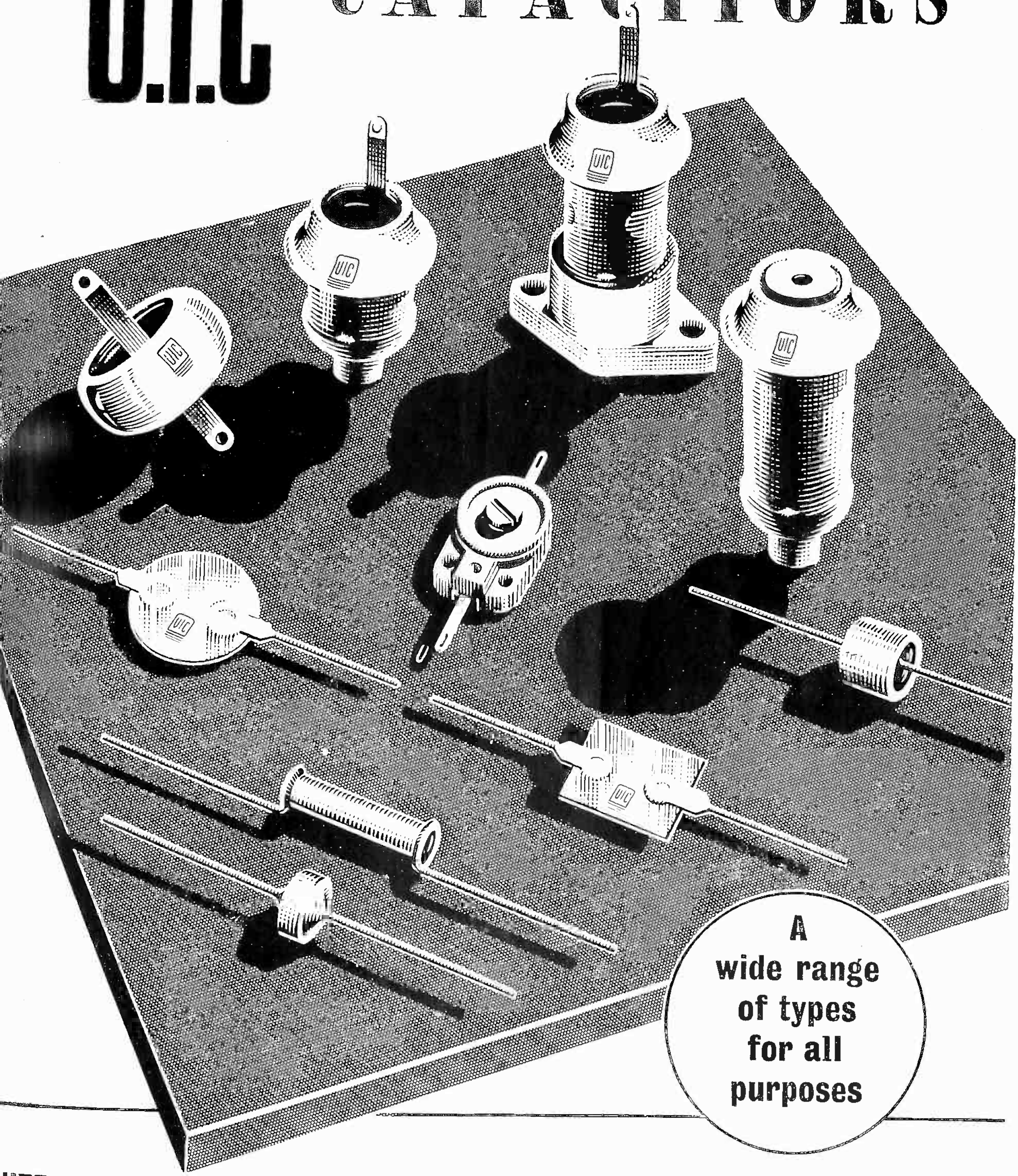
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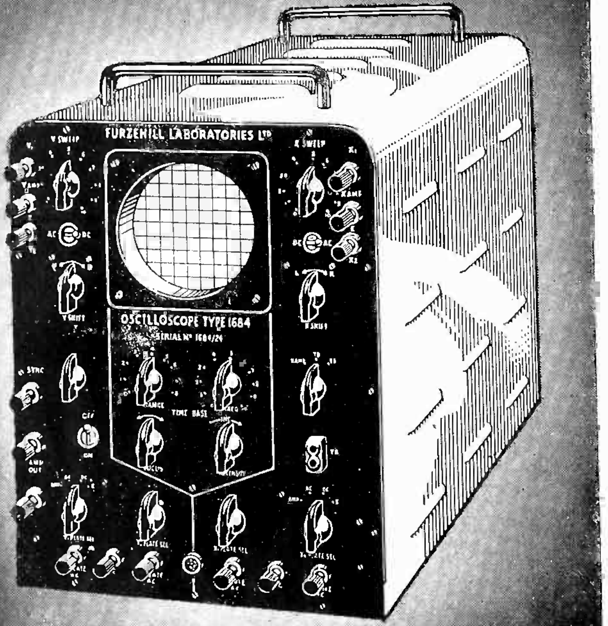

TYPE 1684B

PRINCIPAL FEATURES.

★ TUBE. 3½ in. diam. Blue or green screen.

★ SHIFTS. D.C. thus instantaneous on both axes.

★ AMPLIFIERS. X and Y amplifiers are similar. D.C. to 3 Mc/s 24 mV. r.m.s. per c.m. or D.C. to 1 Mc/s 8 mV. r.m.s. per cm.

★ TIME BASE. 0.2 c/s to 150 Kc/s. Variable through X amplifier 0.2 to 5 screen diameters. Single sweep available.

The Oscilloscope Type 1684B has proved an invaluable instrument for applications ranging from Servo Development, where signal frequencies may be as low as 0.1 c/s, to Television Research. The Oscilloscope is equipped with high gain d.c. coupled amplifiers having a frequency response from d.c. to 3 Mc/s. These amplifiers will handle symmetrical and asymmetrical input. In general the instantaneous shifts, semi-automatic synch, steadiness of image and general ease of operation are features which appeal to all engineers.

Price £100

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B.I.F. OLYMPIA, MAY 5th–16th.

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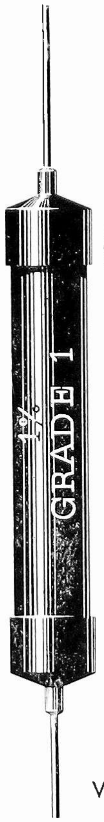
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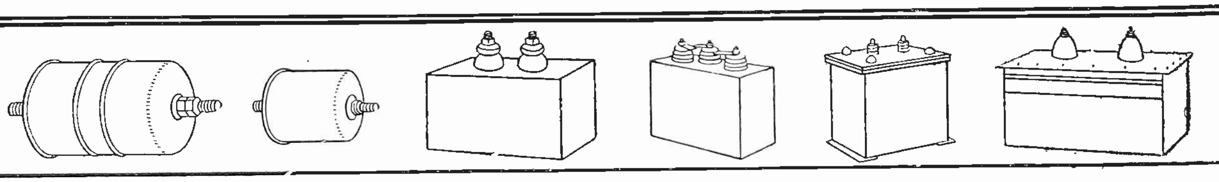
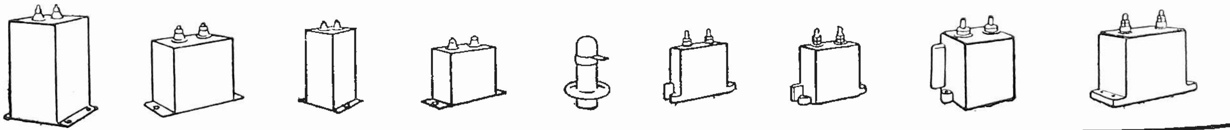




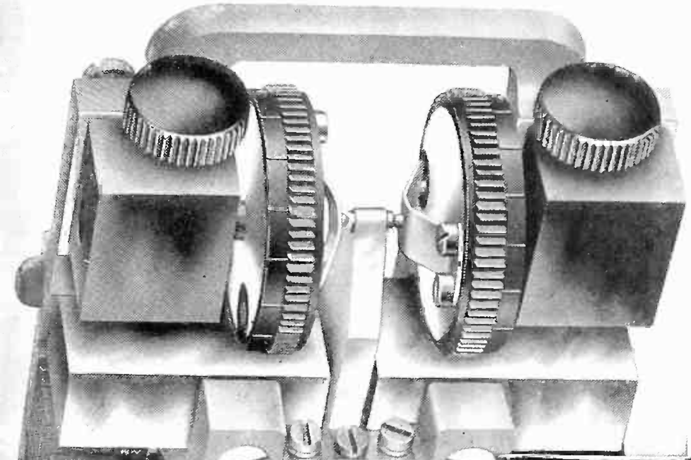
CARPENTER

High Speed Polarised

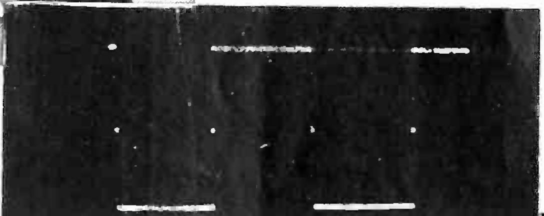
RELAY

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.

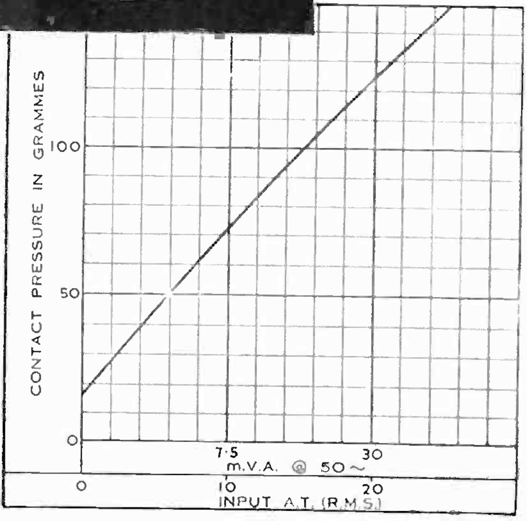


◉ (Above) *Contact mechanism of Relay showing damped compliant mountings of side contacts.*



◉ (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: 2⅜x1$\frac{1}{16}$x4¼. WEIGHT with standard socket: 22 ozs.

Ask for Booklet 1017 W.E.

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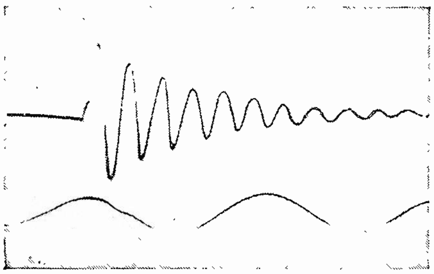

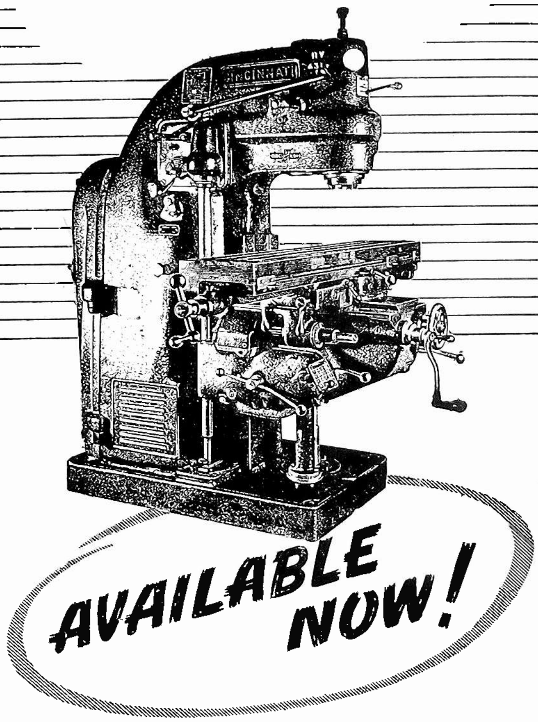
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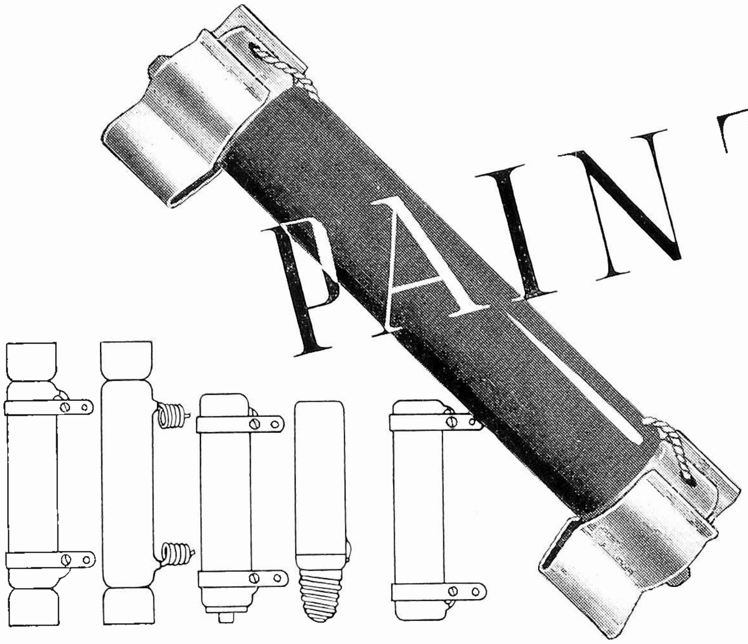
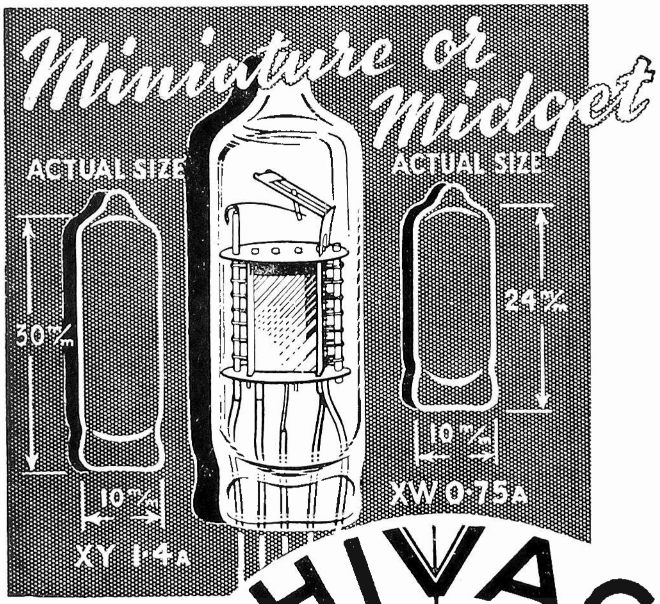
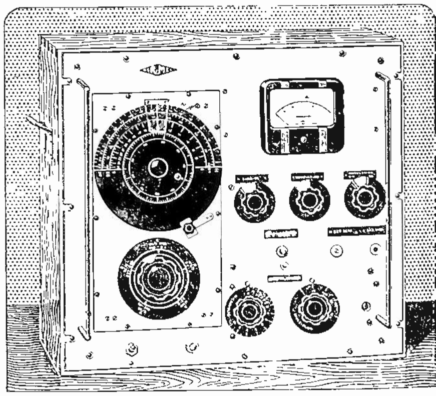



Miniature or Midget
ACTUAL SIZE
30m/m
10m/m
XY 1·4A
ACTUAL SIZE
24m/m
10m/m
XW 0·75A



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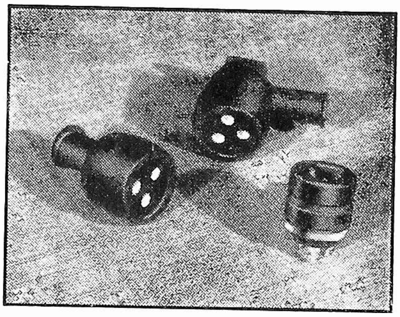

carefully designed rubber housing makes this a
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f connector to I.S.S.R.C. 320, e.g., tested to
stand a water pressure of 25lbs. per sq. inch.
lable either straight through or right angle.
body is moulded bakelite.

The chassis part carrying pins only.

May be used as a line connector by mounting the chassis part in a rubber housing; this provides an ideal trailing lead for outside work, in a laboratory or workshop. For rough handling provision is made for strain cord. Chassis pins have solder spills, flex sockets with tag connection, all metal parts silver-plated. To carry 5 amps.

L563/EP	End entry Flex plug,	Price each **3/-**
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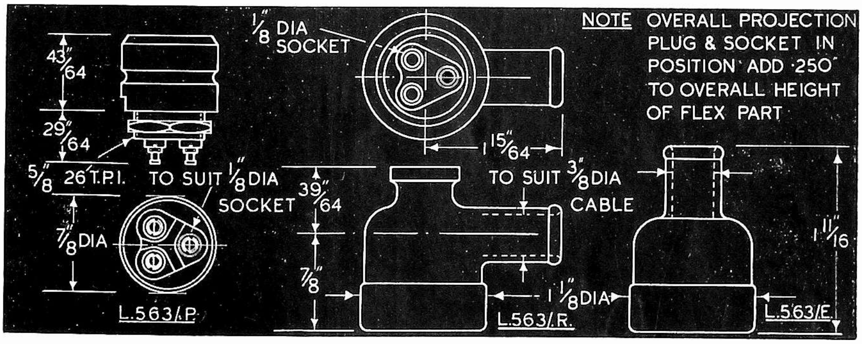

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Designers requiring further information or working drawings, should apply direct to us at Enfield.

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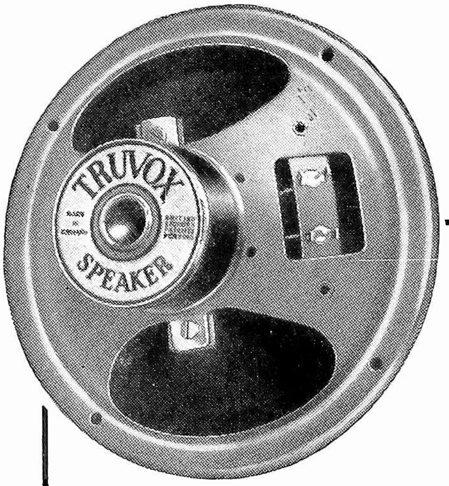
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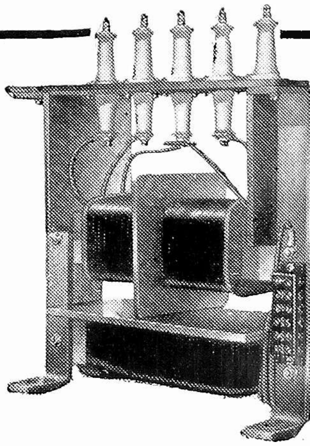

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RADIO SET

FOR THE

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OUR latest combined Wireless Set and Hearing Aid is a powerful all-wave super-heterodyne. This Radio Set for the Deaf can be used by a deaf person either to listen in comfort to broadcast programmes from all parts of the world, or as a powerful hearing aid enabling him or her to join in the general conversation. In this latter capacity, it is certainly the most powerful instrument available anywhere. The instrument incorporates an " output limiter ", which protects the deaf person from sudden loud noises, thoughtless manipulation of the controls, or atmospherics. There is also a tone control, enabling the deaf person to vary the quality of reproduction to his or her individual requirements, and an independent control for adjusting the volume of sound through the headphones without affecting the output from the loudspeaker.

The deaf person has the choice of listening with our patented Unmasked Hearing system, which gives a degree of intelligibility quite unobtainable with any other form of receiver, or with single earphone, miniature earpiece or bone conductor; while the rest of the family can enjoy really fine reproduction through the loudspeaker.

SPECIFICATION: 8-valve super-heterodyne, with 5-watts push-pull pentode output. Delayed Automatic Volume Control on R.F. stages, together with Audio Frequency Automatic Volume Control on Hearing Aid. Variable Tone Control. Built-in Crystal Microphone. Cabinet, horizontal type, Figured Walnut, 24 ins. x 12 ins. x 10 ins. Mains voltages 110-250 volts A.C. 3 Wave Bands: Home and European Model—16-50 m., 200-550 m. 900-2,000 m. Overseas Model—13.5-38 m. 36-120 m., 200-550 m. **PRICE : 40 gns. plus 8 gns. purchase tax.**

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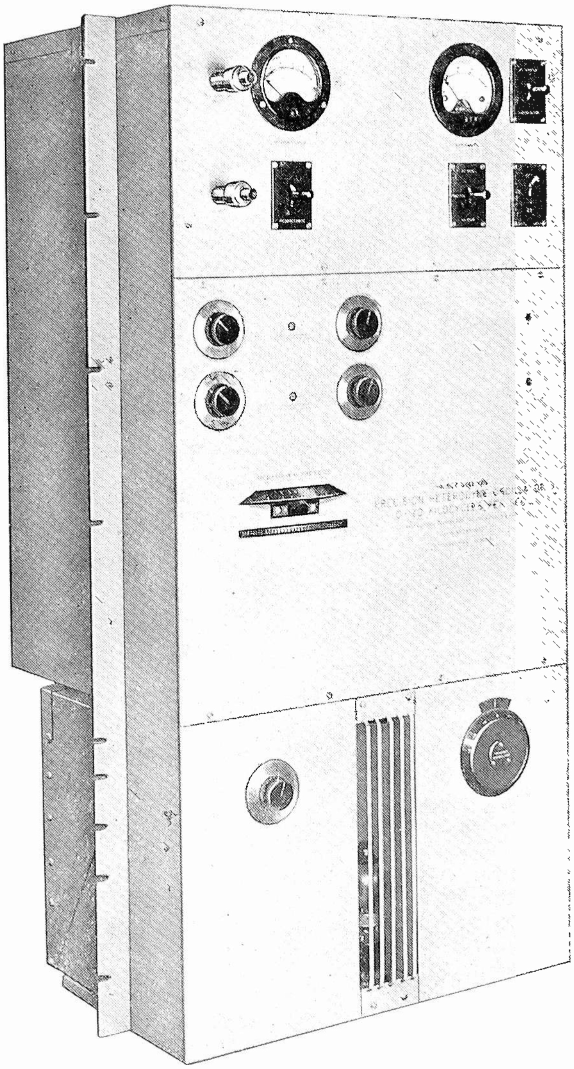

WIRELESS ENGINEER

The Journal of Radio Research & Progress

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MAY 1947

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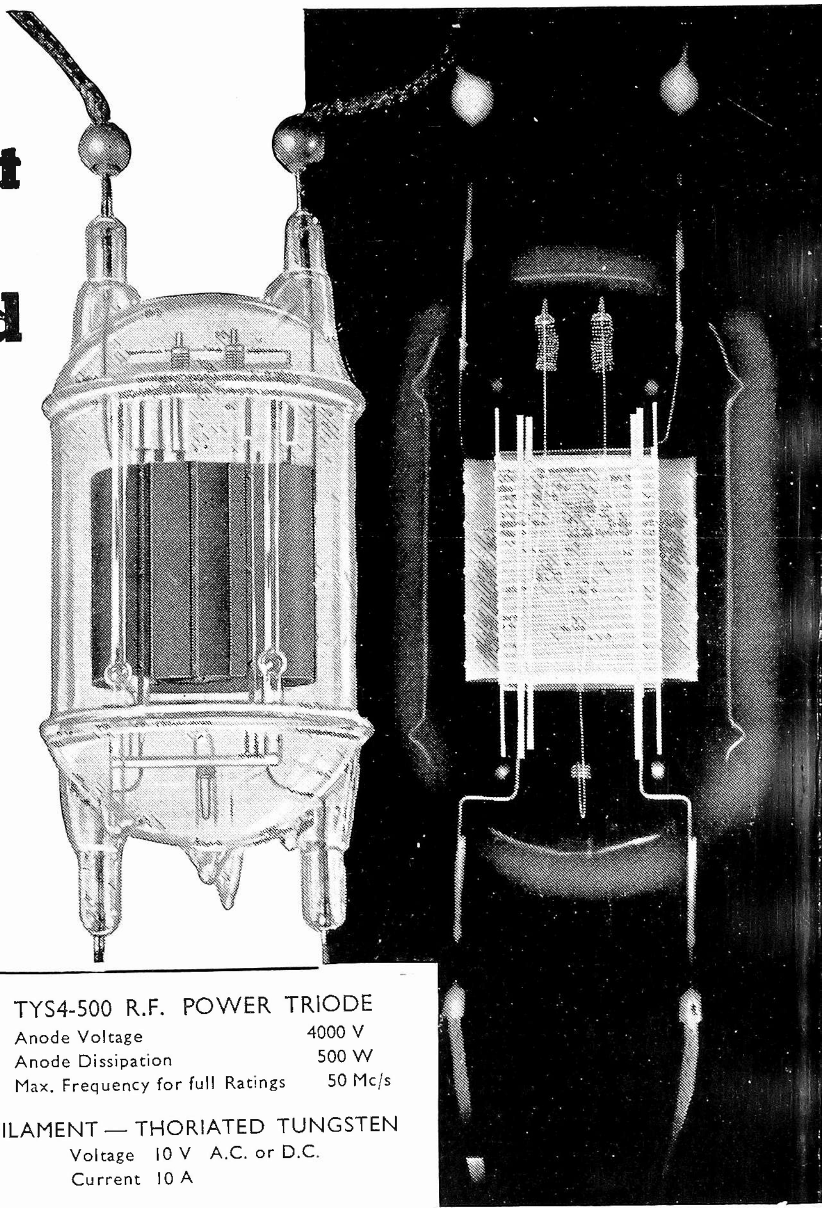

TYS4-500 R.F. POWER TRIODE

Anode Voltage	4000 V
Anode Dissipation	500 W
Max. Frequency for full Ratings	50 Mc/s

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Voltage 10 V A.C. or D.C.

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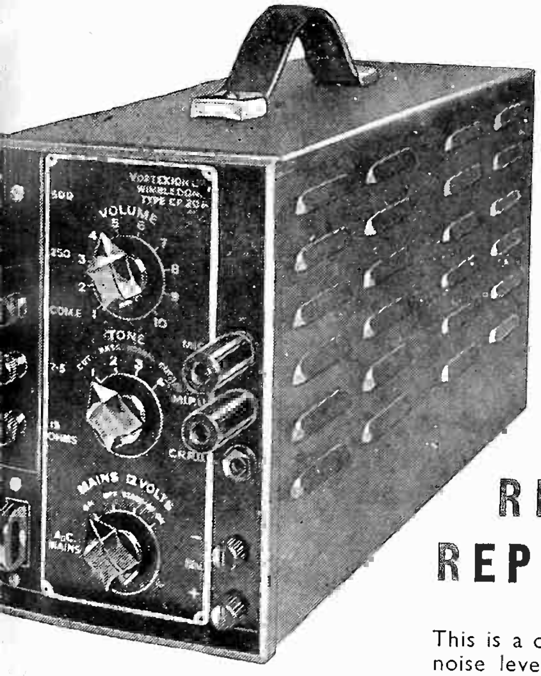

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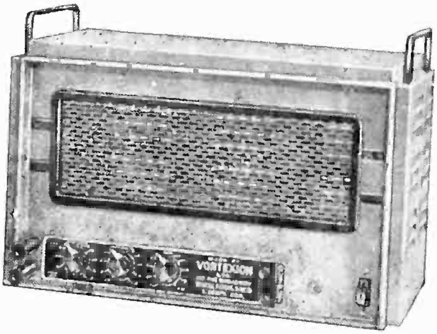

This is a development of the A.C.20 amplifier with special attention to low noise level, good response (30—18,000 cps.) and low harmonic distortion (1 per cent. at 10 watts). Suitable for any type of pick-up with switch for record compensation, double negative feedback circuit to minimise distortion 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.**
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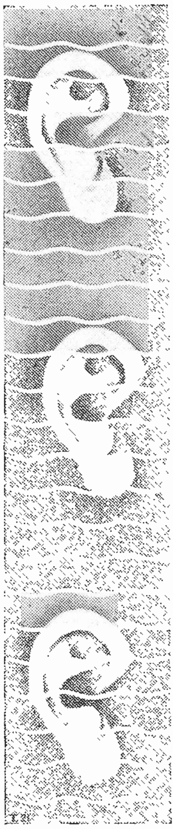

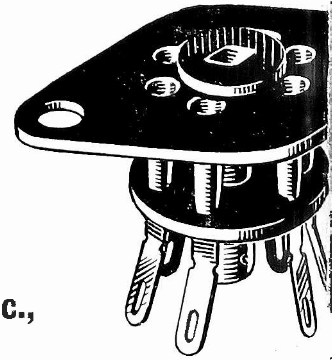

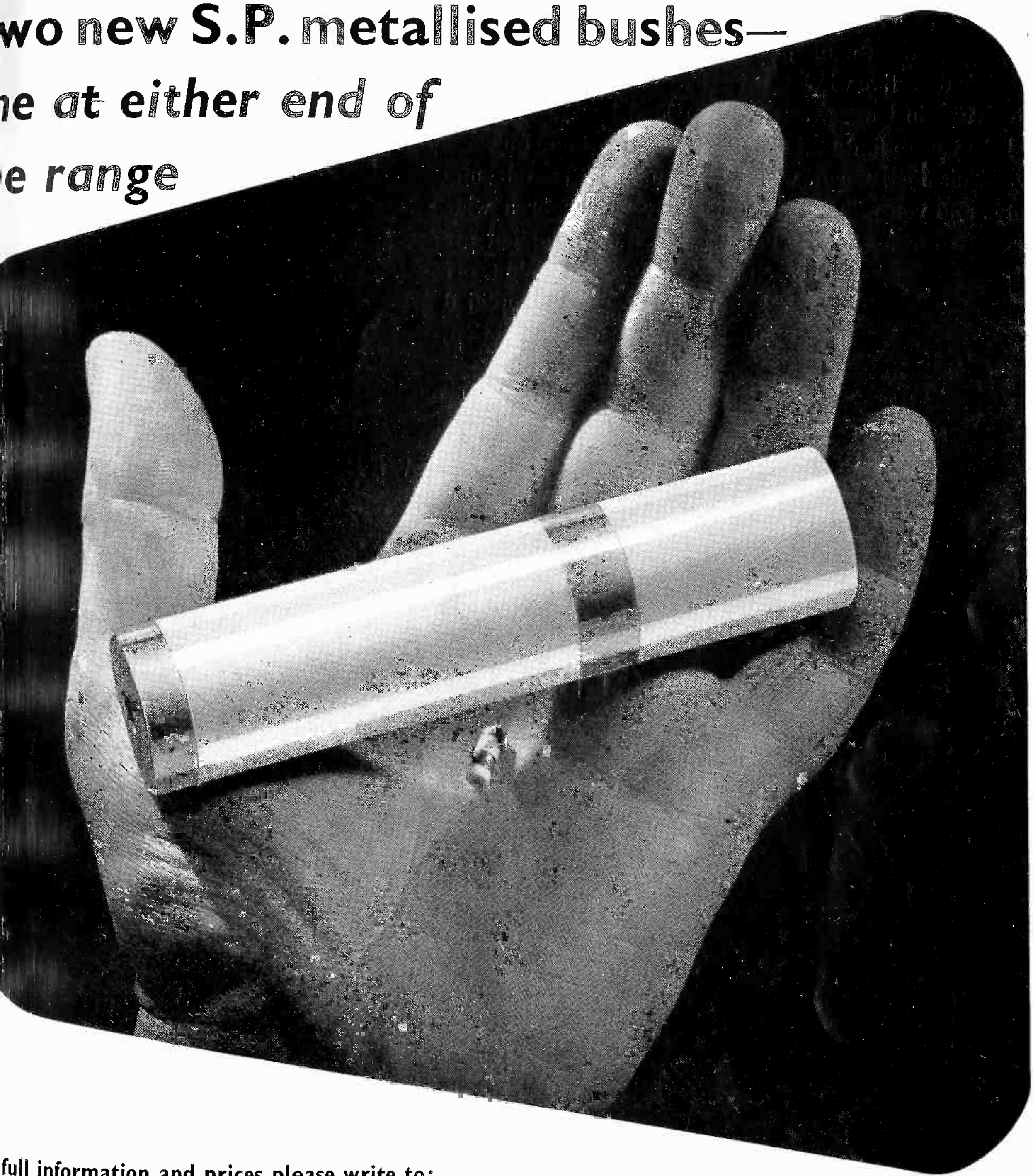

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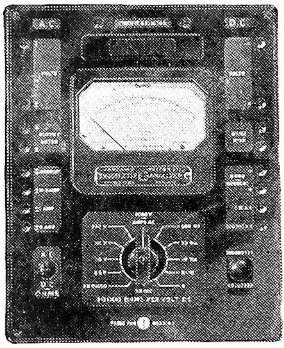

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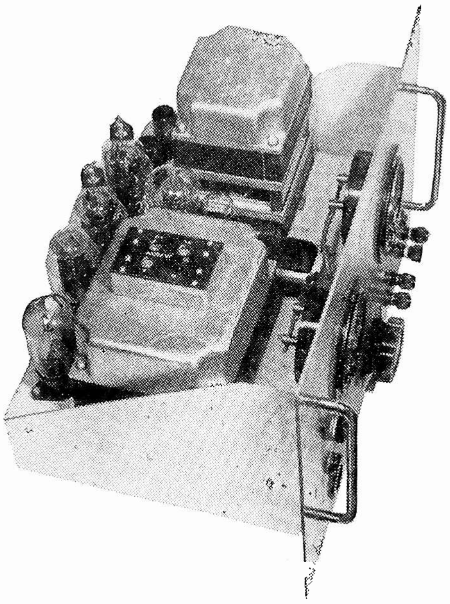

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and pulsed
50/50 square wave
at 1,000∼

★ **ATTENUATION**
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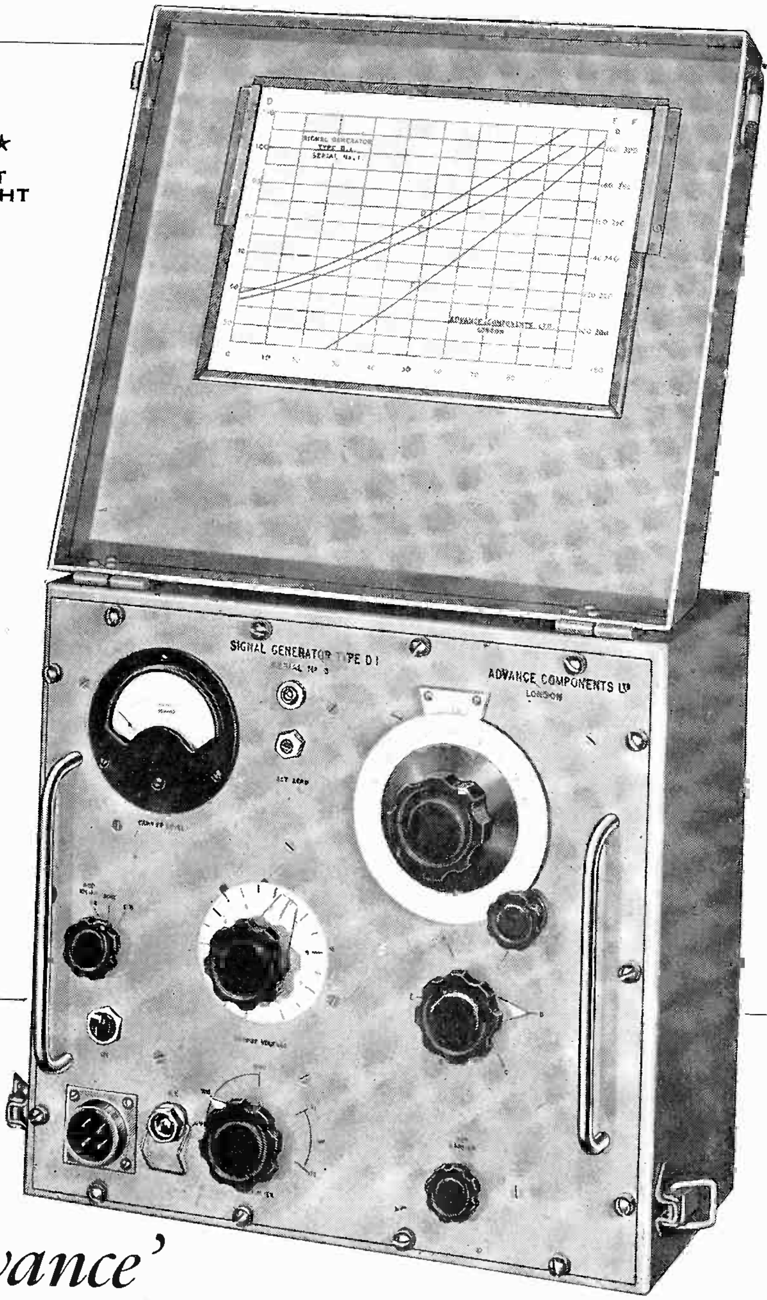
± 2dB.



★ **COMPACT**
12¼″ x 13¼″ x 7¾″

★ **PRECISION SLOW MOTION DIAL**

★ **WIDE RANGE**
10-310 mcs.

★ **FREQUENCY CALIBRATION**
1%

to 310 mcs.

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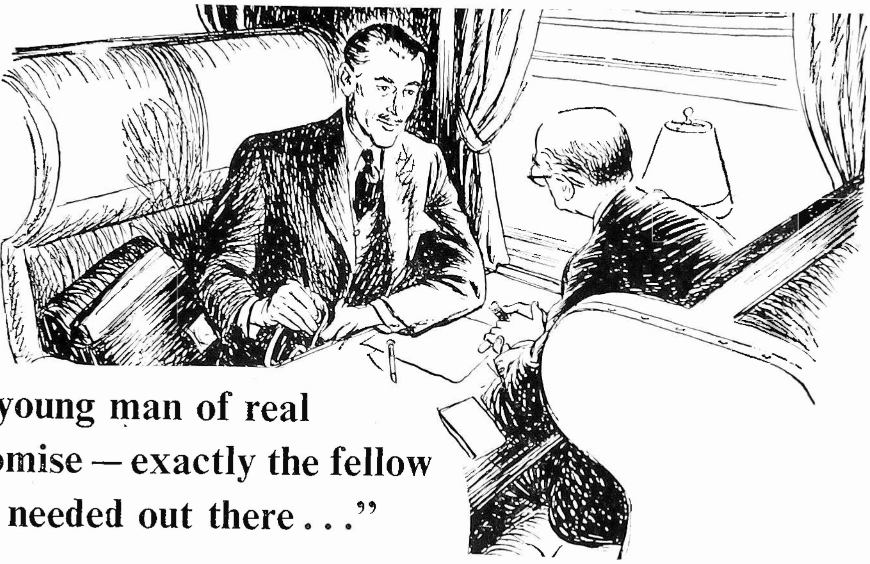

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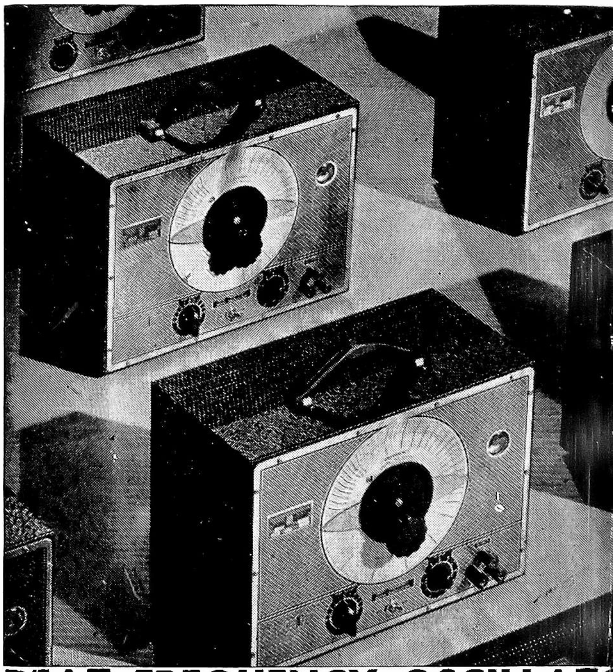

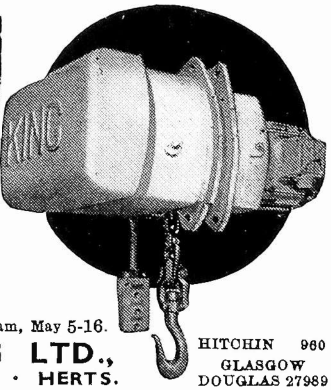

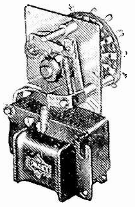

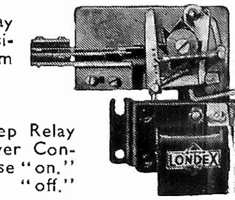

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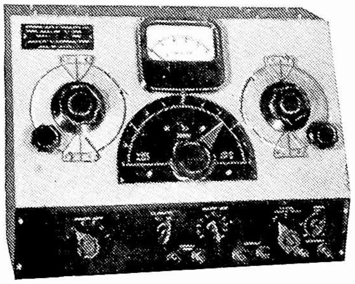

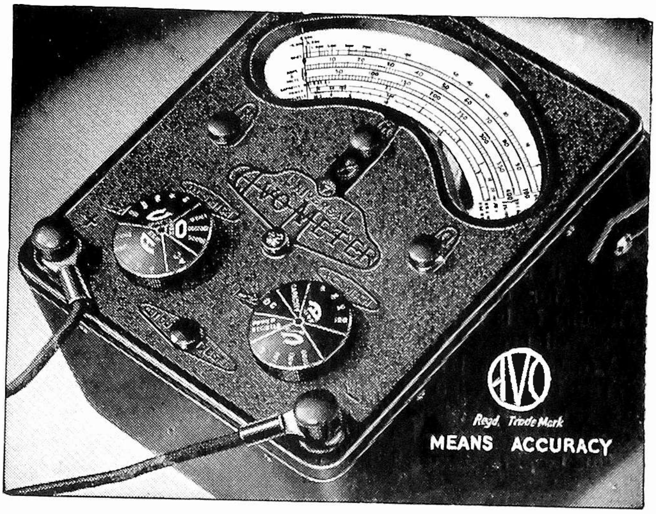
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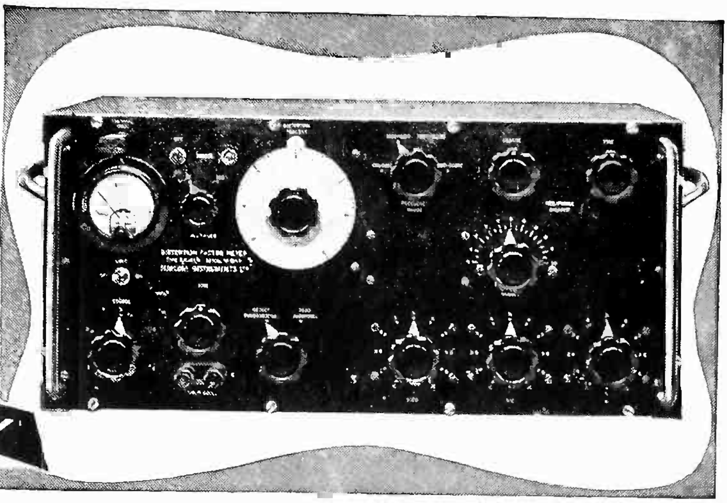

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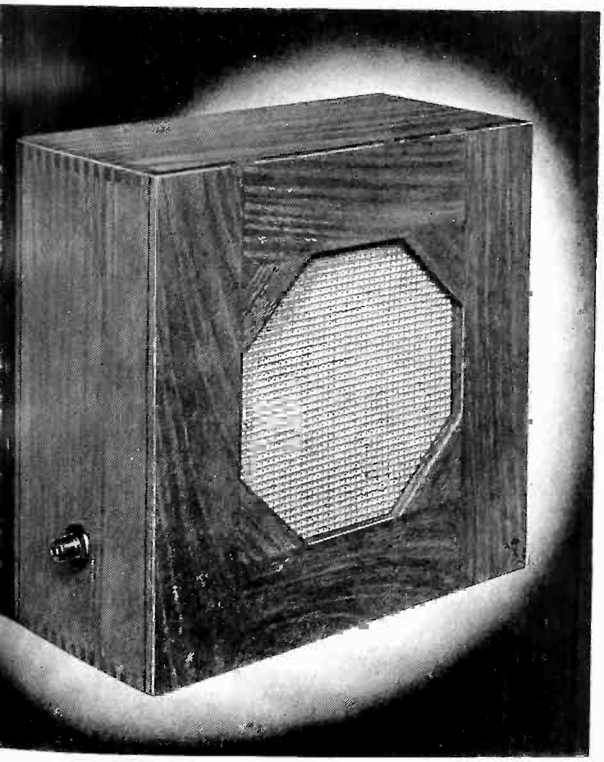

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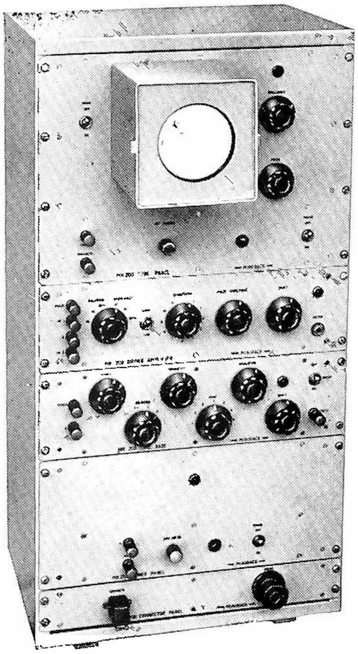

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G.11/47.

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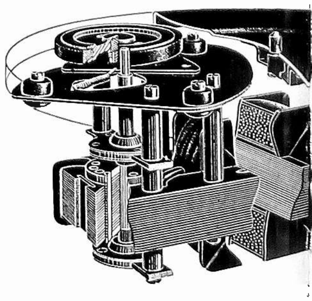

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WIRELESS
ENGINEER

Vol. XXIV. MAY 1947 No. 284

EDITORIAL

The Electric-Magnetic Analogy

IN the January Editorial, entitled "The Use of Analogies," we criticized some strictures made by Professor Livens on the use of the electric-magnetic analogy. In this number we publish a letter from Professor Livens in which he quotes some formulae in support of his contention that the supposed analogy does not exist. He gives formulae for the Lagrangian and Hamiltonian functions L and A for both the electric and magnetic fields. For the electric field the two functions are identical except for a change of sign, viz.,

$$-L = A = \int \mathcal{E} dD = \int \mathcal{E} dP + \mathcal{E}^2/8\pi \quad (1)$$

where $D = P + \mathcal{E}^2/4\pi$

This shows the total energy supplied to the field as made up of two components, one due to the material polarization P, and the other that which would be present in the empty space with the same value of $\mathcal{E}$.

There is, however, another way of looking at it; instead of finding the increase of energy in the space due to the presence of the material dielectric for a given value of $\mathcal{E}$, we might regard the charge or D as fixed and find the decrease of energy due to the presence of the dielectric. On putting $\mathcal{E} = 4\pi(D - P)$ we have

$$\int \mathcal{E} dD = \int (4\pi D) dD - \int (4\pi P) dD$$
$$= \frac{(4\pi D)^2}{8\pi} - \int (4\pi P) dD \quad \ldots \quad (2)$$

The first term is the energy that was in the electric field before the material dielectric was introduced; the second term is the decrease due to the admission of the material dielectric; it represents mechanical work done by the field on the incoming dielectric, the charge being constant.

We have expressed the energy of the electric field in these two different ways in order to show that two closely related electrical phenomena can be expressed by formulae which, if they applied to different phenomena, would hardly suggest the existence of any analogy between them.

When we turn to the magnetic formulae quoted by Professor Livens we find things a little more complicated, for L and A no longer represent the same thing. $A = \frac{1}{4\pi} \int H dB$ is the usual expression for the magnetic energy supplied to the field, as represented by the upper area in the Figure, whereas $L = \frac{1}{4\pi} \int B dH$ represents the lower area. By putting $B = H + 4\pi J$ we get

$$A = \int H dJ + H^2/8\pi \quad \ldots \quad \ldots \quad (3)$$

which is the analogue of (1), whereas by putting $H = B - 4\pi J$ we get

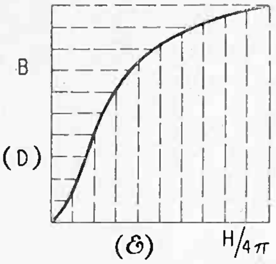
$$A = B^2/8\pi - \int J dB \quad \ldots \quad \ldots \quad (4)$$

which is the analogue of (2) and which agrees with Professor Livens' 4th formula.

The area of the lower part of the Figure can be found either by direct integration or by subtracting the upper area from the rectangle $BH/4\pi$. By direct integration, putting $H = B - 4\pi J$, we get

$$L = \frac{1}{4\pi}\int BdH = \frac{1}{4\pi}\int BdB - \frac{1}{4\pi}\int(4\pi B)dJ$$
$$= B^2/8\pi - \int BdJ \qquad \ldots \qquad \ldots \quad (5)$$

as given by Professor Livens' 2nd formula. By putting $L = BH/4\pi - A$ we get, of course, exactly the same result.



This cannot be expected to line up with either of the electric field formulae which were concerned with the stored energy; that is, with the equivalent of the upper area in the figure. Thus the parallelism between the electric and magnetic formulae holds in the case of A, but breaks down in the case of L owing to its application to the upper area for the electric field and to the lower area for the magnetic field. This raises the question as to why the Lagrangian function differentiates in this way between the electric and the magnetic field. A possible answer is that it does not, but that, since in the electrical case D is proportional to $\mathcal{E}$, the curve becomes a straight line through the origin and the areas above and below the line are equal, so that $\int \mathcal{E}dD = \int Dd\mathcal{E}$ and it is immaterial which one writes. If this is the answer then one may reply that, although it may be immaterial numerically, it is not immaterial but very important when comparing the symbols with those in the analogous magnetic formulae.

It must be emphasized that the attempt to apply similar mathematical formulae to the two fields does not imply any belief in their physical similarity. We agree with Professor Livens as to the danger of basing arguments on supposed analogies. We have on several occasions drawn attention to the fact that $\mathcal{E}$ is analogous in some ways to B rather than to H, and that D is analogous in some ways to H rather than to B, but we feel sure that any attempt to exchange the roles of H and B and thus improve the analogy, as suggested by Professor Livens, is very undesirable and quite impracticable.

G. W. O. H.

NARROW BAND-PASS FILTER USING MODULATION*

By N. F. Barber, M.Sc.

(Admiralty Research Laboratory, Teddington)

It is not easy to build a band-pass filter whose pass-band is very narrow. Filters of this kind usually employ a mechanical resonating system, such as a crystal when the pass band is at a high frequency, or a reed for a low frequency. The mid-frequency of the pass-band is fixed by the mechanical properties of the crystal or reed, and once the filter is built this frequency f_0 cannot be changed. If a very exact specification is needed the construction of a suitable crystal is expensive.

The following method of filtering by modulation seems to offer many advantages. The mid-frequency of the pass-band is fixed by the frequency f_0 of a modulating signal supplied to the filter. It follows that if we provide one source of this frequency we can construct as many filters as we please whose pass-bands will all have exactly the same mid-frequency f_0. This frequency is not a characteristic of the individual filters, and we may adjust their pass-bands to centre upon some new frequency f_1 merely by supplying them with this frequency as a modulating signal. The width of the pass-band is a characteristic of each individual filter and is determined by a low-pass network of electrical components.

The simplest process of filtering by modulation is to multiply the input signal $A \sin (2\pi ft + \alpha)$ by a modulating signal $A_0 \sin 2\pi f_0 t$ to give amongst other tones a difference tone equal to $\frac{1}{2}AA_0 \cos [2\pi (f - f_0) t + \alpha]$. When f is nearly equal to f_0 this difference tone will have a lower frequency than any others present and we may extract it from the rest by means of a low-pass filter. This transmits only tones whose frequency $(f - f_0)$

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* MS accepted by the Editor, October 1946.

is below a certain small value δf_0; thus we only have an output when the input frequency f lies within a narrow range $f_0 - \delta f_0$ to $f_0 + \delta f_0$. When the input consists of a spectrum of frequencies of which more than one lies in the transmitter range we may use a hot-wire instrument to measure the r.m.s. value of the output.

This simple system suffers from two disadvantages. The first is that the phase angle α of the input frequency is quite lost. The second is that an input tone whose frequency is exactly equal to the frequency f_0 of the modulating tone may be absent in the output from the filter. We have seen that the difference tone is

$$\tfrac{1}{2}AA_0 \cos\left[2\pi\,(f - f_0)\,t + \alpha\right]$$

and when f is equal to f_0 this becomes a unidirectional current or voltage

$$\tfrac{1}{2}AA_0 \cos\alpha.$$

If α happens to be 90° the value of this is zero. To avoid these disadvantages we must use a more elaborate system which is indicated in the block schematic diagram and is as follows.

1. First Modulation

We supply the input tone $A \sin(2\pi ft + \alpha)$ to two channels. The modulating tone is supplied to these two channels through a phase-splitting network so that the modulating signals in these channels are

$$+ A_0 \sin 2\pi f_0 t \qquad\qquad + A_0 \cos 2\pi f_0 t$$

The difference tones produced in the two channels are

$$+ \tfrac{1}{2}AA_0 \cos\{2\pi\,(f - f_0)t + \alpha\}$$
$$+ \tfrac{1}{2}AA_0 \sin\{2\pi\,(f - f_0)\,t + \alpha\}$$

2. Low-pass Filters

Each channel has a low-pass filter and they are of identical construction. The frequency $(f - f_0)$ is transmitted in each filter with an attenuation factor N and a phase advance of β. The transmitted signals are

$$+ \tfrac{1}{2}AA_0 N \cos\{2\pi\,(f - f_0)t + \alpha + \beta\}$$
$$+ \tfrac{1}{2}AA_0 N \sin\{2\pi\,(f - f_0)t + \alpha + \beta\}$$

3. Second Modulation and Recombination

The signals in the two channels are multiplied by the original modulating tones interchanged between the two channels, the sign of one modulating tone being changed. The modulating tones are now

$$+ A_0 \cos 2\pi f_0 t \qquad\qquad - A_0 \sin 2\pi f_0 t$$

and the products are

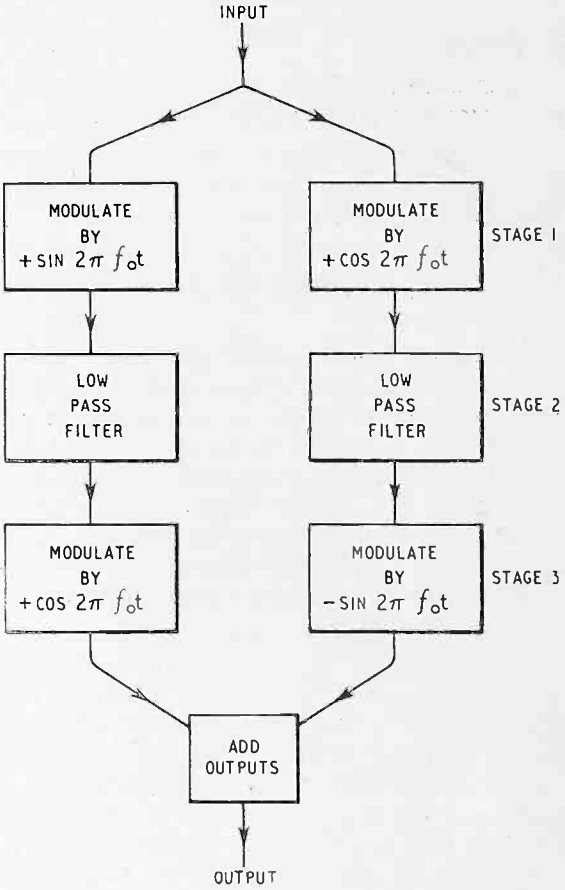
$$\tfrac{1}{2}AA_0^2 N.\cos 2\pi f_0 t.\ \cos\{2\pi\,(f - f_0)\,t + \alpha + \beta\}$$

and

$$-\tfrac{1}{2}AA_0^2 N.\sin 2\pi f_0 t.\ \sin\{2\pi\,(f - f_0)\,t + \alpha + \beta\}$$

These outputs are added in a linear resistance network to give a total output

$$\tfrac{1}{2}AA_0 N.\sin(2\pi ft + \alpha + \beta + \pi/2).$$



A band-pass filter using modulation.

This output signal has the same frequency f as the original input signal. Its amplitude involves N which is very small except when f is nearly equal to f_0. We therefore have a narrow-pass filter. The phase angle of the output signal is advanced on that of the input signal by a quadrant and by an angle β determined by the low-pass filter and dependent on the value of $(f - f_0)$. The factor A_0^2 is the same for all input frequencies and will not appear quite in this form since the process of modulation is not merely that of forming a product. The overall effect is, therefore, that of a narrow band-pass filter in which the mid-frequency is that of the modulating signal f_0 while the character of the pass-band about f_0 is determined by the characteristics N and β of the low-pass filter.

It is simple to make a number of similar low-pass filters. The precise character of the pass-band is not usually so important as the value of the mid-frequency. We are, therefore, able by this means to make two or more filters whose characters are for all practical purposes the same.

4. Errors

It is useful to know what effect errors in construction may have on the result.

(a) *Errors in phase splitting.* If the modulating tones in the two channels are not quite in quadrature, but may be written

$$A_0 \sin 2\pi f_0 t \qquad A_0 \cos (2\pi f_0 t + \epsilon)$$

it appears on repeating the previous working that the output is

$$\tfrac{1}{2} A A_0 N . \cos \epsilon \, . \sin (2\pi f t + \alpha + \beta + \pi/2).$$

The only effect of the phase-splitting error is the term $\cos \epsilon$ which is the same for all frequencies f. The error in amplitude is $(1 - \cos \epsilon)$ which is very small, proportional to ϵ^2 when ϵ is small. There is no error in phase. This insensitivity to error in phase splitting is due to interchanging the modulating tones between stage 1 and stage 3.

(b) *Differences in gain in the channels.* If the overall gains, represented above by A_0^2, are not the same in the two channels, but are in ratio $(1 + a)$ then the output is no longer a pure tone of frequency f. The amplitude of the tone of frequency f is increased by a factor $(1 + a/2)$, and there appears also a tone of frequency $(2f_0 - f)$ whose amplitude is in ratio a to the main tone.

5. Details

The modulation has been treated as a multiplication by a pure tone, but it is possible to use square-top modulation, such as is produced by a rectifier bridge, or by a switching system in the case of low frequencies. This square-topped form involves frequencies f_0, $3f_0$, $5f_0$, etc., but no error will be introduced in stage 1 if the input contains no frequencies as high as $3f_0$, for these higher frequencies in the modulation cannot then produce difference tones near zero frequency. In stage 3 we may modulate by a square-topped wave providing that we introduce into the final output a low-pass filter which excludes frequencies of $3f_0$ and above, but passes frequencies near f_0.

It is probably necessary to use an amplifying stage in each channel. These stages must be of identical construction in the two channels in order to avoid errors due to differences in the gain. These amplifiers have to deal only with low frequencies; they should ideally be d.c. amplifiers. If they do not transmit d.c. the system will not transmit a frequency f_0 in the input and the pass-band will become two narrow pass-bands, one above and one below the frequency f_0.

Stage 3 appears to be a useful means of forming the square root of sum of squares of two outputs A_1, A_2 which are constant or vary slowly with time. When we multiply these outputs by a.c. tones $\sin pt$, $\cos pt$ and add the result we get a total a.c. output of

$$A_1^2 + A_2^2 \sin (pt + \tan^{-1} A_2/A_1)$$

in which the amplitude is $\sqrt{A_1^2 + A_2^2}$ and the phase relative to the modulating tone gives the ratio A_2/A_1.

It is not necessary to use the same modulation frequency in stages 1 and 3. If we use a frequency f_0 in stage 1 this makes the filter pass input signals whose frequency is near to f_0. If the modulating frequency is f_1 in stage 3 the transmitted tones are presented as a band near frequency f_1. An input frequency f becomes an output frequency $(f - f_0 + f_1)$. This is convenient for some purposes. Both modulating tones must be supplied to all the filters in use.

Acknowledgment is made to Chief of the Royal Naval Scientific Service for permission to publish this article.

CAVITY RESONATORS AND ELECTRON BEAMS

By J. H. Owen Harries, A.M.I.E.E., M.I.R.E.

(Concluded from page 118 of the April issue)

12. Introduction to Measurements

IT follows from the theory given earlier that, to be efficient, a resonator has to have a shape which departs from any of the simple cubical or cylindrical shapes, and which is one having electrical characteristics which cannot readily be computed. Moreover, in practice, electrons have to be introduced into the field inside the resonator through holes or grids, and these, and other considerations having to do with the production and control of the electron beam itself, modify the field shapes. The grids will prevent a sharply defined transit angle from existing along the beam path. Therefore, the practical design of resonator/electron-beam combinations must be performed in conjunction with practical measurements, though the theoretical considerations provide a necessary framework.

Efficient conditions for electron beam-resonator operation depend on Ψ exceeding about 10 or so (Fig. 5) and not upon a need for a precise adjustment of this quantity. Therefore, the measurement technique need not possess great accuracy.

Measurements of field strengths and currents in absolute units are not valid in resonant cavities on micro-wavelengths unless extreme precautions are taken. For engineering purposes they are best avoided; but relative indications of electric- and magnetic-field strengths are readily made with vacuum thermojunctions and detectors having ascertainable laws (Bibs. 10 and 11).

Even if reliable aperiodic measuring instruments were in fact readily available, and were calibrated in absolute units of current and field strength, then their uses would be very limited because the nature of resonators is such that "lumped" constants do not exist. A measuring instrument, for example, cannot possibly be arranged directly to read the result of integrating the field. At low frequencies, a voltmeter can be connected to two points across a circuit as a whole, and will then read the electric-field integral (voltage) across the circuit directly; but no two such points exist anywhere in a resonant cavity. Instead, one has to measure the electric-field vectors at all points along a specified path within it, and then integrate, taking into account both direction and magnitude—often no small task—and then (because curl $\mathbf{E} \neq 0$) the result will not be a potential difference which can be specified in volts, but a vector field integral.†

For these and other reasons, the following technique has been devised, and will be explained with reference to the specific parameters developed earlier.

An electromagnetic-field standard, of known characteristics in an analytically tractable resonator shape, is used, and unknown parameters of other resonators of arbitrary shapes are obtainable by comparative measurements between the standard and the resonator to be measured.

By using a rotatable probe, and by measuring boundary fields, the magnitude and direction of the internal magnetic and electric fields of the resonator can be evaluated.

Field-strength indicators, giving relative, and not absolute, readings are employed. Their frequency characteristics are not of consequence, provided the comparative readings of any given set are made on or about the same wavelength.

This technique has been developed only to the accuracy needed for the purpose; but seems to be applicable in a straightforward manner to measurements with more precise limits.

13. The Model Principle

Resonant cavities to be used in microwave valves are usually too small for many measurements to be made. The measuring instruments tend to be comparable in size

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† See the respective definitions of "potential" and "volt" in the "International Technical Vocabulary" (1938) of the International Electrotechnical Commission.

to the wavelength ; therefore "over-size" model cavities have been used on a longer wavelength than the operating one, and the measured results on the models adjusted to the operating wavelength by the use of the relationships already set out.

The principal parameters vary with λ in a given resonator shape as is shown in Table I.

TABLE I

Parameter	Variation with wavelength λ	Certain surface conditions as a factor
Q	$\lambda^{\frac{1}{2}}$	*
Voltage parameter ξ	Does not vary	
Electron coupling ζ parameter	$\lambda^{\frac{1}{2}}$	*
Ψ	$\lambda^{\frac{5}{2}}$	*
Voltage/current density Δ	Non-analytical	
Areas	λ^2	
Volumes	λ^3	
Skin depth δ ..	$\lambda^{\frac{1}{2}}$	*

Since the conditions and material of the surfaces of a large model may necessarily be different from that of the smaller operating cavity, precautions must be taken as regards changes of P_R other than as $\lambda^{\frac{1}{2}}$. The parameters which are liable to this error are marked * in Table I.

Provided that Q is reasonably high (and there is usually no difficulty about this) the field magnitudes, directions, and boundaries may be shown to be independent of λ to a very high degree of accuracy. In what follows, therefore, ξ will be considered as not varying with λ. This assumption is the basis of the use of a "standard" cavity.

A useful range of wavelengths for model resonators is about 150 to 40 cm. A typical signal generator has a micrometer tuning head which is readable to about 4×10^{-5} metres wavelength. The output is fed through an attenuator. Resonators made for this waveband are large enough for field direction measurements (see on) to be made using probes which are very small compared to the wavelength ; but these cavities are rather too large to be readily given smooth and polished internal surfaces for direct measurements of the parameters which are marked * in Table I. An operating wavelength of 10 cm or so is better for * parameters, because physically smaller, and therefore more even and polished copper surfaces, can be used. The provision of two models of a given resonator, one large, and one smaller, may therefore be found on occasions to be a useful expedient.

14. A Standard Resonator

One standard employed by the author is a rectangular copper box resonator of dimensions as follows. The suffix s indicates a standard value.

$$x_0 = z_0 = 0.762 \text{ metre.}$$

$$y_0 = 0.2 \text{ metre.}$$

The lowest frequency (H_{011}) mode is used for measurements ; and λ_s is then 1.08 metres and $y_0/\lambda_s = a = 0.185$.

A simple computation shows that, for $x_0 = z_0$, we have

$$\xi_s = 88.2$$

The measured Q_s varies with the degree of oxidization of the copper walls. The calculated value is 33,000. A measured value is 17,000.

The relative magnitude of $\mathbf{E}'$ in volts/metre and $\mathbf{H}'$ in amps/metre just inside the walls of the standard can be computed. The maximum instantaneous magnitude at the electric antinode, and at the current antinode respectively, have the ratio

$$\frac{\mathbf{E}'}{\mathbf{H}'} = 5.35 \times 10^2$$

Note that, in M.K.S. units, the permeability of free space μ_0 is not unity, and $\mu_0\mathbf{H}' = \mathbf{B}'$ is the magnetic induction in webers per square metre (1 weber per square metre $= 10^4$ gauss).

By inserting a loop indicator for $\mathbf{H}'$, and a crystal or diode probe indicator for $\mathbf{E}'$ at the appropriate points of maximum field in the standard resonator, both indicators may be calibrated in relative $\mathbf{H}'$ and $\mathbf{E}'$ magnitude and are then used to make appropriate measurements in another cavity.

15. Measurement of Q.

The usual method utilizes the property of a resonance curve, which is such that (Bibs. 2 and 12)

$$Q = \lambda/\Delta\lambda \quad .. \quad .. \quad .. \quad .. \quad (43)$$

where

λ = the operative wavelength

$\Delta\lambda$ = the width of the resonance curve at 0.707 times the peak reading in the case of a linear indicator ; or at 0.5 times the peak reading in the case of a square-law indicator.

Q should be measured under conditions such that the field indicator loads the circuit to a negligible extent and so that the cavity is fed from a constant-current source. To ascertain if this is so, several Q measurements should be made at differing coefficients of coupling to the source. A coefficient of coupling must be used which is within a range where Q does not vary with considerable changes in the coefficient. Similarly, the indicator must be in a part of the field where the Q does vary with variations of position of the indicator from weak to stronger parts of the field.

16. Field Indicators

Diode detectors employing "acorn" valves (R.C.A.955, etc.) make useful field indicators, but should be calibrated in relative field values at or about the operating wavelength. This may be conveniently performed against a vacuum thermocouple at the working frequency. It may be necessary to make a correction for transit time if a low-frequency calibration is used.

Some crystal detectors are also of use, but care should be taken to check their performance from time to time. A remarkably stable and convenient type is the cartridge crystal developed during the war for the Services.

It is usually found that low-reading vacuum thermojunctions, or crystals, when used as field-strength indicators, can readily be arranged to load the resonator to a negligible degree ; but in some circumstances two indicators are worth using to obtain the unloaded Q, as follows :—

Three readings are taken :

Reading 1 Q_A with Indicator A.

Reading 2 Q_B with Indicator B.

Reading 3 Q_C with Indicators A and B together.

Since Q_L is inversely proportional to the total power loss $P_L + P_R$ [from (9)] the three readings and the definition of Q, lead to four simultaneous equations =

$$\left.\begin{array}{llll} \dfrac{1}{Q} = \dfrac{P_R}{\omega W_F} ; & \dfrac{1}{Q_A} = \dfrac{P_R + P_A}{\omega W_F} ; \\ \dfrac{1}{Q_B} = \dfrac{P_R + P_B}{\omega W_F} ; & \dfrac{1}{Q_C} = \dfrac{P_R + P_A + P_B}{\omega W_F} \end{array}\right\} \quad \ldots \quad (46.1)$$

where P_A = the power loss in indicator A,
P_B = the power loss in indicator B.

Solving (46.1) leads to

$$\frac{1}{Q} = \frac{1}{Q_A} + \frac{1}{Q_B} - \frac{1}{Q_C} \quad \ldots \quad (46.2)$$

17. Measurement of Electron-Beam Parameters

These are Δ, A_0, i and have, in general, a non-analytical relationship to the resonator parameters. They may, however, be readily observed for a given range of wavelengths and related to the analysis by the use of the device of a reference wavelength which was described earlier.

Quite recently it has been pointed out that it is possible to represent some of the characteristics of even the more complex resonator shapes by network equations (Bib. 13). In accordance with this ingenious idea, a "model" network may be set up which represents the resonator, and then the electrical characteristics of the network can be measured. The results may then be studied analytically by the methods of network analysis.

On the other hand, ingenious and useful though this idea is, it does not take the place of the usual requirements of any scientific investigation, namely that it should be possible to check any theoretical, or quasi-theoretical, prediction by actual measurement of the performance of the device itself, which, in the present case, is a cavity resonator and not a network. This method will not be considered further in this paper.

18. Properties of Vector Fields in Resonant Cavities

In a resonant cavity, the electric field $\mathbf{E}$ is such that

$$\text{div } \mathbf{E} = 0 ; \quad \text{div } \mathbf{H} = 0 ;$$
$$\text{curl } \mathbf{E} \neq 0 ; \quad \text{curl } \mathbf{H} \neq 0 \quad \ldots \quad (47)$$

From the well-known theory of such fields, this means that no electric potential exists, and that even a two-dimensional field cannot be represented by a familiar and convenient artifice of a contour map of equi-potential lines, or by a "hill and dale" model.

In fact, there is no simple and accurate method of representing two-or three-dimensional vector fields of this kind on a sheet of paper.

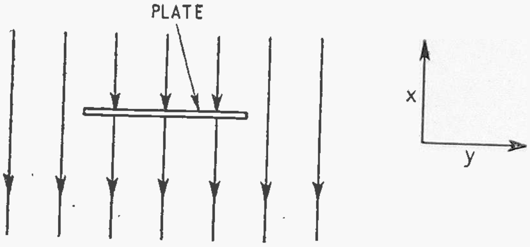

Fig. 12. *An insulated metal-plate probe orientated normally to an electric field.*

All that can be done is to represent the vector-field directions of a two-dimensional field over the area under consideration by means, for instance, of a plot of lines of field direction. At the same time, it is possible to represent the magnitude of the force at various points by numbers written at appropriate places on this plot.

If an electron is present at some point in such a field at an instant of time *t*, then it will experience a force which is the vector sum of the electric force $\mathbf{E}e$ and of the magnetic force $e(\mathbf{H} \times \mathbf{v})$ where **E**, **H**, and **v** are instantaneous values at the time *t*, and × indicates the vector product. In general, such vector fields of **E** and **H** are varying sinusoidally with time so rapidly that the instantaneous value of the magnitude of the fields will change during the time taken by the electron to move from one point to another in the field.

19. Method of Measuring Magnetic and Electric Fields and Field Integrals

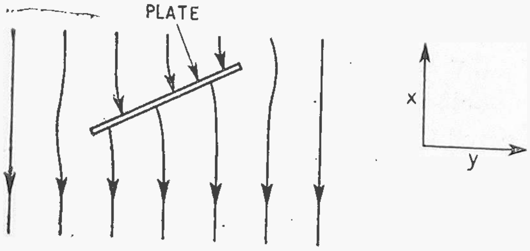

Fig. 13. *An insulated metal-plate probe orientated so as to distort an electric field.*

An experimental technique, which has been employed successfully for some time to measure and record vector electric and magnetic fields in resonators, may be explained briefly as follows:

(a) The field directions throughout the relevant part of the resonator are mapped.

(b) The field magnitude along a boundary of the resonator (or along an axis of electrical symmetry if it exists) is measured.

(c) By a graphical construction, the vector field can then be evaluated throughout the resonator.

(d) The trajectory, and energy relations, of an electron beam which is shot into the field may then be computed by graphical integration.

The method can be applied to three-dimensional, as well as to two-dimensional, fields; but frequently the usual artifices are conveniently used with advantage to reduce a three-dimensional field to two-dimensional representations.

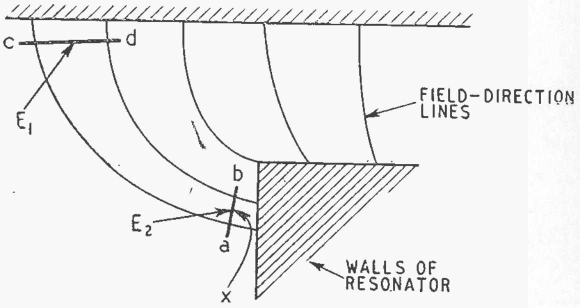

Fig. 14. *Electric-field measurements employing field-direction lines in a resonant cavity.*

When considering electron trajectories, it is seldom necessary to evaluate the effect of the magnetic field, because the electric field is usually strongest and most useful where **H** is very weak.‡

Consider a two-dimensional electric field in a resonator. The directions of the lines of force may be wholly in the *y* direction—that is, $E_y \neq 0$, and $E_x = 0$. If a thin insulated metal plate, which is very small compared to the wavelength, is inserted into the field so that its plane is normal to the lines of force, then, because there is no component of electric force in this direction, the plate will not affect the field, (Fig. 12). The resonator losses and resonant frequency will remain effectively unchanged.

If, however, the plate is orientated so as to lie as, for instance, in Fig. 13, then the lines of force will be distorted (somewhat as shown), and the damping and resonant frequency will be changed by the insertion of the plate into the resonator. If the plate is a good conductor the damping effect

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‡ Exceptions to this statement involve somewhat complicated trajectory equations.

will be very small; but the frequency change in a low-loss cavity will be sufficient to be readily noted.

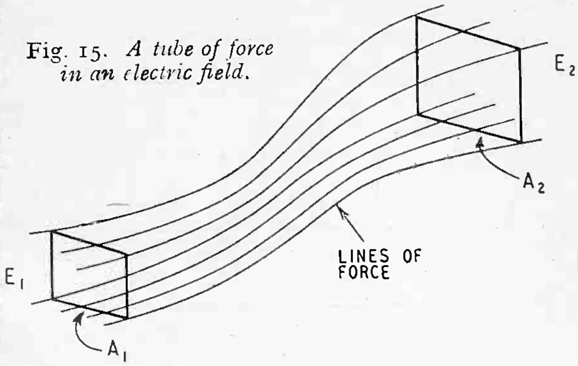
Fig. 15. *A tube of force in an electric field.*

By utilizing this phenomenon, it is possible to map the direction of the field inside a resonator. Those orientations of a small plate which do not change the wavelength are noted when it is inserted into various parts of the field. The field directions can then be drawn from this data in a manner somewhat reminiscent of the familiar "iron-filings map" of a stationary magnetic field.

To obtain the magnitude of the electric field at any point in the field, it is necessary to map the field directions as above, and, further, to measure the field strength at a boundary of the volume or area which is to be examined.

Fig. 14 represents a section of a two-dimensional electric field inside a resonator. The field exists between two boundary walls. Field-direction lines are indicated. The magnitude E_1 of the field vector which exists just inside the top boundary at, for instance, c, d, may be measured by a suitable probe indicator. The field further in is difficult, or even impossible, to measure directly with accuracy; but, nevertheless, it is desired to find its magnitude E_2 at a point x. To do this, draw a line through x normal to the field-direction lines either side of x and cutting them at a and b. Then

$$\frac{E_1}{E_2} = \frac{\text{distance } ab}{\text{distance } cd} \qquad \ldots \qquad \ldots \qquad (48)$$

In the case of a three-dimensional field, areas are to be taken instead of lengths.

By employing this principle, complete field direction and magnitude maps may be produced.

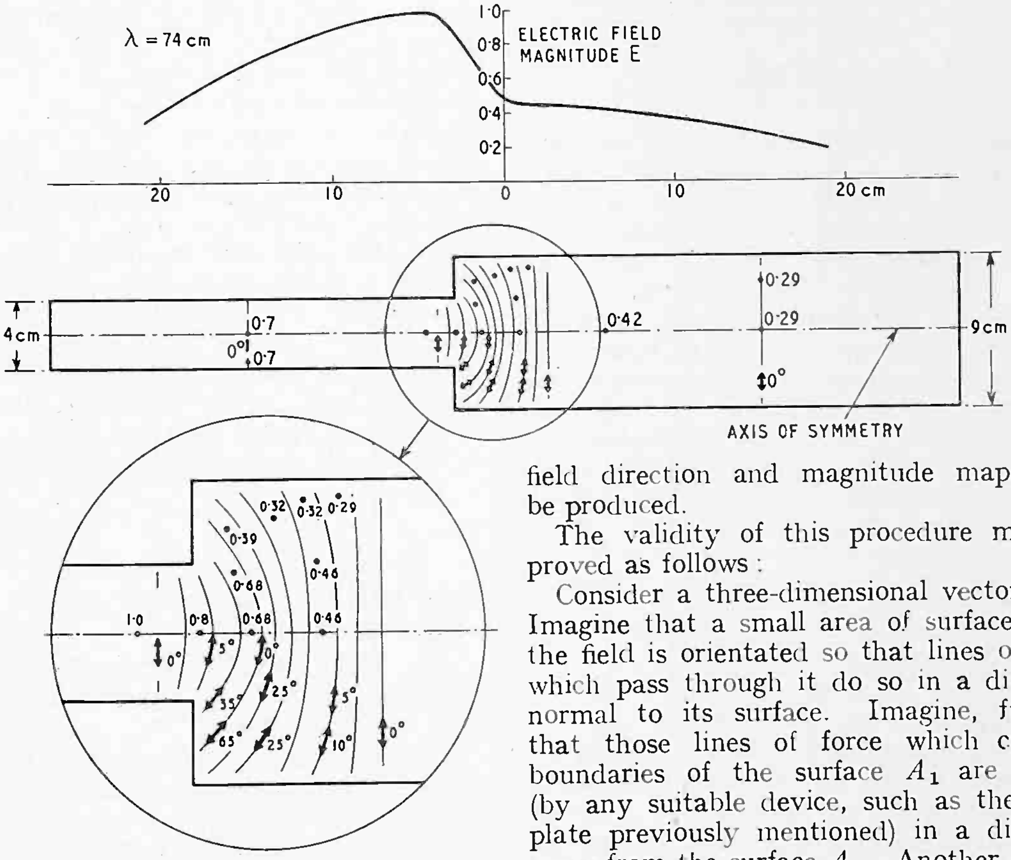
Fig. 16. *Measured electric-field directions and magnitudes in the resonator of Fig. 10.*

The validity of this procedure may be proved as follows:

Consider a three-dimensional vector field. Imagine that a small area of surface A_1 in the field is orientated so that lines of force which pass through it do so in a direction normal to its surface. Imagine, further, that those lines of force which cut the boundaries of the surface A_1 are traced (by any suitable device, such as the small plate previously mentioned) in a direction away from the surface A_1. Another surface A_2 is then positioned so that its edges cut these boundary lines of force, and so that its surface is normal to the lines of force which pass through it. This concept is illustrated in Fig. 15, and will be recognised as a "tube of force."

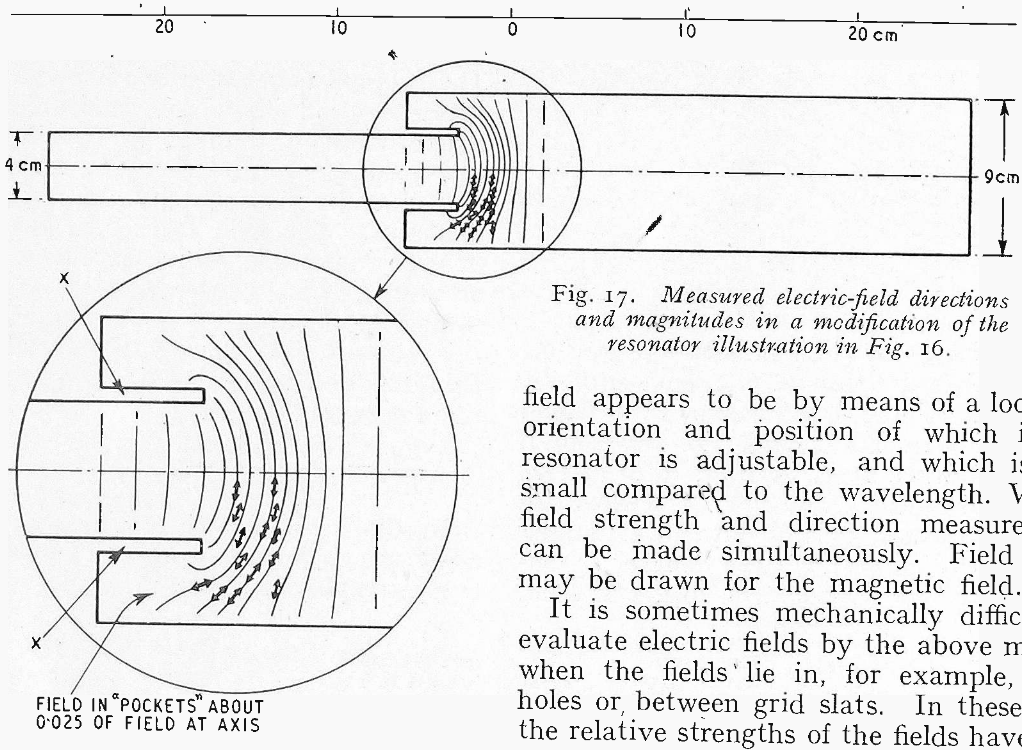

Fig. 17. *Measured electric-field directions and magnitudes in a modification of the resonator illustration in Fig. 16.*

Since, in the electric fields under consideration, div $\mathbf{E} = 0$, then, by Gauss' theorem, $\int_0 \mathbf{D} d\mathbf{a} = 0$ (where $\mathbf{D} = \epsilon_0 \mathbf{E}$) and as many lines of force must leave the volume which is bounded by A_1, by A_2, and by the surface of the tube of force between them, as enter that volume. Moreover, because, by hypothesis, the lines of force in fact enter and leave this volume only through the respective areas A_1 and A_2, it follows that the flux passing through A_1 must equal the flux passing through A_2. If it is further assumed that the flux density over both these areas is even, it follows that:

$$\frac{E_1}{E_2} = \frac{A_2}{A_1} \quad \cdots \quad \cdots \quad \cdots \quad (49)$$

where E_1 is the field magnitude at A_1, and E_2 is the field magnitude at A_2.

Therefore, referring again to Fig. 14, provided that the field-direction lines in this two-dimensional field are drawn sufficiently closely for the field to be looked upon as even between them, (e.g., between *c* and *d*, and between *a* and *b*), we have the relationship of equation (49), and therefore of equation (48).

The spacing between any two field-direction lines is proportional to the field strength between them, but not necessarily to the field strength elsewhere.

The best method of plotting the magnetic field appears to be by means of a loop, the orientation and position of which in the resonator is adjustable, and which is very small compared to the wavelength. Vector-field strength and direction measurements can be made simultaneously. Field maps may be drawn for the magnetic field.

It is sometimes mechanically difficult to evaluate electric fields by the above method when the fields lie in, for example, small holes or, between grid slats. In these cases the relative strengths of the fields have been evaluated by comparing the relative damping effect produced by the insertion of a small ball of resistance material supported on an insulating polystyrene rod. A 10-mm diameter ball made from the resistance material used in a 5-watt 10,000-ohm carbon resistor is suitable. Either too high or too low a specific resistance of the ball will not damp the cavity to a measurable degree. Provided that the resonator is so loosely coupled to a signal generator that the field readings on a diode are proportional to added damping, we have

$$\frac{E_1}{E_2} = \sqrt{\frac{\left(\frac{\phi}{\phi_1} - 1\right)}{\left(\frac{\phi}{\phi_2} - 1\right)}} \quad \cdots \quad \cdots \quad (50)$$

where

E_1 is the field at a point in the resonator;

E_2 is the field at a second point in the resonator;

ϕ is the field reading when the resistance ball is not inserted into the resonator;

ϕ_1 is the field reading with the ball inserted at the first of the two points in the resonator;

ϕ_2 is the field reading with the ball inserted at the second point in the resonator.

The disadvantage of this method is that the balls have to be physically large if accurately readable differences between ϕ, ϕ_1 and ϕ_2 are to be produced. This may introduce an error both in the field itself and in the effective point at which it is measured. It has, however, been used successfully for evaluating the shape of comparatively intense electric fields in and around " grid " apertures.

20. Examples of Field Measurements

Figs. 16, 17, and 18 show typical field plots of some resonant cavities.

field magnitude and directions are known throughout the cavity.

It is found that the necessary integration of the field is quite easily performed to the desired accuracy by graphical means based upon the field maps described previously.

In addition, the field in some complicated resonators may be split up into several component parts each of simple configuration. The field integrals of each part may then be mathematically computed.

For example, consider a part consisting of a parallelepiped having sides *a*, *b*, *l*, then :

$$\frac{2\pi c}{\lambda} W_F = \frac{2\pi c}{\lambda}\frac{\epsilon_0}{2} abl\mathbf{E}^2$$
$$= 8.35 \times 10^{-3}\frac{abl}{\lambda} E^2$$

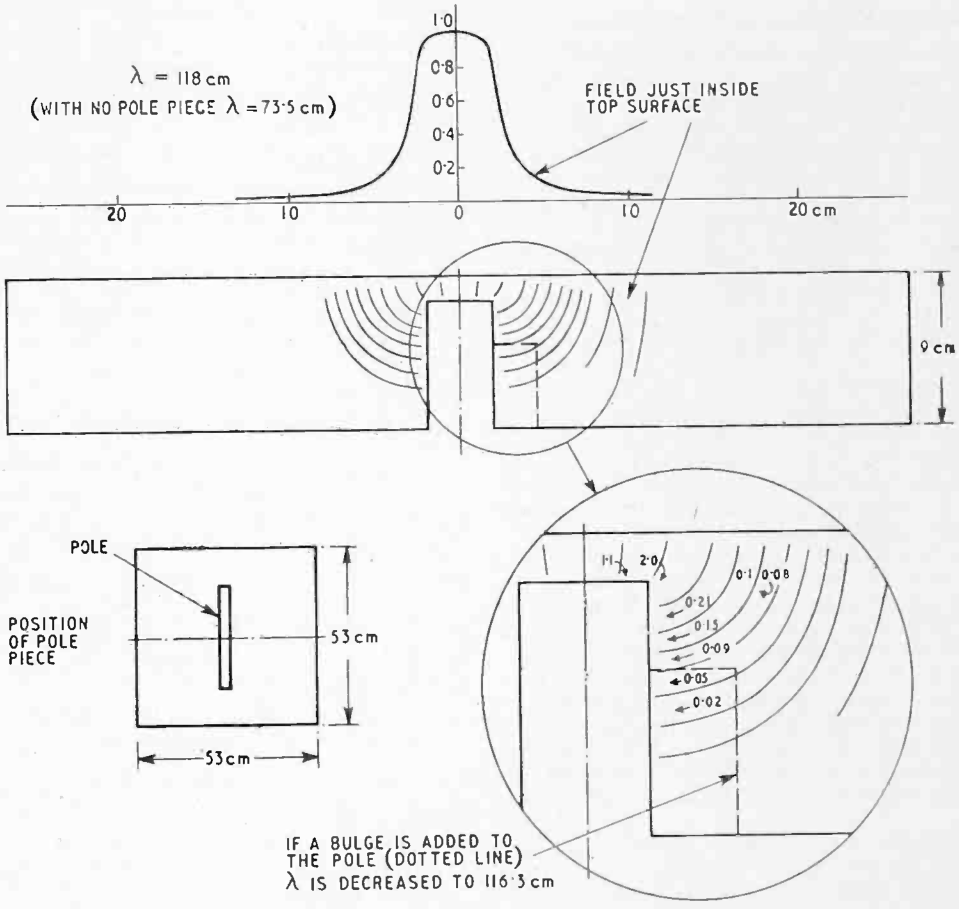

Fig. 18. *Measured electric-field directions and magnitudes in a rectangular-box resonator as Fig. 9 ; but with a " pole-piece " added.*

Referring to equation (34) and remembering that Q can be measured very readily by the resonance method, ζ is easily obtainable if ξ is known.

ξ may be evaluated for any resonator shape and mode provided that the electric if the field is in the l direction and of even intensity throughout. Should it vary as a complete half-sinusoid in one of the three dimensions, then the above expression should be divided by two for each dimension in which the variation occurs. W_F values for other component parts of the resonator—for instance, those of cylindrical and other shapes—may likewise be computed. Provided that the relative maximum values of field in these various component parts of the resonant cavity are known, the total field integrals can be obtained by summing up those of the individual parts.

21. Acknowledgment.

This analysis and the measurements were performed as part of a research programme carried out in the Electronics Dept. of Rediffusion Ltd., London. The author wishes to express his thanks to that company for permission to publish this paper.

APPENDIX

Theoretical Maximum Beam Current

Consider a cylindrical beam of electrons of radius σ passing along the axis of a conducting tube of radius r; the length l of the beam and tube being assumed to be large compared with these radii.

Using the very useful graphs and nomograms of Petrie (Bib. 15), the theoretical value of the current i for a given accelerating and cylinder voltage V ($= V_{OB}$ in the present analysis) can be found for a given beam configuration. These voltages and currents will be assumed to be quasi-stationary.

It is also assumed that any transverse entrance velocities of the electrons are negligible.

There will be the following effects due to space charge :

(i) The potential of the centre of the beam will be less than that of the edges by an amount V_M, and, if the beam current is increased relatively to the other parameters, then the point will be reached when a virtual cathode is formed and the beam will cease to exist as such, and the electrons will travel to the cylinder walls.

(ii) At current values far less than this, however, there will be a considerable difference between the velocity of the electrons at the centre of the beam, and the velocities near the edges. Such a condition is not compatible with the requirements of microwave tubes and must be avoided. The analysis of long transit angle power relations used in this paper is only valid if this condition is avoided.

(iii) The radial field acting on the electrons causes them to diverge ; this depends, other things being equal, upon the magnitude of the current density.

Considering the cross-sectional velocity distribution ; if v is the velocity at a radius r, and v_0 the velocity in the centre and at the entrance point, we can, by a straight-forward analysis, obtain the variation of velocity $\frac{v}{v_0}$ at the end of the length l in terms of $\frac{V_M}{V_0}$; i.e., of the dip in potential due to space charge. Such an analysis (Petrie's Figs. 8 and 9) shows that $\frac{v}{v_0}$ will be quite negligible, and the spreading of the beam also negligible (over values $\frac{l}{\sigma}$ in which the present analysis is concerned) if $\frac{V_M}{V_0}$ is about 0.95 or less. Salzberg & Haeff's (Bib. 16) dimensionless parameter P_a is used for this estimation, and is taken as 0.8.

We then have (from Petrie's nomogram, Fig. 1) the relationship Fig. 4 of the present paper for the ratio Δ between voltage and beam current density as a function the voltage. Fig. 4 is in M.K.S. units. Δ is therefore in volts/amps/metre^2.

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ELECTROMAGNETIC RADIATION*

By James Greig, M.Sc., Ph.D., M.I.E.E.

IN the elementary treatment of electromagnetic radiation and of the uniform line, it is convenient to postulate as a basic assumption the finite velocity of propagation of electric and magnetic forces. This assumption may be employed to bring out, in a simple qualitative way, the main phenomena of electromagnetic radiation and it is the purpose of this note to draw attention to some of these points.

Heaviside formed a physical picture of electromagnetic radiation from a "dumb-bell" radiator by considering the sudden establishment of charges upon its ends. It is useful to modify this procedure by having the radiator initially charged and allowed (or made) to execute *one* complete reversal of charge. Imagine the two spheres of Fig. 1 to be initially charged and insulated. A connecting wire is placed between the spheres at time $t = 0$ and a half cycle of oscillation takes place reversing the charges. At this instant the process is terminated by the removal of the connecting wire. Let it be assumed, for the moment, that the reversal of charge can take place without loss so that the final reversed voltage is equal in magnitude to the initial voltage. Let the interval occupied by this reversal be ΔT sec.

At the instant of placing the connecting wire in position the electrostatic field begins to "collapse" into the wire and a current flows discharging the capacitance. The appropriate changes in the field are propagated outwards with the high but finite velocity of light, c, in free space. At the instant of complete discharge the whole electrostatic field would, if the velocity of propagation were infinite, have vanished and have been replaced by the magnetic field corresponding to the maximum current. As however, the velocity of propagation is c cm/sec and the time occupied by the discharge has been $\frac{\Delta T}{2}$ sec, changes in field distribution cannot extend beyond points on the surface of a sphere of radius $\frac{c\Delta T}{2}$ cm centred on the oscillator. Within this sphere the field will be partly magnetic and partly electric, the amount of magnetic energy replacing exactly the amount of electrostatic energy which has disappeared. During the next quarter cycle the current is maintained by the collapsing magnetic flux until at the end of ΔT sec, from the start, the process of reversal of charge is complete.

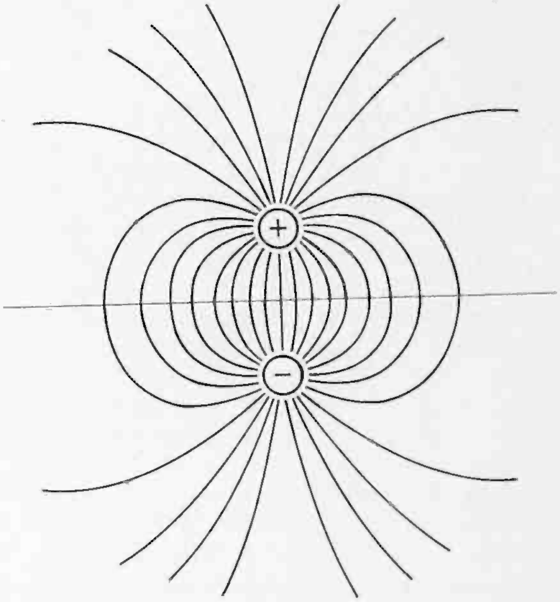

Fig. 1. *The electrostatic field between two insulated charged spheres.*

With the removal of the connecting wire the new steady state is about to be established and will be found everywhere within a second sphere of radius $(t-\Delta T)c$ cm. Thus a spherical shell of radial depth ΔTc, expanding with the velocity of light, separates two regions, one outside the outer sphere where the old steady-state field still exists and one inside the inner sphere where the new steady-state field has been set up. In these two regions the field is purely electrostatic. Within the expanding shell the field is partly electric and partly magnetic.

The configuration of the electric field a short time after the new steady state has been established at the oscillator will, if the law of continuity is to hold, be somewhat as shown in Fig. 2.

The tubes of force lying outside the outer

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* MS accepted by the Editor, October, 1946

sphere must close on themselves within the shell for, at the instant of zero charge, no tubes terminate on the oscillator and the induction must be everywhere continuous. Similarly, the tubes of the new steady-state field which pass through the inner sphere must close on themselves within the spherical shell.

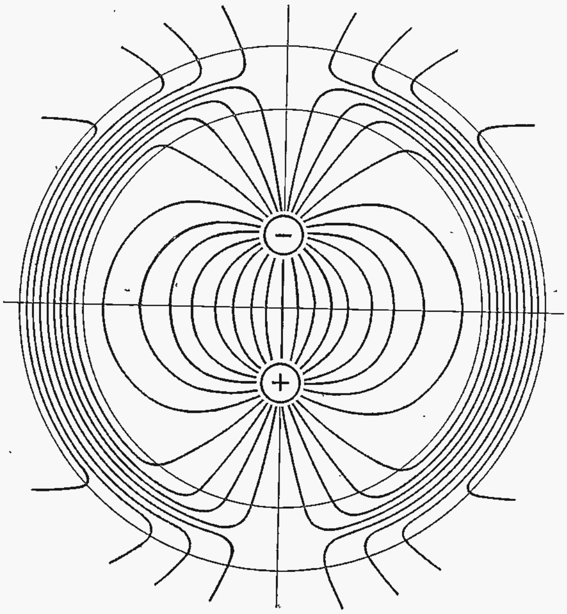

Fig. 2. *The electric field around two spheres after one half-cycle of oscillation.*

The first point of importance brought out by this physical picture is the identity of changing electric induction (displacement current) and conduction current in the production of magnetic force. Consider a circular path of radius $>\Delta Tc$ lying in the equatorial plane of the oscillator. This path links the conductor joining the spheres and with a current in the conductor will be associated a line integral of magnetic force round such a path. Now, during the *establishment* of the spherical shell a current flows in the conductor but *no* magnetic force can be experienced at the radius ΔTc on account of the propagation time delay. If the circuital law is to hold it follows that at every instant during the establishment of the spherical shell the rate of change of electric induction in the space lying between the oscillator and this radius produces a magnetic effect exactly equal and opposite to that of the conduction current flowing in the wire. As the spherical shell expands after the cessation of the conduction current there is no change in the total electric induction through any circular area in the equatorial plane having a boundary beyond the wave front. This is necessarily true as the closed loops of the "old" field, which collapse as the wave front advances, each cut the equatorial plane *twice*. There is, however, a diminution of induction as the shell crosses the boundary. There must therefore be a system of circular lines of magnetic force contained within the expanding shell.

The second point concerns the detachment of energy from the oscillator as a result of the reversal. On the assumption of reversal to equal voltage the total energy lying inside the inner sphere, for any position of the expanding shell, will be the same as prior to the reversal. Outside the outer sphere no change has taken place. Now the electric intensity within the shell is higher than in the steady state at the same point due to the concentration of the induction within the annular space. The electrostatic energy density being proportional to the square of the electric intensity is, therefore, higher within the region occupied at any instant by the shell than in the same region in the steady state. In addition there is, within the shell the energy of the associated magnetic field. Thus more energy lies *outside* the inner sphere than is required for the laying down of the new steady-state electrostatic field beyond that point. There is therefore a net detachment of energy from the oscillator in reversing the field so that, if no extra energy is supplied, the system cannot recharge to the initial voltage.

Clearly the proportion of energy thus lost in radiation depends upon the thinness of the shell; i.e., upon the rapidity of the reversal. If, for example, the thickness of the shell were halved the electric intensity at all points in the shell would be doubled and the energy density increased four times. The volume of the shell being halved the *total* energy in the shell would in consequence, be twice its previous value.

PARTIALLY-SCREENED OPEN AERIALS*

By R. E. Burgess, B.Sc.

(Communication from the National Physical Laboratory)

SUMMARY.—A simple approximate theory based on the transmission-line equations is developed for an open aerial, a portion of which is enclosed in a concentric conducting screen. The voltage and current distributions in the transmitting case are deduced. From these the effective heights of the "screened" and unscreened portions of the aerial are calculated and it is found that as the length of the unscreened portions increases so the effective height of the screened portion tends to equality with its length, as was first demonstrated experimentally by Smith-Rose and Barfield.

The susceptance of the aerial is calculated on the assumption of no losses and it is found that the anti-resonant frequencies are displaced by the presence of the screens while the resonant frequencies occur when the length of the inner conductor *or of the screen* is equal to an odd number of quarter-wavelengths.

A simple equivalent circuit is given for an aerial which is short compared with the wavelength.

1. Introduction

IN a number of applications it is common practice to screen a portion of an open aerial by an earthed concentric sheath. An equivalent system arises when an open aerial is connected to a concentric feeder, as for example in U-type Adcock systems. It is often required to know the effective height and impedance of such systems in order to determine the effect and the effectiveness of the screen, and the present paper gives a simple theory. The transmission-line method of analysis is the same as that which has been applied to the loop and the screened loop and, within the assumptions of perfect conductors, small cross-section and uniformly distributed constants, should provide formulae for effective height and reactance of comparable accuracy. The theory is compared with the early pioneering experiments by Smith-Rose and Barfield[1] on screening at low frequencies.

These experiments established a number of fundamental relations in screening, the importance and significance of which still seem to be insufficiently appreciated. In particular, if an aerial is partially surrounded by a metallic screen, the screening action is not fully effective so long as the aerial wire projects from the screen. This may be attributed to the action of the secondary field from the screen on the projecting portion of the aerial.

The general configuration of the system considered is shown in Fig. 1 (a) and the most important practical forms are shown in (b) and (c) in which the screened and unscreened portions are respectively collinear and orthogonal. The collinear type occurs, for example, when the downlead of an elevated vertical aerial is (supposedly) screened by the use of a concentric feeder; such an arrangement would not provide protection against local interference owing to the ineffectiveness of the screening of the feeder and only by providing a screened transformer at the junction of the aerial and feeder could the desired effect be obtained. The system in which the screened and unscreened portions are at right angles arises in the U-type of Adcock direction finder but the analysis presented here does not consider the effects of multiple earthing or burying the feeder which are known to reduce appreciably the pick-up on the "screened" feeder.

The properties of the aerial with a concentric feeder perpendicular to it are still sometimes not understood. For example, a vertical aerial connected to a horizontal feeder will radiate (or receive) horizontally polarized waves. Similarly a horizontal aerial with a vertical feeder will radiate or receive vertically polarized waves and the experiments of Smith-Rose and Barfield on the L-aerial with a screen around the vertical conductor demonstrated the effect of the length of the horizontal conductor on the receptive properties of this system and on the efficacy of the vertical screening.

It is desirable, at some later date, to carry out measurements at high frequencies where the resonant effects given by the analysis presented here will be important and can be confirmed quantitatively.

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* MS accepted by the Editor, August 1946.

2. General Analysis

It is assumed that the conductors are perfect and have uniform cross-sections small compared with their lengths. Let the inner conductor be denoted by suffix 1 and the outer conductor by suffix 2, their respective lengths being l_1 and l_2 ($l_1 > l_2$). Let x be the coordinate measured from the common lower end of the conductors (Fig. 1). If v and i denote the potentials and currents, the differential equations over the common portion ($x \leqslant l_2$) are

$$\left.\begin{aligned}\frac{\partial v_1}{\partial x} &= -j\omega(L_{11}i_1 + L_{12}i_2)\ ; \\ \frac{\partial v_2}{\partial x} &= -j\omega(L_{12}i_1 + L_{22}i_2) \\ \frac{\partial i_1}{\partial x} &= -j\omega(C_{11}v_1 + C_{12}v_2)\ ; \\ \frac{\partial i_2}{\partial x} &= -j\omega(C_{12}v_1 + C_{22}v_2)\end{aligned}\right\} \quad (1)$$

It is further assumed that the inductance and capacitance coefficients are uniform and that the dielectric constant is everywhere unity.

Now the screening condition is

$$L_{12} = L_{22}\ ;\ C_{12} = -C_{11} \quad .. \quad .. \quad (2)$$

and it is convenient to introduce a coefficient of coupling k given by

$$k^2 = \frac{L_{12}^{\ 2}}{L_{11}L_{22}} = \frac{C_{12}^{\ 2}}{C_{11}C_{22}} = \frac{L_{22}}{L_{11}} = \frac{C_{11}}{C_{22}} \quad (3)$$

with the relation

$$c^2\,(1 - k^2) = \frac{1}{L_{11}C_{11}} = \frac{1}{L_{22}C_{22}} \quad .. \quad (4)$$

where c is the wave velocity in vacuo.

The voltages and currents over the common region ($0 \leqslant x \leqslant l_2$) are shown in the Appendix to be given by

$$\left.\begin{aligned}v_1 &= \frac{v_0}{\cos Bl_1}\cos B\,(l_1 - x) \\ v_2 &= \frac{v_0k^2 \sin Bl}{\cos Bl_1 \cos Bl_2}\sin Bx \\ i_1 &= \frac{-jcC_{11}v_0}{\cos Bl_1 \cos Bl_2} \\ &\qquad [k_2 \cos Bx \sin Bl - \\ &\qquad\quad \cos Bl_2 \sin B(l_1 - x)] \\ i_2 &= \frac{-jcC_{11}v_0}{\cos Bl_2}\sin B\,(l_2 - x)\end{aligned}\right\} \quad (5)$$

with the summation current

$$i_1 + i_2 = \frac{jcC_{11}v_0\,(1 - k^2)\sin Bl}{\cos Bl_1 \cos Bl_2}\cos Bx \quad .. \quad .. \quad (6)$$

In the region where the inner conductor projects

$$\left.\begin{aligned}v_1 &= \frac{v_0}{\cos Bl_1}\cos B\,(l_1 - x) \\ i_1 &= \frac{jv_0cC_{11}(1 - k^2)}{\cos Bl_1}\sin B\,(l_1 - x)\end{aligned}\right\} \quad (7)$$

It is noted that the same function describes the potential v_1 on the inner conductor in both regions.

The results given by equations (5), (6) and (7) are now applied to the calculation of the effective height and reactance of the system.

A further useful parameter introduced in the analysis is

$$C_0 \equiv C_{11}\,(1 - k^2) \quad .. \quad .. \quad .. \quad (8)$$

which is the capacitance per unit length of the unscreened portion of conductor 1.

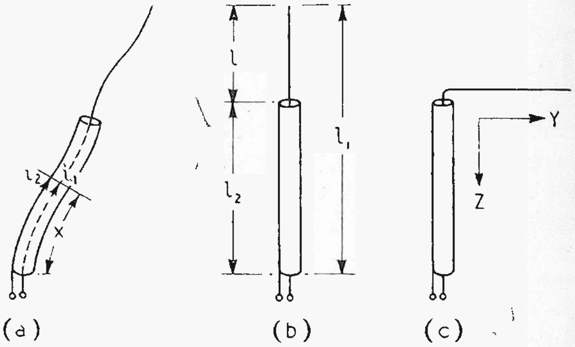


Fig. 1. *Forms of a partially-screened open aerial; (a) general configuration; (b) collinear system; (c) orthogonal system.*

3. Susceptance

Since ohmic and radiation losses have been ignored the admittance of the aerial calculated from the above equations is purely imaginary; i.e., wholly reactive. However, these values of susceptance are probably reasonably accurate except near resonant conditions.

The susceptance appearing at the base of the aerial is given by

$$\begin{aligned}S &= \frac{i_1(0)}{jv_0} \\ &= \frac{(1 - k^2)\tan Bl_1 + k^2 \tan Bl_2}{cL_{11}\,(1 - k^2)}\end{aligned} \quad (9)$$

At low frequencies ($Bl_1 \leqslant \tfrac{1}{2}\pi$) the susceptance becomes

$$\begin{aligned}S &= \omega\,[C_{11}\,(1 - k^2)\,l + C_{11}l_2] \\ &= \omega\,[C_0l + C_{11}l_2] \quad .. \quad .. \quad (10)\end{aligned}$$

corresponding to the capacitances of the unscreened and the screened portions in parallel.

The resonant frequencies are given by

$$\cos Bl_1 = 0\ ; \quad \cos Bl_2 = 0 \qquad \ldots \quad (11)$$

corresponding to the odd quarter-wave modes of the inner conductor and of the screen respectively. Thus the screen does not affect the resonances of the aerial but introduces fresh resonant frequencies.

The antiresonant frequencies of the aerial, at which its susceptance vanishes, are given by

$$(1 - k^2) \tan Bl_1 + k^2 \tan Bl_2 = 0 \quad (12)$$

which is a transcendental equation in B which cannot be solved in simple terms unless l_1 and l_2 are simply related. In the special case of $k^2 = 0.5$ the anti-resonant frequencies are evenly spaced and given by $B(l_1 + l_2) = n\pi$ but in general they are not uniformly spaced.

To take a numerical example let

Total aerial length $l_1 = 5$ m
Screened length $l_2 = 3$ m
$k^2 = 0.6$

then the resonant frequencies are at 15, 25, 45, 75, 105, 125 Mc/s, etc., while the anti-resonant frequencies occur at about 18, 38, 56 Mc/s, etc. The screen has introduced the fresh resonant frequencies at 25 and 125 Mc/s while at 75 Mc/s both the screen and the aerial are resonant; in the absence of the screen the anti-resonant frequencies would have been at 30, 60, 90 Mc/s, etc.

4. Effective Height

The effective height of an aerial is defined for the case of reception as the ratio of the induced e.m.f. appearing at the aerial terminals to the electric field intensity producing it, the polarization and direction of propagation of the exciting wave being prescribed. In the case of transmission the product of the current entering the aerial at its terminals and its effective height give the effective moment (in metre-amperes) of the aerial.

Application of the Principle of Reciprocity enables the effective height of the aerial to be most readily calculated from the current distribution in the transmitting condition. In general, if a current i_0 is applied at the aerial terminals and i is the *total* current (in the case of multi-conductors) in dx at x, the e.m.f. appearing at the aerial terminals due to any arbitrary exciting field $E(x)$ of the same frequency at i_0 is given by

$$e = \frac{1}{i_0}\int i(x)\, E(x)\, .\, dx \qquad \ldots \qquad \ldots \quad (13)$$

the integral extending over the whole of the aerial, i and E being treated as complex quantities. If now E is uniform the effective height is taken as

$$h = \frac{e}{E} = \frac{1}{i_0}\int i(x)\, .\, dx.$$

In the case of the system shown in Fig. 1 (c) let uniform fields Y and Z act parallel to the unscreened and screened portions respectively. Then the terminal e.m.f. is given by

$$Zh_z + Yh_y = e$$
$$= \frac{1}{i_0}\int_0^{l_2}(i_1 + i_2)\, Z\, dx + \frac{1}{i_0}\int_{l_2}^{l_1} i_1 Y\, .\, dx \qquad \ldots \quad \ldots \quad \ldots \quad (14)$$

so that the effective heights of the separate portions are

$$h_y = \frac{1}{i_0}\int_{l_2}^{l_1} i_1\, .\, dx$$
$$= \frac{(1 - k^2)(1 - \cos Bl) \cos Bl_2}{B(\sin Bl_1 \sin Bl_2 - k^2 \sin Bl)} \quad (15)$$

$$h_z = \frac{1}{i_0}\int_0^{l_2}(i_1 + i_2)\, dx$$
$$= \frac{(1 - k^2) \sin Bl \sin Bl_2}{B(\sin Bl_1 \sin Bl_2 - k^2 \sin Bl)} \quad (16)$$

The sum of these effective heights which is the relevant quantity for the collinear system in a uniform field is

$$h = \frac{1 - k^2}{B}\, \frac{\cos Bl_2 - \cos Bl_1}{\sin Bl_1 \sin Bl_2 - k^2 \sin Bl} \quad (17)$$

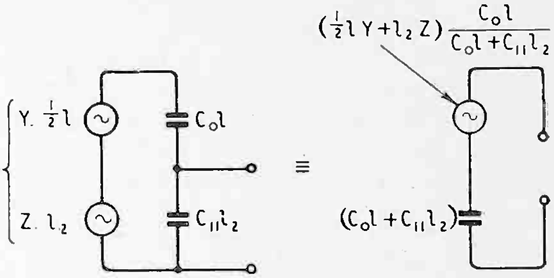


Fig. 2. *Equivalent circuit of the orthogonal system at low frequencies.*

As expected both heights vanish when the unscreened length l is zero. As l is increased from zero there is both direct pick-up of the Y field on the unscreened portion and pick-up of the Z field which can be regarded as being due to the secondary field from the screen acting on the projecting portion or, what is equivalent, due to the currents i_1 and i_2

in the screened portion no longer being equal and opposite at all values of x so that the summation current $(i_1 + i_2)$ is no longer zero.

The ratio of the effective heights for the two fields is simply

$$\frac{h_y}{h_z} = \frac{\tan \frac{1}{2}Bl}{\tan Bl_2} \qquad \ldots \quad \ldots \quad \ldots \quad (18)$$

which becomes $\frac{1}{2}l/l_2$ when the system is small compared with the wavelength.

For short conductors the effective heights are

$$h_y = \frac{l}{2} \cdot \frac{l(1-k^2)}{l_1 - lk^2} \; ; \; h_z = l_2 \frac{l(1-k^2)}{l_1 - lk^2} \quad (19)$$

The common reduction factor $l(1-k^2)/(l_1 - lk^2)$ is shown in Fig. 3 as a function of l/l_1 for $k^2 = 0.4$ and 0.6. In practice k^2 is not likely to lie outside these limits since it is very slowly dependent on the dimensions of the system. The reduction factor is seen to rise steadily from zero to unity as the fraction of the aerial length which is unscreened increases from 0 to 1.

It is easy to interpret the factor physically as the ratio of the capacitance $C_0 l$ of the unscreened portion of the aerial to the total capacitance $C_0 l + C_{11} l_2$. Thus for systems short compared with the wavelength the e.m.fs. induced by the fields Y and Z can be written

$$Yh_y + Zh_z = (\tfrac{1}{2}lY + l_2 Z)\frac{C_0 l}{C_0 l + C_{11} l_2} \quad (20)$$

which leads to the simple equivalent circuit of Fig. 2 in which the e.m.fs. $\frac{1}{2}lY$ due to Y and $l_2 Z$ due to Z are effectively induced in the unscreened part of the aerial and then divided by the capacitive potential divider formed by the unscreened and screened parts.

It is of interest to compare these effective heights at low frequencies with the values for an unscreened system for which

$$h_{y0} = \int_{l_2}^{l_1} \left(1 - \frac{x}{l_1}\right) dx = \frac{l^2}{2l_1} \qquad \ldots \quad (21)$$

$$h_{z0} = \int_{0}^{l_2} \left(1 - \frac{x}{l_1}\right) dx = l_2\left(1 - \frac{l_2}{2l_1}\right)$$
$$= \frac{l_2}{l}\left(1 + \frac{l}{l_1}\right) \ldots \quad \ldots \quad \ldots \quad (22)$$

These values are shown as dashed lines in Fig. 3. The ratio of the heights in the unscreened case is

$$\frac{h_{y0}}{h_{z0}} = \frac{l}{l_2\left(1 + \frac{l_1}{l}\right)} < \frac{1}{2} \cdot \frac{l}{l_2} = \frac{h_y}{h_z} \quad \ldots \quad (23)$$

Thus the effect of screening the Z portion of the aerial is also to reduce the Z pick-up relative to the Y pick-up, the reduction being great when the fraction l/l_1 of unscreened conductor is small. This is mainly due to the large reduction of the Z pick-up since in the screened case the e.m.f. Zl_2 is induced in the small capacitance of the unscreened portion.

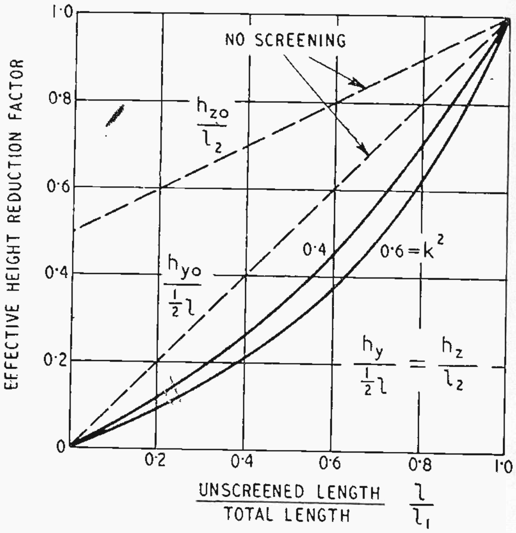


Fig. 3. *Effective height factor at low frequencies.*

5. Conclusions

The simple transmission-line theory is applied to the calculation of the susceptance and effective height of a partially screened open aerial assuming that the dielectric everywhere has a permittivity of unity and that losses are negligible.

The conclusions of the analysis are as follows :—

(*a*) The potential distribution on the inner conductor is of simple cosine form over its whole length when excited at the base [v_1 in equations (5) and (7)].

(*b*) The resonant frequencies of the aerial occur when the length of the aerial or of the screen is an odd number of quarter wavelengths [equation (11)].

(*c*) The anti-resonant frequencies of the aerial alternate with the resonant frequencies and are not in general uniformly spaced [equation (12)].

(*d*) The effective height of the screened portion h_z of the aerial increases from zero to the length of that portion l_2 as the length of the unscreened portion is increased, when the dimensions are small compared with the wavelength.

(*e*) The effective height of the unscreened portion h_y increases from zero to half its length l as the length is increased when the dimensions are small compared with the wavelength.

(*f*) For small systems the simple equivalent circuit of Fig. 2 gives the capacitance and effective height of the aerial.

6. Acknowledgments

The work described above was carried out in the Radio Division of the National Physical Laboratory as part of the programme of the Radio Research Board, and this paper is published by permission of the Department of Scientific and Industrial Research.

REFERENCE

[1] R. L. Smith-Rose and R. H. Barfield: "Screening in Receiving Aerials." *Wireless World*, 1926, Vol. 18, pp. 61-65.

APPENDIX

Solutions of the Differential Equations for Current and Voltage.

The second-order differential equations all assume the form $\frac{\partial^2}{x^2} = -\frac{\omega^2}{c^2}$ and show that all the voltages and currents are propagated with velocity c; thus putting $B = \omega/c$ and letting the screen potential be zero at $x = 0$ and the potential of the inner v_0 then we have for the common portion of the conductors :—

$$v_1 = v_0 \cos Bx + A_1 \sin Bx$$
$$v_2 = A^2 \sin Bx$$

from which the currents are given by

$$i_1 = -jcC_{11}\,[v_0 \sin Bx - (A_1 - A_2) \cos Bx]$$
$$i_2 = jcC_{11}\,\left[-v_0 \sin Bx - \left(\frac{A_2}{k^2} - A_1\right) \cos Bx\right]$$

Since the screen is open at $x = l_2$, $i_2(l_2) = 0$ giving

$$A_2 = k^2\,(A_1 - v_0 \tan Bl_2)$$

$$\text{and } i_2 = -jcC_{11}\,v_0 \frac{\sin B\,(l_2 - x)}{\cos Bl_2}$$

In the region $(l_1 > x > l_2)$ where the inner wire projects, the differential equations are

$$\frac{\partial v_1}{\partial x} = -j\omega L_{11} i_1$$
$$\frac{\partial v_1}{\partial x} = -j\omega C_0 v_1 = -j\omega C_{11}\,(1 - k^2)\,v_1$$

where $C_0 = C_{11}\,(1 - k^2)$ is the capacitance per unit length of the unscreened conductor. As the current vanishes at the end $x = l_1$

$$i_1 = I \sin B\,(l_1 - x)$$
$$v_1 = -jcL_{11}\,I \cos B\,(l_1 - x)$$

giving, as expected, for the admittance of the projecting open wire

$$Y_1\,(l_2) = \frac{i_1\,(l_2)}{v_1\,(l_2)} = \frac{j \tan Bl}{cL_{11}}$$

where $l = l_1 - l_2$ is the length of the projection.

Since the voltage and current on the inner conductor are continuous at $x = l_2$

$$= \frac{jcC_{11}\,[v_0 \sin Bl_2 - (A_1 - A_2) \cos Bl_2]}{v_0 \cos Bl_2 + A_1 \sin Bl_2}$$
$$= \frac{j \tan Bl}{cL_{11}}$$

giving after some simple reduction

$$A_1 = v_0 \tan Bl_1$$
$$A_2 = v_0 k^2\,(\tan Bl_1 - \tan Bl_2)$$
$$I = \frac{j\,v_0}{cL_{11}} \sec Bl_1$$

RADIOCOMMUNICATION CONVENTION

Held on 25th–28th March and 2nd April, 1947, the Institution of Electrical Engineers' Radiocommunication Convention included papers covering most aspects of wartime communication. Like the Radiolocation Convention, held last year, it comprised a number of main and supporting papers.

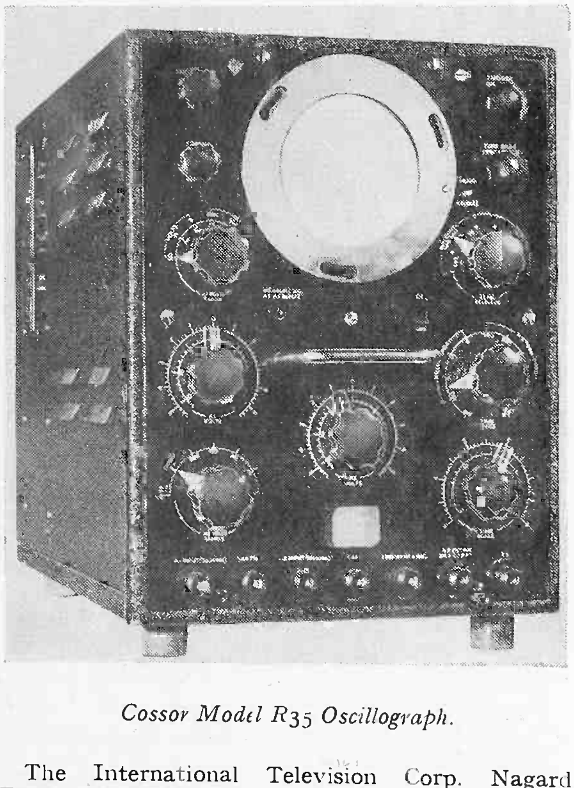
The main papers read were :—

- "Telecommunications in War," Col. Sir Stanley Angwin.
- "Long-Distance Point-to-Point Communication," A. H. Mumford.
- "Low-, Medium- and High-Frequency Communication to and from H.M. Ships," E. J. Grainger and W. P. Anderson.
- "Military Radio Communications," Brigadier J. B. Hickman.
- "Aeronautical Communications," B. G. Gates.
- "Pulse Communication," D. Cooke, A. J. Oxford, Z. Jelonik and E. Fitch.
- "Ultra-High-Frequency Technique Applied to Mobile and Fixed Services," J. Thomson, J. D. Denly, I. J. Richmond, F. Pugliese and H. Borg.
- "Resumé of V.H.F. Point-to-Point Communication," C. W. Sowton and F. Hollinghurst.
- "Naval Radio Direction-Finding," C. Crampton.
- "Fundamental Problems in Radio Direction-Finding at High Frequencies (3.30 Mc/s)," W. Ross.
- "Wartime Activities of the Engineering Division of the B.B.C," H. Bishop.
- "The Investigation and Forecasting of Ionospheric Conditions," Sir Edward Appleton.
- "The Influence of Propagation on the Planning of Short-Wave Communications," K. W. Tremellen and J. W. Cox.
- "Manufacturing Aspect of Component Developments," E. M. Lee.
- "Component Development for Wartime Service Applications," I. M. Ross.
- "Review of the Convention and Future Trends," Sir Clifford Paterson.
- "The Development of C. W. Radio Navigation Aids with Particular Reference to Long-Range Operation," R. V. Whelpton and P. G. Redgement.
- "A Survey of Continuous-Wave Short-Distance Navigation and Landing Aids for Aircraft," Caradoc Williams.

PHYSICAL SOCIETY'S EXHIBITION

THE thirty-first exhibition of scientific instruments and apparatus was held by the Physical Society at Imperial College from 9th–12th April, and once again, the visitor could not fail to be impressed by the great preponderance of wireless and electronic equipment. The apparatus ranged from high-precision laboratory-type measuring equipment through the intermediate grades to what might well be termed the better class of serviceman's test sets, while in the research section there were many demonstrations, including nuclear physics and atomic research.

Measuring equipment of one kind or another undoubtedly formed the largest single section of the exhibition and in it the cathode-ray oscilloscope was well to the fore. There is now a tendency to provide directly-calibrated voltage scales—a tendency which is well exemplified by the Cossor Model 1035 having seven ranges directly calibrated with an accuracy of ± 10 per cent. This instrument includes a time-base which can be used repetitive, triggered or single-stroke to provide sweeps of from 15 μsec to 150 msec duration. The Y-amplifier provides an amplification of up to 3,000 times with a frequency response dropping by 10 per cent at 60 kc/s. As the gain is reduced the response improves and extends to 7 Mc/s for an amplification of three times. A double-beam tube is used.



Cossor Model R35 Oscillograph.

The International Television Corp. Nagard Type 1025 oscilloscope is unusual in that it includes a deflexion-modulated valve for generating the sweep voltage. Reliable synchronization is claimed for input frequencies up to 1.5 Mc/s, and for modulated inputs up to 6 Mc/s. Voltage measurements over the range of 0.01–200 V can be made with an accuracy of 2 per cent. The Y-amplifier has a response of –4 db at 2 c/s and 3 Mc/s and the deflexion sensitivity with the 5½-in tube is 0.36 mm/mV. The principles of the deflexion valve[1] and the oscilloscope[2] have previously been fully described.

Mullard have two types of oscilloscope each with a 3½-in tube. The model E.800 is specially designed for very low-frequency work and the Y-amplifier response is –2 db at 0.1 c/s, while the model 805 is intended for high frequencies, having an amplifier usable up to 5 Mc/s.

A feature of the oscilloscopes produced by Furzehill Laboratories is the provision of sweep-expansion to permit the detailed examination of a small part of a waveform. In the Type 1684B, with a 3½-in diameter tube, the expansion has a range of from 0.2 to 5 screen diameters and as it is a gain control on the X-amplifier it functions without affecting the sweep frequency or the synchronizing. There is a horizontal shift control so that any part of the expanded sweep can be centred on the tube.

The Y-amplifier is direct-coupled and balanced, and arranged for use with balanced or unbalanced inputs. The response is zero to 3 Mc/s for a deflexion sensitivity of 24 mV r.m.s. per cm or to 1 Mc/s for 8 mV per cm. A smaller oscilloscope with a 2¾-in tube—Type 1936—has a thyratron time-base with a linearizing pentode. The Y-amplifier covers 1 c/s to 15 kc/s. Both these oscilloscopes include a limiter in the sync input circuit, so that synchronizing is largely independent of the signal amplitude.

The use of a "wobbulated" oscillator with a cathode-ray indicator for the visual alignment of tuned circuits is well known, as is also the fact that an excessive rate of wobbulation distorts the resonance curve. In the Plessey I.F. Alignment Oscillator the wobbulation rate is controllable from zero to 50 c/s and a c.r. tube with a long-persistence screen is used so that a clear picture is obtainable at the slowest speeds. A crystal calibrator is included.

Cathode-Ray Indicators

The principle of frequency modulation is also adopted in an instrument for the measurement of mechanical force, pressure and strain made by Southern Instruments. An oscillator covering 0–20 kc/s is frequency modulated by the quantity to be measured and a c.r. tube is used to indicate the resulting frequency change.

Furzehill Laboratories use the c.r. tube in an electronic clock timer. The "tick" is picked up by a microphone and can be heard through an amplifier and loudspeaker. It also generates pulses which are compared with the output of a crystal oscillator, the difference being used to control brightening pulses on a circular time base. The visual effect is a spot flickering in synchronism with the "tick" and moving around the circular trace at a rate dependent on the error in rate of the

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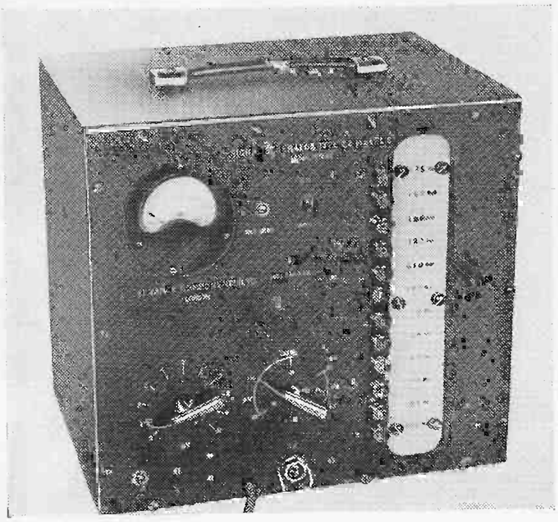
[1] "The a Signal Converter," by P. Nagy and M. J. Goddard *Wireless Engineer*, June 1943, Vol. 20, p. 273.

[2] "Oscillograph for the Direct Measurement of Frequency Employing a Signal Converter," by P. Nagy and M. J. Goddard *Wireless Engineer*, September and October 1945, Vol. 22, pp. 429 and 489.

clock and in a direction dependent on the sign of the error.

Valve voltmeters are now usually multi-range instruments of a robust character and are often, if not generally, designed for a.c. mains operation.



Advance Components Type C2 press-button signal generator.

A model shown by J. L. Thompson is of the diode probe type with an input capacitance of 0.5 μμF and resistance of 7 MΩ. The a.c. ranges are 3, 10, 30, and 100 V r.m.s. with a frequency range of 20 c/s to 50 Mc/s and an accuracy of ± 2 per cent. There are also d.c. ranges.

The Furzehill Laboratories Model 378A has a two-stage amplifier feeding a diode bridge rectifier and covers 1 mV to 100 V in five ranges. The frequency range is 50 c/s to 250 c/s and the input impedance is 2 MΩ. The indicating meter has pole pieces shaped to give a logarithmic scale. A diode type, the 281B, produced by the same firm has a frequency range of 50 kc/s to 250 Mc/s and covers 0.1–150 V in four ranges. The diode is in a probe and there is a d.c. amplifier.

The multi-range meter is now well-established and the tendency towards higher quality is exemplified by the Sub-standard Avometer which has its d.c. ranges of B.S.I. sub-standard accuracy and its a.c. ranges to one-half of the B.S.I. Specification. The ranges are 1–1,000 V, 2 mA–10 A, and 0–1 MΩ, there being four a.c. and five d.c. ranges for voltage and current and three ohmmeter ranges. The Sangamo-Weston Model 527 multi-range test set has a voltmeter resistance of 20 kΩ/V and provides a.c. and d.c. ranges up to 1,500 V and 15 A and resistance up to 500 MΩ. A quick-acting circuit breaker is incorporated to protect both the meter and the shunts against overloads.

An unusual fitting to the Taylor Universal Meter, Model 75A, is a buzzer for use in continuity testing; a.c. and d.c. ranges up to 1,000V and 5A are provided, with resistance up to 10 MΩ. The voltmeter resistance is 20 kΩ/V.

The British Physical Laboratories Super Ranger test set covers up to 5,000V a.c. and d.c. and 1mA–10A d.c., 100mA–10A a.c., and resistance up to 1 MΩ. It can also be used as an output meter for a.f. purposes with a range of 0–60 db.

Bridge Instruments

Bridge methods are commonly adopted for impedance measurements, and Baldwins have the Logohm Resistance Bridge with a direct-reading scale which is visible through the same window as the galvanometer scale. The calibration covers 5–500 with a logarithmic wire-wound potentiometer and multipliers of 0.01, 1, 100 and 10,000 provide a coverage of 0.05 Ω to 5 MΩ with an accuracy of ± 1 per cent. The galvanometer has pole pieces specially shaped to give high sensitivity around the centre zero, but greatly reduced sensitivity at maximum deflexion to protect the meter against overload.

Gambrell have a switched Wheatstone bridge of sub-standard grade. A portable mirror galvanometer of the suspension type with a sensitivity of 32 mm/μA at 6 in forms the indicating instrument; it has a resistance of 700 Ω.

An inductance and coupling-coefficient bridge was shown by British Physical Laboratories. It covers 1 μH to 1 H and coupling coefficients from 0.001 to 0.999. The test frequency is 20 kc/s and provided that the resonance frequency of the coil under test with any shunt capacitance is not less than 160 kc/s the coil can be measured without disconnecting it from its tuning capacitor.

The Baldwin Mufer Capacity Bridge has a range of 50 μμF to 4 μF with an accuracy of ± 2 per cent. It is energized by a high-note buzzer.

Signal generators and test oscillators are now essential parts of even the meanest laboratory

Marconi Instruments Type TF 888 signal generator.

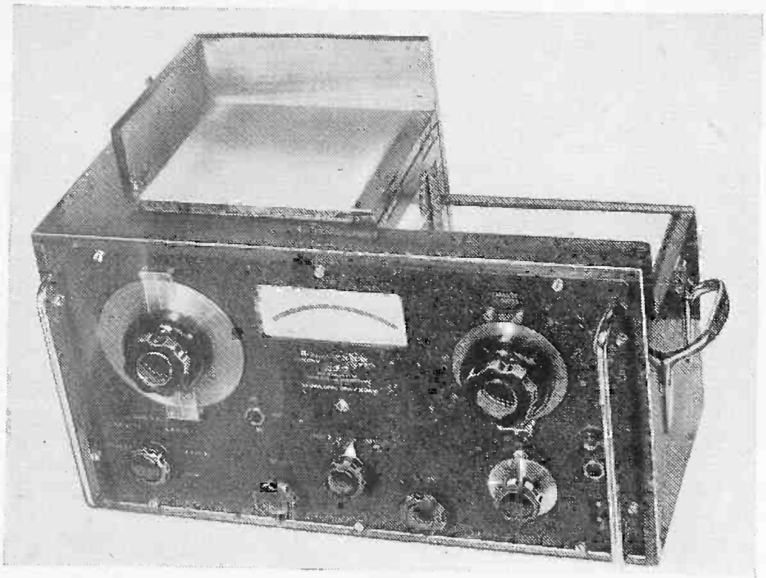
There is no hard and fast dividing line between them but one might, perhaps, draw such a line by defining signal generators as instruments embodying a calibrated attenuator and test oscillators as those without. On this basis most of the apparatus shown falls into the signal-generator category.

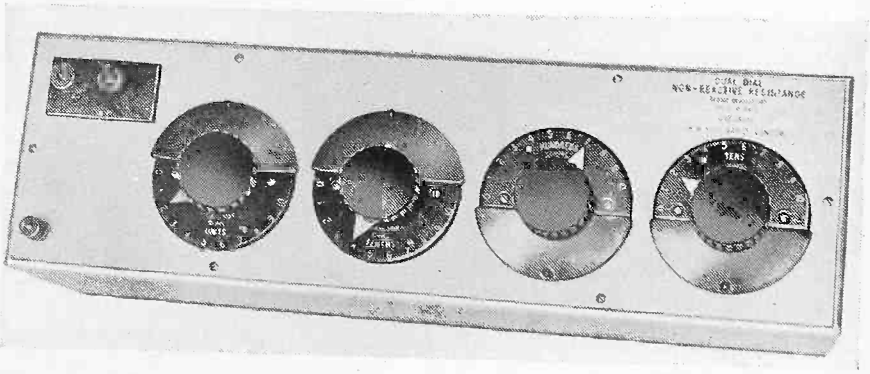
Advance Components showed two varieties. The type F is an inexpensive signal generator covering 100 kc/s to 60 Mc/s in six ranges. By making use of harmonics the range can be extended to 120 Mc/s. A stepped attenuator and slide-wire provide an output control covering 1 μV to 100 mV with an output impedance of 75 Ω. A frequency accuracy of ± 1 per cent is claimed. There is internal amplitude modulation at 400 c/s and the apparatus is a.c. mains operated.

The Model C2 has push-button frequency selection for twelve frequencies in the band 50 kc/s to 30 Mc/s with an adjustment of ± 10 per cent on each, and is intended for production testing. The output is 1 μV to 100 mV and a transitron-type oscillator is used.

Automatic Coil Winder Co. have an a.c.-operated generator covering 50 kc/s–50 Mc/s in six bands with turret coil switching. A feedback circuit is used to maintain a constant r.f. input of 0.5 V ± 3 db to the attenuator. This is a combination of a stepped attenuator and slide wire; a maximum output of 50 mV in 100 Ω is obtained. The internal modulation is at 400 c/s and is available as a separate output.

Marconi Instruments TF888 covers 70 kc/s–50 Mc/s with internal modulation at 1,000 c/s. A crystal calibrator is included with crystals of 500 kc/s and 5 Mc/s, permitting check points in every range. The attenuator controls the output down to − 70 db. An unusual feature is the inclusion of an output meter covering 1 mW–1 W in impedances of 3, 33, 150 or 600 Ω. It is available for external use.





(*Above*) *Salford H.F. Q-meter type BW 424.*
(*Right*) *Sullivan dual-dial decade resistance box.*

Frequency Standards

Frequency standards are of various types. Sullivans have a Direct-Reading Universal Wavemeter covering 30 kc/s to 24 Mc/s with eight plug-in coils each providing two ranges. It is a second-grade standard instrument with an accuracy of 0.1 per cent. There are slip-on frequency calibrated scales for each range.

The Furzehill Laboratories Portable Frequency Standard, which is available for either battery or mains operation, has a 1-Mc/s quartz crystal oscillator with 100 kc/s and 10 kc/s multivibrators and harmonics up to 50 Mc/s are available. The mains model has an additional 1 kc/s multivibrator.

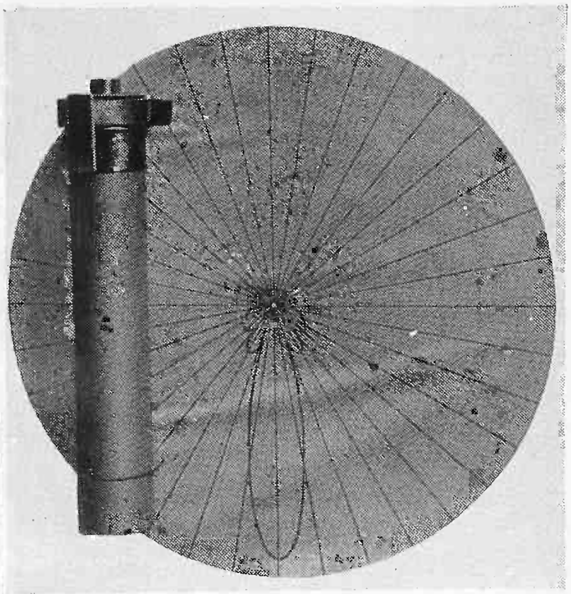
Salford were showing an extremely compact crystal calibrator having a 100-kc/s crystal and providing harmonics up to 30 Mc/s.

The resistance-capacitance oscillator is now a common a.f. source. The British Physical Laboratories model covers 30 c/s to 33 kc/s. The oscillator is followed by an RC amplifier with cathode-follower output at an impedance of 600 Ω. There is a calibrated attenuator giving a range of 4 mV to 40 V. The frequency control is a variable capacitor.

The beat-frequency oscillator is still popular, however, particularly when a wide frequency coverage in a single range is needed. The Marconi Instruments TF894 cover 0–12 kc/s in one range. The output meter is also available for external use and is calibrated + 2½ db to − 20 db.

Q-meters were shown by Salford Electrical. The V.H.F. Model is direct reading with ranges of 0–250 and 0–500 with an accuracy of ± 5 per cent. The coverage is 15–150 Mc/s and another model, the M933B, covers 25 kc/s to 50 Mc/s. An unusual feature is the use of capacitance, instead of resistance, coupling to the coil under test.

The Sullivan Dual Dial Decade Resistance Box has two decade resistances controlled by each knob. The control has a 180° rotation for the switch of one decade. A semi-circular disc, which acts as a switch stop, covers half the scale and can be rotated to expose either half of the full 360° rotation. Thus each knob controls two decade switches.



Polar diagram at 3 cm of cardboard tube.

A decade switch which can be readily dismantled for cleaning is made by Salford. It has a laminated phosphor-bronze rotor and the contact studs are spaced at 30°.

The well-known Muirhead slow-motion dial is now available with a scale which can be detached for calibration. This firm also has a range of wire-wound non-reactive standard resistors hermetically sealed in ceramic tubes. With an accuracy of 0.1 per cent in the $\frac{1}{2}$-watt rating or 0.5 per cent in the 1-watt, the values cover 1Ω to 75 Ω.

A low-temperature coefficient tuning fork, constant to within 2 parts in 10^6 over the range of 14—26°C was shown by Muirhead.

Radyne r.f. heaters are available with outputs up to 6.5 kW and include silica-envelope valves with a guaranteed life of 1,500 hours. These valves can be re-filamented at half the cost of a new valve. Models for plasticizing and moisture evaporation have ovens on the cabinet top and are designed to fit in with a conveyor belt system. This firm also showed a seam welder for thermoplastic sheet.

A material having a marked negative temperature coefficient of resistance was shown by Mullard. It is a ceramic semi-conductor,—" Varite,"—and has a negligible voltage coefficient. One of its applications is to the voltage-dropping heater resistance in a.c./d.c. sets.

This firm is also making under the name " Kaymax " ceramic dielectrics of high permittivity and zero and negative temperature coefficients.

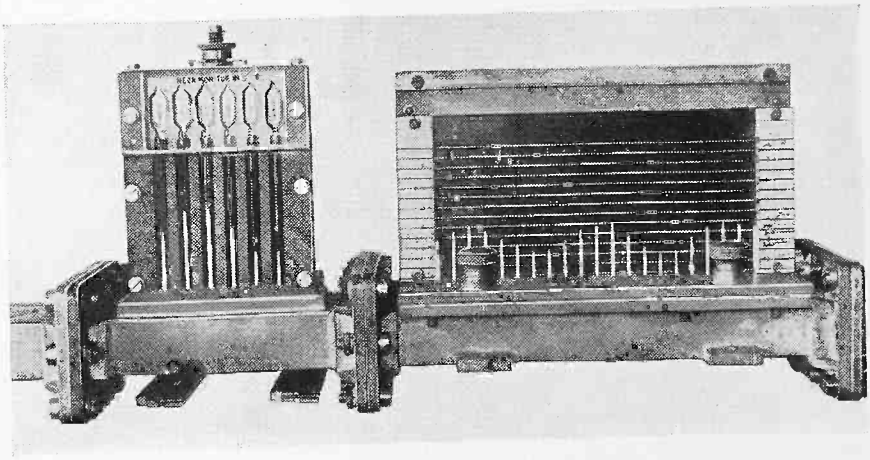
Magnetic Materials

Plessey have a non-conducting magnetic material " Caslox " which is a mixture of cobalt and iron oxide powder with a plastic. It can readily be moulded and has a high coercive force. Powder metallurgy is applied by Murex to making sintered production of awkward shapes in hard and brittle magnets and it has special application to the alloys.

Transformer Steels were showing " Crystalloy " in which a fine crystalline structure, oriented in the direction of the magnetic field, is produced by cold rolling. It is supplied in continuous strip from which conventional core shapes can be built or the core can be wound as a continuous spiral and then cut for fitting to the windings. Corner losses are thus avoided and a high flux density can be used. The working density is 17,500 lines/cm^2 while the loss at $B = 10,000$ is 0.32 watt per lb at 50 c/s.

Muirhead were showing a portable battery-operated strain gauge, Type D-423-A, in which stretched steel wires are kept in vibration by means of a valve oscillator. The strain alters the natural frequency of one wire and beats are produced with a standard and indicated by a rectifier meter or in phones. The strain is measured by adjusting the standard to zero beat by means of a calibrated tension spring.

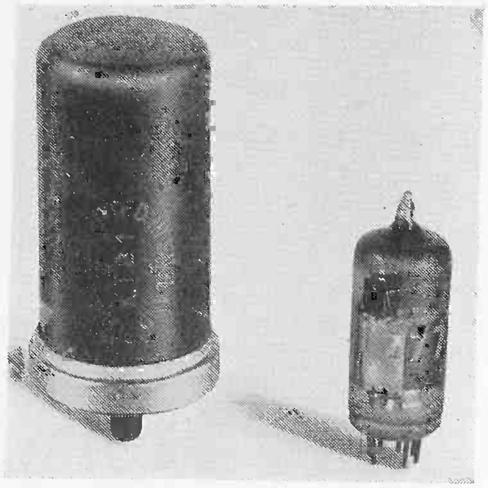
In the Research Section one application of the strain gauge was shown to lie in building research, and illustrates but one of the ways in which radio technique is being applied to completely non-radio subjects. Even mathematical computation and research are not exempt and De Haviland Propellers showed apparatus for solving four simultaneous equations operating on a potentiometer method. Another equipment demonstrated by Dr. Rymer was for harmonic analysis and synthesis based on ordinates selected at 10° intervals. This necessitates



Multiple neon tube standing-wave monitor shown by Admiralty Research Establishment.

a 36-way switch; it is constructed by using 36 pairs of parallel wires stretched in a frame with 36 insulation strips at right angles which control 36 "hairpins." Pulling the strips forwards causes the hairpins to contact the parallel wires.

Standard Telephones and Cables showed a polar-diagram computor which is partly mechanical and partly electrical. It enables the radiation diagram of an aerial array of up to five units to be calculated.



KT81 and Z77 valves shown by M-O Valve Co.

Ferranti showed a Fourier transformer. This shows on a c.r. tube the Fourier transform of the input wave; thus, if fed by a pulse, which is an amplitude-time graph, it depicts its frequency spectrum,—an amplitude-frequency graph.

The crystal detector, so widely used in radar, is now taking its place in measuring equipment. Silicon types are used in the a.c. voltmeters shown by B.T.H., and enable the production of an instrument with a resistance of 10 kΩ per volt and useful up to 1,000 Mc/s. The maximum input is about 10V.

Germanium rectifiers suitable for inputs of up to 40 V were shown by G.E.C. The forward resistance is 50 Ω and the backward 0.2 MΩ; they have application for d.c. restoration circuits and limiters in pulse technique.

Comparatively few new valves were shown this year but the M-O Valve Co. had a wide range of types with pressed-glass bases. They included triode-hexodes for frequencies up to 300 Mc/s as well as the usual r.f. pentodes, duo-diode-triodes, output tetrodes and rectifiers. In the miniature types the Z77 r.f. pentode with a mutual conductance of 7.5 mA/V is of particular interest since it lends itself admirably to the construction of compact high-gain wide-band amplifiers for television and radar.

Mullard were showing mainly silica power valves for industrial and communication purposes, and Ferranti had a high-voltage rectifier of particular interest for television. Of the miniature type its filament takes only 55 mA at 0.65 V and it will withstand 12 kV peak inverse. It is intended for use in circuits in which the E.H.T. supply is taken from the line scan fly back.

BOOK REVIEWS

The Physical Principles of Wave Guide Transmission and Antenna Systems.

By W. H. WATSON. Pp. 207+xiii, 95 figs. Oxford University Press. Price 20s.

This is one of the series of international monographs on radio edited by Sir Edward Appleton and H. G. Booker. Its aim is to describe to physicists and engineers with theoretical interests the way in which the technique of handling radio-frequency transmission lines has been extended to deal with waveguides. The author, who is Professor of Mathematics at the University of Saskatchewan, was engaged during the war in research at McGill University; this book is the outcome of that research. and is an attempt to make amends for the security restrictions in the dissemination of the knowledge of the newly acquired technique.

The preface opens with the interesting statement that "the propagation of electromagnetic waves of high frequency in waveguides is one of the most fruitful fields for the application of Maxwell's Electromagnetic Theory in the form given by Heaviside." The mathematics throughout the book are in a form familiar to electrical engineers. The opening chapter entitled "plane electromagnetic waves" begins with the consideration of a transmission line consisting of two parallel strips between which the electric and magnetic fields are uniform.

This section, entitled "The strip transmission line and circle diagram," carried us back in imagination to September, 1913, when a paper on "The nature of the waves employed in radio-telegraphy and the mode of their propagation" was read before the British Association*. It opened with the statement that "if power be transmitted by . . . two wide strips of thin copper placed face to face and close together . . . the consideration of such a transmission line proves an excellent method of approaching such conceptions as are involved in Poynting's theorem and electromagnetic wave phenomena." This was followed by a consideration of the circle diagram, and then led up to the waves radiated from an aerial. It is very interesting to see exactly the same line of approach adopted in this book thirty-four years later. The author uses matrices on p. 3 and advises the reader to study the early pages of any introductory text-book on the subject because of its general utility. Reflection and refraction of plane waves at oblique incidence are also dealt with in the opening chapter.

The second chapter deals with the currents and fields in rectangular waveguides, and the third chapter with measurements of standing-wave ratio, power, phase, etc. and the properties of dielectrics at microwave frequencies. Then follows

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*[*The Electrician*, Vol. LXXI, p. 965.]

a chapter on multiple propagation, as distinct from the dominant wave considered in Chapter II. Chapter V returns to the rectangular guide but considers obstructions in it, and antennas supplying or withdrawing power, the effect of slots in the walls, which introduces Babinet's principle, the effect of bends, twists, etc.

The remaining five chapters, representing more than half the book, are largely concerned with the effect of slots in the waveguide walls. This is obviously a branch of the subject to which the author has devoted a great amount of attention and research. Chapter VI deals with the coupling of a rectangular slot in a rectangular waveguide, and Chapter VII, with guide coupling by slots. Chapter VIII on waveguide arrays, states that slot arrays were invented at McGill University in 1943 as the natural outcome of the search for radiating elements which can be coupled so as to present a low pure conductance to the wave in the guide. Chapter IX deals with a number of microwave devices connected with the use of waveguides. The final chapter entitled " Field representations " deals with the actual distribution of electric and magnetic force; just as transmission lines are calculated and expressed without explicit reference to the electric and magnetic fields, so up to this point have the waveguides been discussed in a similar manner, much to the simplification of the treatment. The basis of the treatment in this chapter is the determination of expressions for the Hertz-vectors of the field in a waveguide, and it is consequently much more highly mathematical than the rest of the book.

There is a name index and a very full bibliography. The book shows every sign of having been very carefully prepared. The paper, type and illustrations are all excellent. The book can be unreservedly recommended to anyone in any way interested in waveguides. G.W.O.H.

Principles of Radar (Second Edition).

By members of the staff of the Radar School, Massachusetts Institute of Technology. McGraw-Hill Publishing Co. Ltd., Aldwych House, Aldwych, London, W.C.2. Price 25s.

The first glance at this volume, which is printed by an offset (typescript facsimile) process, may give an impression that it was something hastily thrown together for high-speed war instruction, and is now being unloaded as surplus stock on the post-war student. The second glance at the list of chapters, each contributed by its own author or group of authors, may remind one of other works composed in this way, and prepare one to fear the worst. The third glance, at the " blurb " on the jacket, may fall on the statement " The topic of Super-regeneration in Chapter XIII has been rewritten in more concise form," and when scrutiny of the book shows that conciseness in this case has been carried to the limiting point of non-existence, it seems that one's fears have been confirmed.

It is a pity that super-regeneration has been left out, but in spite of this initial disappointment the reviewer laid the book down with the assurance that first impressions were entirely misleading. So far from showing the expected signs of war emergency and composite authorship, this work seems by some miracle to have combined the advantages of single and multiple authorship. It deals with each aspect of the whole wide field of radar with equal thoroughness and specialized knowledge, while achieving a remarkable consistency of treatment and organic unity.

" Radar " is defined in the strictest sense, excluding i.f.f. and navigational aids, and the nearly 900 pages are not padded out with material common to ordinary radio engineering textbooks, so it has been possible to supply a very large amount of information in a style that is accessible to a wide range of students. The chapter headings are: Introduction; Timing Circuits; Indicators; Receivers; Magnetrons; Modulators; Triode Transmitters; Radio-Frequency Lines; Radar Antennas and Propagation; Wave Guides and Cavity Resonators; Transmit-Receive Devices; Synchros and Servo-Mechanisms.

Although self-limited to military radar, the book is sufficiently basic for this to be no great drawback to the reader interested in peaceful applications; in fact, it is a most instructive text for the radio engineer who is not concerned with radar at all. Nor is its American origin excessively obstrusive. It is true that the phantastron circuits differ somewhat from those shown by T.R.E. in this country, and so does the approach to them. It is all to the good to have both. There are a few of the usual American departures from international abbreviation standards (e.g., " ma," " MEG," and " μv "), but there is less to complain about than usual in this respect—in particular, the objectionable " mc " (for " Mc ") seems to have been entirely avoided.

It may be said that the treatment is mathematical to the extent that is necessary or desirable, and no more; and the results are in a form directly applicable to design, and are illustrated by numerical examples and other data. Instead of dealing with innumerable circuits and devices in their unrelated complexity, the authors transform them (with the frequent help of Thevenin's Theorem) into their basic equivalents. This policy has left room for the comparatively few basic arrangements to be discussed very thoroughly, giving the reader equipment whereby he is able to tackle new variations intelligently. Discussion is not confined to " ideal " waveforms, or to loss-free lines or guides; and misunderstandings are guarded against at every turn.

In short: to an exceptional degree the book justifies its title.

M. G. S.

BOOKS RECEIVED

Reference Data for Radio Engineers (2nd Edition)

Pp. 322. Federal Telephone and Radio Corp., 67, Broad St., New York, U.S.A., Price $2.

The Cathode-Ray Tube Handbook (2nd Edition)

By S. K. Lewer. Pp. 103+viii. Sir Isaac Pitman & Sons, Ltd., Pitman House, Parker St., Kingsway, London, W.C.2. Price 6s.

Radio's Conquest of Space

By Donald McNicol. Pp. 374 + x. Published by Murray Hill Books, Inc., 232, Madison Avenue, New York 16, N.Y. Price $4.

An historical review of the development of wireless.

CORRESPONDENCE

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

The Electric-Magnetic Analogy

To the Editor, "Wireless Engineer."

SIR,—In his Editorial in the January number, Prof. Howe, discussing certain views expressed by me in a recent article in the *Philosophical Magazine*, quotes two magnetic formulae with the corresponding electric ones and concludes that the parallelism between the relations of the two fields is so striking that it is difficult to understand how anyone can complain, as I did in the article mentioned, of the persistent adherence to a supposed analogy which does not exist.

In a series of studies extending over the last thirty years and aimed at obtaining a completely consistent account of Maxwell's electrodynamic scheme in its most general form, a whole series of relations for the two fields has been obtained and the two formulae quoted by Prof. Howe are about the only ones for which the analogy holds. As one of the two formulae quoted by Prof. Howe is an energy function I will content myself by quoting here the complete series of such functions to show how little parallelism really exists. And as the assumption of a linear law of induction ($B = \mu H$), which does not hold in some of the most important cases, tends to obscure differences which are otherwise very obvious I prefer to frame my results in completely general form which will hold for any law of induction.

In Maxwell's Theory the only energy functions recognised are the Electrokinetic Potential or Lagrangian function from which the details of the motion in both the material and electrical coordinates of the system can be determined by a recognised procedure, and the Hamiltonian function which measures the mechanically available energy of the system; but both of these functions have eventually to be resolved into different constituents as belonging to the field (ether), properly speaking, and the matter. We quote first the results for the Lagrangian function for the two fields in its compact and resolved forms. For the electric field this, per unit volume, is

$$L = -\int_0^D E\,dD = -\int_0^P E\,dP - \frac{1}{8\pi}E^2$$

whilst the corresponding result for the magnetic field is

$$L = +\frac{1}{4\pi}\int_0^H B\,dH = -\int_0^J B\,dJ + \frac{1}{8\pi}B^2$$

The Hamiltonian functions A show a little closer similarity and it is the special compact form of these results which are quoted by Prof. Howe. For the electric field per unit volume

$$A = +\int_0^D E\,dD = \int_0^P E\,dP + \frac{1}{8\pi}E^2$$

whilst for the magnetic field

$$A = +\frac{1}{4\pi}\int_0^B H\,dB = -\int_0^B J\,dB + \frac{1}{8\pi}B^2.$$

It is with formulae such as these in mind that I assert that the analogy between the relations of the two fields does not in fact exist.

If there is one conclusion which can be drawn from a comparison of the two sets of formulae it is that the magnetic vector, which takes the place in the magnetic formulae that the E takes in the electric ones, is B rather than H. This is one of the reasons why I suggest that the roles of the vectors H and B in magnetic theory should really be interchanged.

I agree with Prof. Howe on the use of analogies in general; they are often very helpful, but before we use them we must be quite sure that they apply, otherwise the consequences may be disastrous. We used to think that the electric-magnetic analogy existed and the result, whether we like it or not, is that we have acquired a most topsyturvy view on the relations of the magnetic field, which when carried beyond the limits of the formulae quoted by Prof. Howe, lands us in a whole series of difficulties and uncertainties, which it is my aim to remove, even at the expense of creating a revolution in the subject.

G. H. LIVENS.

University College,
Cardiff.

Is Rotation Relative or Absolute?

To the Editor, "Wireless Engineer."

SIR,—The hypothetical experiment described by Mr. Lacey in your February issue is an attempt to determine absolute rotation by means of a centripetal force, and is therefore the same in principle as the experiment which Newton actually performed with a bucket of water. Newton observed that the water showed a concave surface when rotating "absolutely" although at rest relative to the bucket, but a plane surface when at "absolute" rest, although rotating relative to the bucket. In my view Ernst Mach has countered this criterion of absolute rotation decisively in his "Science of Mechanics." He shows there that all we can say from observation and experiment is that a centripetal force appears when a mass is in relative rotation to the mean orientation of other masses in the Universe. Perhaps the effect of the relative rotation of more distant masses is less than that of nearer ones, in which case the mean orientation will be a "weighted" mean, each mass having ascribed to it a weight in respect of its distance. Mach says of the Newtonian experiment, "No one is competent to say how the experiment would turn out if the sides of the vessel increased in thickness and mass until they were ultimately several leagues thick." Similarly no one can say how Mr. Lacey's dynamometer would behave if his transverse axis (rigidly attached to the masses) were increased in diameter and mass indefinitely.

GEOFFREY STEDMAN.

Westcliff,
Essex.

Iron-Dust Cores

To the Editor, "Wireless Engineer."

SIR,—In the Editorial of the February 1947 issue it was mentioned that there were few reports of any measurements having been made upon the iron-dust composition known as "Ferrocart." I think, therefore, that a brief account of some measurements made on this material in 1934/35 may be of interest.

The Ferrocart that was used was in the form of a toroid, having inner and outer diameters of 6 and 8 cm, respectively, and a depth of 2.8 cm The specific gravity was 3.7. Ballistic galvanometer tests showed that the permeability μ, was about 8.2, and the relation between B and H was nearly linear up to 50 gauss.

A.C. bridge measurements were made at various frequencies up to 100 kc/s, and resonant circuit measurements up to 1.6 Mc/s. Measurements were also made on a non-magnetic toroid carrying similar windings so that the copper losses could be obtained and separated from the iron losses of the Ferrocart. It was found that the permeability was nearly constant over the whole frequency range. The iron losses were obtained as an equivalent resistance, and for frequencies up to about 100 kc/s, could be represented by the formula $W = I^2(0.0606f + 4.86f^2)$ microwatts per cubic centimetre. Above about 500 kc/s, however, the losses increased more rapidly with frequency and it was necessary to add a cubic term to the formula.

The work was carried out at Queen Mary College under the supervision of C. R. Stoner. It is fully described in my thesis for the degree of M.Sc. and copies of the thesis are held in the library of the University of London.

G. H. M. GLEADLE.

Harrow, Middx.

Minimum phase-shift networks.

To the Editor, "Wireless Engineer."

SIR,—In the established usage of the word a minimum phase-shift network is understood to be a network that introduces the minimum amount of phase-shift which is compatible with a prescribed attenuation versus frequency characteristic.

On the basis of the above definition it could be implied that if a network N is a minimum phase-shift network, then the same network but with the polarity of its output terminals reversed, is not a minimum phase-shift network.

It seems that the above misunderstanding could be avoided, and some ambiguities inherent in the term "phase" could be removed, by changing the term "minimum phase-shift network" to "minimum net phase-shift network" where "net phase-shift" is defined as the total angle swept by G ($G = E_2/E_1$ is the complex gain of the network) in the G-plane when ω varies from zero to the value of ω in question.

It is also convenient to define "initial phase-shift" as the limit of the principal value of the argument of G as ω approaches zero from the right. Then, at a frequency ω

phase = initial phase-shift + net phase-shift.

It is seen that the choice of polarities affects the initial phase-shift and phase, but not the net phase-shift.

LOTFI A. ZADEH.

Columbia University,
New York City, U.S.A.

Triode Characteristics

To the Editor, "Wireless Engineer."

SIR,—If it is assumed that the equivalent voltage V_L at the grid plane of a triode is determined by the actual voltage applied to the grid and the charge density on the grid wires, then it is legitimate to put

$$V_L = V_g + \frac{x_2}{\mu}\left[\left.\frac{dV}{dx}\right|_2 - \left.\frac{dV}{dx}\right|_1\right] \quad \text{.. .. (1)}$$

where $\left.\frac{dV}{dx}\right|_1$, $\left.\frac{dV}{dx}\right|_2$ represent respectively the potential gradients on the cathode and anode side of the grid plane, and x_2 is the grid-to-anode gap; x_1 will be taken as the cathode-to-grid gap. The calculation of $\left.\frac{dV}{dx}\right|_2$ can be carried out by finding the potential distribution in the grid-to-anode space in a similar manner to the calculation for the screen-to-anode space in a beam tetrode, except that a potential minimum has to be assumed which is negative in value and its position lies outside the grid to anode space.

If we write $v_L = \sqrt{V_L/V_A}$, $u = \sqrt{-V_m/V_A}$ then it is found that

$$\left.\frac{dV}{dx}\right|_2 = \frac{4}{3} V_A \frac{v_L^{3/2}}{x_1}\left(u + v_L\right)^{1/2} \quad \text{.. .. (2)}$$

where u is to be ascertained from the following equation :—

$$v_L^{3/2}\frac{x_2}{x_1} = (2u - v_L)(u + v_L)^{1/2} - (2u - 1)(u + 1)^{1/2} \quad \text{.. .. .. .. (3)}$$

Now $\left.\frac{dV}{dx}\right|_1$ is simply $\frac{4}{3}\frac{V_L}{x_1}$

Thus from an assumed value of V_L, the anode current is

$$I_A = 2.33 \times 10^{-6}\frac{V_L^{3/2}}{x_1^2} \text{ Amp/cm}^2 \quad (4)$$

whereas V_g is given from equation (1), and an exact solution, ignoring thermionic velocities, is attained.

As a first approximation, with V_L small—

$$V_L = \frac{\dfrac{V_A}{\mu} + V_g}{1 + \dfrac{x_1 + \frac{1}{3}x_2}{\mu x_1}} \quad \text{.. .. .. (5)}$$

which is equivalent to Tellegen's result.[1]

As a next approximation

$$\frac{V_A}{\mu} + V_g = V_L\left[1 + \frac{1 + \frac{4}{3}\frac{x_2}{x_1} + \frac{16}{27}\left(\frac{x_2}{x_1}\right)^2\left(\frac{V_L}{V_A}\right)^{1/2} + \ldots}{\mu}\right] \quad \text{.. .. .. (6)}$$

where the additional term betrays the effect of space charge in the grid-to-anode region.

When $u = 0$, in Equ. (3), V_L is found to equal V_g, at the value $\left(\frac{x_1}{x_1 + x_2}\right)^{4/3} V_A$, which clearly should be so.

S. RODDA

New Barnet, Herts.

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[1] *Phil. Mag.* June, 1940, p.901

THE PHYSICAL SOCIETY

The Acoustics Group of the Physical Society was formed during February and membership of it is open both to members and non-members of the Society. Formed to permit workers on acoustical problems to meet and discuss the scientific and technical implications of their work, it is hoped to have six meetings a year. The Chairman and Vice-Chairman for 1947-48 are H. L. Kirke and Dr. A. Wood. Further information is obtainable from the Secretary, 1, Lowther Gardens, Prince Consort Road, London, S.W.7.

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

579 738.—Gramophone pick-up of the piezo-electric type designed to eliminate the so-called "pinch" effect.

The Brush Development Co. (assignees of S. J. Begun). Convention date (U.S.A.), 31st July, 1941.

580 099.—Wide-band amplifier in which the filter coupling is designed to accept very low frequencies.

The General Electric Co., Ltd., and D. C. Espley. Application dates 18th February, and 7th and 12th April, 1944.

AERIALS AND AERIAL SYSTEMS

579 745.—Pyramidal horn-shaped aerial with internal partitions for eliminating secondary lobes of radiation.

Sperry Gyroscope Co., Inc. (assignees W. L. Barrow and W. M. Hall). Convention date (U.S.A.), 29th January, 1942.

579 773.—Aerial system comprising a number of parallel open-end waveguides, arranged side-by-side and in echelon, for end-on radiation.

Western Electric Co., Inc. Convention date (U.S.A.), 11th June, 1942.

579 778.—A hollow cylindrical aerial containing a coaxial conductor which forms a short-circuited stub of zero impedance at the mean operating frequency.

Standard Telephones and Cables, Ltd., and E. O. Willoughby. Application date 5th November, 1943.

580 090.—Electromagnetic horn or waveguide aerial having a specified cross-section to provide a directivity-pattern that is uniform within its limits.

E. C. Cork and M. Bowman-Manifold. Application date 21st May, 1943.

580 114.—Electromagnetic horn or waveguide aerial fitted with means to prevent currents from flowing on the rim or external surface of the horn (divided from 580 090).

E. C. Cork and M. Bowman-Manifold. Application date 21st May, 1943.

580 115.—Electromagnetic horn or waveguide aerial and means for exciting it (divided from 580 090).

E. C. Cork and M. Bowman-Manifold, Application date 26th April, 1944.

DIRECTIONAL AND NAVIGATIONAL SYSTEMS

579 763.—Short-wave d.f. system comprising a waveguide feed, a parabolic reflector, and a movable deflecting device for scanning a given field by the radiated beam.

Sperry Gyroscope Co., Inc. (assignees of R. J. Marshall, W. L. Barrow and W. W. Mieher). Convention date (U.S.A.) 4th February, 1942.

579 764.—Coupling a fixed waveguide or coaxial transmission-line to a similar line which feeds a rotating aerial, as used say, for radiolocation.

Sperry Gyroscope Co., Inc. (assignees of R. O. Haxby). Convention date (U.S.A.) 27th May, 1942.

579 813.—Radiolocation or remote-television system, depending upon reflected waves, wherein scanning is effected statically; i.e., by passing exploring waves of different frequency through a refracting or dispersing medium.

J. Forman and Pye, Ltd. Application dates 30th September and 21st November, 1941.

589 853.—Circuit for generating "marker" pulses with predetermined leading and trailing edges for application to a cathode-ray indicator, as used in radiolocation.

Standard Telephones and Cables, Ltd. (assignees of A. Rothbart). Convention date (U.S.A.) 8th January, 1943.

579 859.—Aerial system for rotating the plane of polarization of the exploring wave in radiolocation so as to prevent fading effects.

Western Electric Co., Inc. Convention date (U.S.A.) 24th November, 1942.

579 863.—Radiolocation system in which the pulse recurrence-frequency is determined by the distance of the target, and is then utilized to inform a remote receiver of the target-distance.

Standard Telephones and Cables, Ltd. (assignees of L. A. de Rosa). Convention date (U.S.A.) 20th February, 1943.

579 865.—Navigational system for giving a combined approach and glide path, wherein the receiver is made responsive only to one or other of the two indications, in alternation.

Standard Telephones and Cables, Ltd. and J. D. Weston. Application date 1st March, 1944.

580 170.—Mechanism for rotating the parabolic reflector of a dipole so that the radiated beam is given a spiral scanning movement over the area to be explored, say, in radiolocation.

Nash and Thompson, Ltd., A. G. Fraser-Nash, A. Whitaker and N. Barnes. Application date 5th January, 1942.

580 257.—Means for coupling a fixed coaxial feed-line to another similar line connected to a rotating aerial as used, say, in radiolocation.

Standard Telephones and Cables, Ltd. (assignees of E. Labin and A. G. Kandoian). Convention date (U.S.A.) 23rd January, 1943.

580 324.—Automatic gain control system, particularly for receiving approach-path and blind-landing signals.

Standard Telephones and Cables, Ltd. and H P. Williams. Application date 27th June, 1944

580 361. — Direct-reading cathode-ray direction-finder, based on the periodic combination of the signals received from a rotating and fixed aerial respectively.

Standard Telephones and Cables, Ltd. (communi-

cated by International Standard Electric Corpn.) Application date 6th August, 1942.

RECEIVING CIRCUITS AND APPARATUS

579 824.—Electrolytic treatment as a stage in the processing of a silicon-crystal rectifier for ultra-short waves.

The General Electric Co., Ltd. and C. E. Ransley Application date 11th August, 1943.

579 860.—Receiver for time-modulated pulsed signals in which a time-delay network prevents any response to parasitic or other disturbances.

Standard Telephones and Cables, Ltd. (communicated by International Standard Electric Corpn.). Application date 11th February, 1944.

580 077.—Stabilizing the tuning and operation of a superheterodyne receiver in which one local oscillator supplies two frequency-changing stages.

Standard Telephones and Cables, Ltd. (communicated by International Standard Electric Corpn.). Application date 19th May, 1944.

580 297.—Tracking arrangement for the permeability-tuning control of a superheterodyne receiver.

Marconi's W. T. Co., Ltd. (assignees of W. F. Sands). Convention date (U.S.A.) 28th June, 1943.

TRANSMITTING CIRCUITS AND APPARATUS

579 736.—Frequency - modulation circuit with tuned-cathode coupling for the carrier-oscillations, and grid-control by the signal voltage.

D. L. Hings. Application date, 23rd July, 1942.

579 745.—Frequency - modulation circuit in which part of a hollow-resonator is vibrated mechanically by the applied signal-voltage.

The General Electric Co., Ltd. and D. O. Hawes Application date 18th December, 1942.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

579 777.—Generating time- or phase-modulated pulses by a method which includes the rectification of a sinusoidal wave.

Standard Telephones and Cables, Ltd. (communicated by International Standard Electric Corporation). Application date 29th October, 1943.

579 794.—Producing a sinusoidal wave from a pulse, for synchronizing purposes or for multiple signalling systems.

L. W. Germany, and Pye, Ltd. Application date 3rd April, 1944.

579 872.—Pulse-control system for periodically changing the frequency used for intercommunication between a number of different stations; e.g., to offset enemy jamming.

Standard Telephones and Cables, Ltd. (assignees of M. Silver). Convention date (U.S.A.) 27th April, 1943.

579 973.—Cathode-ray circuit for determining and monitoring the duration of signalling-pulses of the order of microseconds.

Standard Telephones and Cables, Ltd., P. K. Chatterjea, C. T. Scully, and D. M. Ambrose. Application date 21st July, 1942.

580 167.—Secret system in which the signal is sent in two parts (each unintelligible), through separate channels, which are combined into an intelligible message in the receiver.

Standard Telephones and Cables, Ltd., and M. M. Levy. Application date 9th July, 1941.

580 253.—Spark-gap discharge circuit with shaping and synchronizing means for generating a train of carrier-pulses, suitable say for signal-modulation.

Standard Telephones and Cables, Ltd. (assignees of E. Labin and E. M. Ostlund). Convention date (U.S.A.) 13th February, 1943.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

579 155.—Discharge-tube of the velocity-modulation type, wherein a part of the magnetic control-field is supplied by pole-pieces located inside the tube.

Standard Telephones and Cables Ltd., J. H. Fremlin and R. N. Hall. Application date 2nd August, 1940.

579 156.—Ring-shaped resonator arranged for velocity-modulation, so that the electron-beam passes near the anti-node of the field in the cavity.

Standard Telephones and Cables Ltd. and J. H. Fremlin. Application date 2nd August, 1940.

579 233.—Generating or amplifying centimetre waves by periodically deflecting a beam of electrons so as to scan the apertures of a cavity-resonator.

H. Hughes and Son Ltd., A. H. W. Beck and A. J. Hughes. Application date 26th August, 1941.

579 234.—Electrode-arrangement of a valve for handling ultra-high frequencies, wherein cavity resonators serve as low-loss impedances.

Marconi's W.T. Co., Ltd. (communicated by The Radio Corporation of America). Application date 29th April, 1942.

579 315.—Construction and arrangement of the reflecting electrodes in an electron-discharge tube of the velocity-modulation type.

M. Bowman-Manifold. Application date 29th March, 1941.

579 317.—Movable-strip attachment for tuning the cavity resonator in a discharge tube for velocity-modulation.

A. F. Pearce. Application date 13th February 1942.

579 319.—Tubular spacing-device for ensuring a predetermined small clearance between the electrodes of a short-wave oscillator or amplifier.

G. Liebmann and Cathodeon Ltd. Application date 23rd February, 1942.

579 320.—Means for maintaining electrodes in a predetermined position, relatively to the resonator apertures, in a velocity-modulation tube.

J. W. Hill. Application date 26th March, 1942.

579 384.—Construction and spacing of the electrodes in a velocity-modulation tube, designed to minimize space-charge effects on the bunched stream.

Western Electric Co., Inc. Convention date (U.S.A.) 19th June, 1942.

579 412.—Velocity-modulation tube wherein any change in the gap-width, for the purpose of tuning, automatically alters the relative spacing of the reflector.

The British Thomson-Houston Co. Ltd., W. J. Scott, R. G. Saunders and R. Lathom. Application *dates 9th July 1941 and 27th February and 17th April, 1942.*

579 536.—Electrode structure of a short-wave amplifier, in which the cathode and anode are coupled to concentric-line resonators, and means for tuning the latter.

Standard Telephones and Cables Ltd. (assignees of W. Hotine.) Convention date (U.S.A.) 30th January, 1943.

579 648.—Design and operation of a tuning-plunger which is associated with the hollow resonator in a velocity-modulation discharge-tube.

B. J. Mayo and H. E. Holman. Application date 17th February, 1942.

579 651.—Forming a centre band of square cross-section on the sealing tube for the glass stub of a thermionic valve to avoid accidental displacement of the associated metal parts in the course of assembly.

The M-O Valve Co., Ltd. and J. A. Smith. Application date 24th June, 1942.

579 653.—Electrode assembly and internal screening-devices for a valve intended to take exceptionally-high operating voltages.

A. C. Cossor Ltd. and P. T. Hodgson. Application date 19th March, 1943.

579 803.—Construction and arrangement of the resonator system in a discharge tube of the velocity-modulation type.

The General Electric Co., Ltd., G. W. Edwards and R. W. Sloane. Application date 5th June, 1940.

579 818.—Velocity-modulation tube in which the effect of secondary emission is utilized to reduce the normal operating voltages.

B. J. Mayo. Application date 29th May, 1943.

579 834.—Tuning-device for the hollow cylindrical resonator of a velocity-modulation tube of the "Monotron" type, where resonance is not dependent upon the axial length of the cylinder.

N. C. Barford. Application date 20th November, 1943.

579 845.—Electrode-assembly in a point-discharge or "auto-electronic" device for rectifying or "mixing" ultra-short waves.

The General Electric Co., Ltd., M. Benjamin, B. S. Gossling and J. W. Ryde. Application date 18th September, 1940.

579 893.—Electrode arrangement for a velocity-modulation tube handling centimetre waves, by which the spacing conditions are made less rigorous.

N. C. Barford. Application date 24th November, 1943.

579 965.—Method of assembling and centering or aligning the electrodes of a cathode-ray tube.

The M-O Valve Co., Ltd., N. L. Harris, J. W. Ryde and J. H. Shaylor. Application date 18th June, 1940.

579 987.—Electrode arrangement of a multi-anode magnetron in which certain elements simulate a quarter-wave transmission-line in order to stabilize operation.

The British Thomson-Houston Co., Ltd. (communicated by the General Electric Co.). Application date 24th September, 1943.

580 002.—Resonant-electrode device, consisting of a centre rod surrounded by a number of parallel rods, suitable for velocity modulation.

Standard Telephones and Cables, Ltd., and J. H. Fremlin. Application date 21st February, 1941.

580 004.—The use of an auxiliary triode to prevent the so-called "locking" effect due to secondary emission at the grid of a conventional multi-grid valve, but particularly in a discharge tube for velocity modulation.

The British Thomson-Houston Co., Ltd., and C. J. Milner. Application date 25th January, 1943.

580 009.—Tuning-device for a cavity resonator wherein the movement of one of the walls causes a change in the dimensions of the resonator in two different directions, thereby increasing the range of adjustment.

Western Electric Co. Inc. Convention date (U.S.A.) 13th February, 1943.

580 041.—Screw adjusters for equalizing or balancing the tuning of the cavity resonators in a magnetron valve of the "block" type.

The M-O Valve Co., Ltd., and E. M. Hickin. Application date 21st September 1942.

580 080.—Electrode structure and spacing of a triode valve for handling centimetre waves.

The M-O Valve Co., Ltd., and G. W. Warren. Application date 14th November, 1940.

580 081.—Electrode arrangement of a velocity-modulation tube designed to reduce the "gap capacity" of the hollow resonator.

L. F. Broadway. Application date 29th January, 1941.

580 082.—Oscillation-generator in which an electron beam is first broken-up into pulses and then passed through a hollow resonator.

Marconi's W.T. Co., Ltd., and C. S. Franklin. Application date 19th March, 1941.

SUBSIDIARY APPARATUS AND MATERIALS

579 195.—Offsetting the effects of input-capacitance in a pair of cathode-coupled valves for generating or amplifying square-shaped waves.

J. P. W. Houchin. Application date 30th December, 1942.

579 325.—Sine and cosine potential-dividers in a "magslip resolver" for calculating the range and fuzing of a shell to be fired at a moving target.

A. C. Cossor Ltd., L. H. Bedford, J. Bell and E. M. Langham. Application date 30th November, 1942.

579 439.—Bar magnet forming part of a bridge circuit and operating as an earth-indicator compass or direction-indicator.

General Motors Corporation (assignees of E. J. Martin and C. E. Grinstead). Convention date (U.S.A.) 19th May, 1943.

579 498.—Pulse-generating circuit in which a pair of cold-cathode gas-discharge tubes are arranged to short-circuit one of two capacitors alternately.

Standard Telephones and Cables Ltd. and R. H. Dunn. Application date 4th May, 1944.

579 679.—Pulse-generator in which two capacitors are charged in parallel through reversed rectifiers, and tuned inductances and are discharged through a switch synchronized with the a.c. supply.

The General Electric Co., Ltd. and W. M. Michaelis. Application date 31st December, 1943.

579 682.—Trigger-operated time-base circuit for a c.r. tube in which the sweep precedes the return, and is initiated by the wave-front to be observed.

Standard Telephones and Cables Ltd. and R. Hilton. Application date 3rd February, 1944.

ABSTRACTS AND REFERENCES

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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

34.232 **1304**

A Contribution to the Theory of Acoustic Radia- on.—C. J. Bouwkamp. (*Philips Res. Rep.*, ug. 1946, Vol. 1, No. 4, pp. 251–277.) Study of the field of radiation produced by a harmonically scillating membrane with arbitrary amplitude stribution in a closely fitting aperture of an finite rigid plane ”.

4.321.9.001.8 **1305**

Supersonic Applications.—T. F. LoGiudice. (*Radio aft*, Dec. 1946, Vol. 18, No. 3, pp. 16–17, 67.)

4.6 : 621.395.61. **1306**

Application of Regulators to Acoustic Measure- ents.—A. Moles. (*C. R. Acad. Sci., Paris*, 13th n. 1947, Vol. 224, No. 2, pp. 101–104.) The gulator described consists of a standard micro- one, amplifier and detector. The microphone is ctrically corrected to have a sensibly flat response rve. The voltage from the detector is used to ntrol inversely the gain of a variable-μ pentode ose grid receives the signal from the microphone be tested. The response curve can thus be orded directly on a rotating drum. A block gram of the equipment is given.

534.861 **1307**

The Acoustic Problems of Broadcasting.—R. Braillard. (*Bull. Soc. franç. Élect.*, April 1946, Vol. 6, No. 58, pp. 173–180.) In broadcasting, mere intelligibility is not sufficient. Quality reproduction is of great importance, involving detailed study not only of electro-acoustics, but also of both physiological and psychological acoustics.

621.395.61 **1308**

Rapid Method of determining the Characteristics of a Microphone.—A. Moles. (*Radio en France*, 1945, No. 4, pp. 30–33.) A comparison method using a standard electrostatic microphone. The e.m.f. from the microphone under test and that from the standard are applied, after amplification in a known ratio, to the two sets of plates of a c.r.o., both microphones being subjected to the same sound field.

621.395.616 **1309**

The Condenser Microphone.—P. G. Bordoni. (*Alta Frequenza*, Sept. 1946, Vol. 15, No. 3, pp. 167–204. In Italian, with English summary.) A general treatment, with a bibliography of 130 papers and books on the subject.

621.395.623.7 **1310**

The Acoustic Problems of Electrodynamic Loudspeakers.—E. Synek. (*Radio Tech., Vienna*, Aug./Sept. 1946, Vol. 22, Nos. 4/5, pp. 229–232.)

621.395.623.7 **1311**

Report of the Commission on Loudspeakers (Ministry of Industrial Production).—(*Radio en France*, 1945, No. 4, pp. 34–37.) General directions are given for the graphical representation of various measurements on loudspeakers; terms are defined and technical characteristics described.

621.395.623.7 **1312**

Rational Study of Loudspeakers.—A. Clausing. (*Radio en France*, 1945, No. 4, pp. 22–27.) An account of equipment for the routine testing of loudspeakers, giving frequency characteristics, directional characteristics for different frequencies, nonlinear distortion and impedance as functions of frequency.

621.395.623.7.015.3 **1313**

Loudspeaker Transient Response.—D. E. L. Shorter. (*B.B.C. Quart.*, Oct. 1946, Vol. 1, No. 3, 9 pp. Reprint.) The frequency response curve taken after the interruption of the test note may show marked resonances which are not present in the steady state. Tests were made on four types of cones with delays of 10–40 ms and the response was determined by measuring the rate of decay of the sound. Tonal coloration, glitter, and other irritating effects were found to be associated with the additional resonances. See also *Wireless World*, Dec. 1946, Vol. 52, No. 12, pp. 424–425.

621.395.623.8 **1314**

Large Electroacoustic Installations.—J. Müller-Strobel. (*Schweiz. Bauztg*, 3rd & 10th Feb. 1945, Vol. 125, Nos. 5 & 6. Reprint.) A general description of equipment manufactured by the Albiswerk Zurich A.-G. and particularly suitable for railway stations, concert halls, works, etc. A special feature of the system is automatic control of the output volume by means of a voltage derived from a microphone which picks up the noise in the room or hall where the loudspeakers are situated.

621.395.623.8 **1315**

United Nations Broadcasting and Sound System.—(*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 90–93 . . 154.) Technical details of broadcasting and amplification equipment at Flushing Meadows and Lake Success.

621.395.667 **1316**

Three-Band Variable Equalizer.—L. D. Grignon. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 112–115.) "Provides gain or attenuation adjustment in one-db steps independently in the low-, high-, or mid-frequency bands of the audio spectrum. Applications include recording, rerecording, sound system compensation, and broadcast station equipment." For a fuller account see 1170 of 1946.

AERIALS AND TRANSMISSION LINES

621.392 + 537.291 **1317**

Electronic Amplifier formed by a Guided Wave in a Medium of High Dielectric Constant.—R. Wallauschek. (*C. R. Acad. Sci., Paris*, 20th Jan. 1947, Vol. 224, No. 3, pp. 191–193.) A wave of the longitudinal electric type (E_0) is propagated in a cylindrical guide in which almost the whole cross-section is filled with a dielectric of high permittivity. The phase velocity of the wave is thus much less than that of light. Around the electric axis of the guide is an evacuated cylinder traversed in the direction of propagation of the wave by a beam of electrons of velocity very near the phase velocity of the wave. A solution is obtained of the problem of the interaction of wave and beam in the guide. Formulae are given for the progressive waves. Four possible reflected waves are found. Two of these exist for a small range of beam velocities around the phase velocity of the primitive wave; one has increasing, the other decreasing amplitude. These two waves have a phase velocity less than the velocity of the beam. The other two waves are of constant amplitude, one progressive and the other retrogressive, and their phase velocity is greater than the electron velocity. By combining these four waves, the limiting conditions at the ends of the guide can be satisfied. *Cf.* 1330 below (Blanc-Lapierre & Lapostolle).

621.392.029.62 + 621.396.67.029.62 **1318**

Wide-Band Aerials and Transmission Lines for 20 to 85 Mc/s.—F. E. Lutkin, R. H. J. Cary & G. N. Harding. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 3, pp. 552–558.) Systems covering the frequency bands 20–30 Mc/s, 40–50 Mc/s and 50–85 Mc/s are described which can deal with pulse transmissions of 600 kW peak power. The aerial arrays are built up of full-wave centre-fed dipoles of wire-cage construction, with an input impedance of 600 Ω. Open-wire transmission lines are used throughout. Wire-mesh reflectors are used to obtain the horizontal polar diagram required; their effect on dipole impedance is discussed. An exponential transformer is described which simplifies the construction of arrays consisting of four full-wave dipoles, its function being to transform an impedance of 300 Ω to 600 Ω. Compensating stubs may be used to increase the bandwidth of the wide-band aerials.

621.392.029.64 **1319**

Waveguide Data.—L. E. Sherbin. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 122–124.) Curves are given of attenuation and power-carrying capacity as a function of frequency for rectangular copper waveguides of various dimensions operating in the $TE_{1,0}$ mode. Frequencies from 1 600 Mc/s to 44 000 Mc/s are covered.

621.392.029.64 **1320**

Propagation in Curved Guides.—M. Jouguet. (*C. R. Acad. Sci., Paris*, 13th Jan. 1947, Vol. 224, No. 2, pp. 107–109.) The method of perturbation (2469 of 1946 and 16 of January) is applied to the study of $H_{0,n}$ and $E_{0,n}$ waves in a perfectly conducting circular waveguide of radius R to determine those which reduce to $E_{m,n}$ and $H_{m,n}$ waves when R increases indefinitely. The E'_1 wave behaves normally, but the E'_1 and H_0 waves can only exist in a perfectly conducting curved guide if in combination and with amplitudes in the ratio $\sqrt{2} : 1$, so that the transported energy is equally divided. The effect of curvature on the phase velocity of this type of wave is not, to the second order, zero. This differs from the corresponding result for a cylindrical guide as long as the curvature is finite. In an actual guide, propagation of an H_0 or E'_1 wave by itself is possible provided that the curvature is sufficiently small and tends towards zero with the resistivity of the wall.

621.392.029.64 **1321**

Some Applications of the Principle of Variation of Wavelength in Wave Guides by the Internal Movement of Dielectric Sections.—G. E. Bacon & J. C. Duckworth. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 633–638.) This principle is used for loading adjustment of centimetre-wave magnetrons working into a complex load, for beam swinging in directive arrays without mechanical movement, and in switching systems.

621.392.029.64 **1322**

Discussion on "Wave Guides" [I.E.E. radiolocation convention].—(*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, p. 778.) Points raised include the effect on performance of replacement of damaged parts, and the effect on standing-wave ratio of a small frequency shift.

621.392.029.64 : 538.3 **1323**

Quasi-Stationary Field Theory and Its Application to Diaphragms and Junctions in Transmission Lines and Wave Guides.—G G Macfarlane. (*J. Instn* *elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 703–719.) Calculations are made of the shunt admittance of capacitive and inductive diaphragms in strip transmission lines and rectangular waveguides. By combining quasi-stationary field theory and Babinet's principle for electromagnetism a valid result is derived for the case when the diaphragm cross-section is comparable with, or greater than, a wavelength.

621.392.029.64 : 621.317.336.6 **1324**

Standing Wave Meter.—Kallmann. (*See* 1503.)

621.392.029.64 : 621.318.572 **1325**

The Rhumbatron Wave-Guide Switch.—A. Maclese & J. Ashmead. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 700–702.) The switch operates electrically by tuning and detuning a cavity coupled to the waveguide. High switching speeds are possible and fading is consequently minimized.

621.392.029.64 : 621.396.615.141.2 **1326**

Problems and Practice in the Production of Wave-Guide Transmission Systems.—L. W. Brown. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 639–646.) The performance requirements of waveguides are considered in terms of reflections and standing-wave ratios. Careful selection or matching must be adopted rather than random choice or interchange of sections when the number of sections exceeds 2 or 3. Particular reference is made to the case of waveguides used with magnetron sources.

621.392.029.64.091 **1327**

Attenuation Curves for 2 : 1 Rectangular, Square and Circular Wave Guides.—E. O. Willoughby & E. M. Williams. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 723–724.) Graphs are given which show the relationship between frequency and physical size for various values of attenuation in copper waveguides.

621.392.029.64.091 **1328**

Calculation of Attenuation in Wave Guides.—S. Kuhn. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 663–678.) Tables and curves are derived which give the field equations and attenuation constants of rectangular and circular waveguides excited in any mode likely to be met with in practice. Field equations are expressed in terms of field impedances and of the power transmitted by the wave, by introducing the concept of 'characteristic density' of energy. The attenuation constant caused by wall losses is tabulated for the case of an air-filled copper guide. The attenuation constant and phase constant are also tabulated for the case of an enclosed dielectric of low loss; i.e., for values of tan δ below 0.1.

21.392.1 : 512.831 **1329**

Matrix Methods in Transmission-Line and Impe-ance Calculations.—W. H. Watson. (*J. Instn ect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 37–746.) An ordered exposition of methods pplicable not only to calculations of the principal ave on a two-conductor transmission line, but so to all plane wave processes capable of represen-tion in terms of transmission lines. Some new sults are also indicated.

621.392.2 **1330**

The Interaction between a Progressive Wave and a Beam of Electrons of Velocity near that of the Wave.—A. Blanc-Lapierre & P. Lapostolle. (*C.R. Acad. Sci., Paris*, 13th Jan. 1947, Vol. 224, No. 2, pp. 104–105.) For an infinite line made up of discrete equal sections, the wave amplitude increases exponentially and the wave velocity is slightly lower than the beam velocity. For an infinite uniform continuous line, four waves are possible, only one of them increasing in amplitude. Such a line can be regarded as a model explaining qualitatively the phenomena of interaction in progressive-wave amplifiers.

621.392.43 **1331**

Impedance Matching by Tapered Transmission Lines.—A. W. Gent & P. J. Wallis. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 3, pp. 559–563.) The lines considered are coaxial, the conductors being tapered from one radius to another. Expressions are found for the impedance deviations with change of wavelength at the input of a tapered section when its far end is joined to a coaxial line terminated by its characteristic impedance. The added resistance and reactance are least when the length of the tapered section is approximately an integral multiple of λ/2. If both the outer and inner conductors are tapered, there is an optimum taper which will give unity standing-wave ratio (s.w.r.) for λ/2 sections and a s.w.r. only slightly different from unity for other lengths. If it is desired to keep the diameter of one conductor the same on both sides of the junction, the best method is to taper the two conductors in opposite ways for a half-wavelength and then in the same way, thus producing either a bulge on the inner conductor or a constriction in the outer conductor. A summary of this paper is given in Part IIIA, 1946, Vol. 93, No. 1, pp. 58–59.

621.396.611.029.5 **1332**

Theory of Mode Separation in a Coaxial Oscillator.—P. J. Sutro. (*Proc. Inst. Radio Engrs, W. & E.*, Dec. 1946, Vol. 34, No. 12, pp. 960–962.) An analysis of the separation of the first and third modes in a coaxial oscillator. It is shown that the difference between the two resonant lengths of one line which give these modes increases with the difference between the products of the terminating inter-electrode capacitance and the characteristic impedance for the two lines.

621.396.67 **1333**

Aerials.—K. Fränz. (*Elektrotech. Z.*, 15th June 1944, Vol. 65, Nos. 23/24, pp. 229–233.) A review of physical principles and developments, with special reference to the directional properties and impedance of various aerial arrays.

621.396.67 **1334**

The Receiving Dipole Aerial.—J. Müller-Strobel & J. Patry. (*Schweiz. Arch. angew. Wiss. Tech.*, July 1946, Vol. 12, No. 7, pp. 201–213.) An inclusive account of work previously noted in 795 and 3527 of 1945 and 22 of January.

621.396.67 **1335**

Slot Aerials and Their Relation to Complementary Wire Aerials (Babinet's Principle).—H. G. Booker. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, 1946, Vol. 93, No. 3, pp. 588–597.) A general account of such aerial arrays and their characteristics, with particular reference to their use in C.H.L. and G.C.I. systems. Practical details of a mobile G.C.I. system are given and also of a fixed G.C.I. station, including a specially designed rotary capacitance switch capable of handling peak power up to 150 kW.

621.396.677.029.62 **1356**

Variable-Elevation Beam-Aerial Systems for $1\frac{1}{2}$ Metres.—G. E. Bacon. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 3, pp. 539–544.) A stack of nine banks of four dipoles each, mounted on a 120-ft tower, is used to produce a beam which is very narrow in the vertical direction but wide horizontally. A special phase-shifting device, located near the centre of the stack and inserted in the feed line from the transmitter, enables the beam elevation to be varied rapidly. Two such installations are described, the first giving a 3° beam and measuring elevation to an accuracy of about $\pm 0.3°$ from $1\frac{3}{4}°$ to 15° and the second a $1\frac{1}{2}°$ beam measuring from $\frac{3}{4}°$ to 15° with a maximum error of 0.15°. The beam elevation obtained in practice agreed sufficiently well with the theoretical position for elevation calibration to be unnecessary. A summary of this paper is given in Part IIIA, 1946, Vol. 93, No. 1, pp. 52–53.

621.396.677.029.64 **1357**

A Detailed Experimental Study of the Factors influencing the Polar Diagram of a Dipole in a Parabolic Mirror.—E. G. Brewitt-Taylor. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 679–682.) Details are given of the effect on beam position of variations in wavelength, dipole length and position, length of balancing sheath on the coaxial transmission line, and parasitic reflector position. Results are also given for a dipole designed to give a 'skewed' beam without mechanical displacement.

621.396.677.029.64 **1358**

A Dielectric-Lens Aerial for Wide-Angle Beam Scanning.—F. G. Friedlander. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 658–662.) The design of an aplanatic dielectric lens suitable for an aerial system of the sectoral horn type is considered. For certain values of the refractive index a plano-convex lens can be found which can be regarded as aplanatic in practice. To avoid distortion when the beam is scanned through a large angle by moving the source, a ray from the focus must meet the corresponding final ray on a circle with centre at the focus and radius equal to the focal length.

621.396.677.029.64 : 621.392.029.64 **1359**

Directive Couplers in Wave Guides.—M. Surdin. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 725–736.) The directivity and attenuation is calculated by a method due to H. A. Bethe (706 of 1945) for systems such as two parallel or crossed waveguides, using circular holes or linear slots as coupling elements. Broad-band couplers are obtained by multiplication of these coupling elements. The importance of mechanical accuracy, perfect matching, and finite size of coupling elements is discussed.

621.396.677.029.64 : 621.392.029.64 **1360**

Resonant Slots.—W. H. Watson. (*J. Instn elect. Engrs*, Part IIIA, 1946, Vol. 93, No. 4, pp. 747–777.) The coupling of a resonant half-wave slot to a rectangular waveguide is discussed in relation to the feeding of microwave radiators. "The laws of guide coupling are explained in terms of the manner in which impedance is transferred from the position of the slot centre in guide 2 into guide 1 at the same position." The coupling of variable reactances to produce a T-section load is discussed. The waveguide feed for a microwave array is analysed with reference to the bandwidth of the system, and performance details are given of a broad-band array of inclined displaced slots. Radiation patterns are given for a 5% frequency change in the S-band.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.012.3 : 515.53 **1361**

The Application of Riemann's Number Sphere and Its Projections to A.C. Engineering.—F. Steiner. (*Radio Welt*, Oct. 1946, Vol. 1, No. 2, pp. 23–26.) Stereographic projection of the number sphere leads to a better representation of resistances than that using the Gauss plane; transfer from resistance to conductance merely requires a rotation through 180°. A parallel projection method is developed for obtaining the terminating resistance from measurements of the terminal voltages of two quadripoles in series.

621.314.223 : 621.392.5.012.8 **1362**

General Theory of the Autotransformer.—P. Thévenin. (*Radio en France*, 1947, No. 2, pp. 37–38.) The quadripole equivalent of an autotransformer is of T type and appropriate formulae are derived. The T scheme is found particularly suitable for determining short-circuit voltages.

621.316.726.078.3 : 621.396.62.029.64 **1363**

Crystal Control for Stability in V.H.F. Receivers.—N. L. Chalfin. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 71–73.) By using crystal harmonics, no-drift sets can be designed for cheap production.

621.318.572 **1364**

Modern Geiger-Muller Counters.—A. Graves. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 80–83.) A counting circuit providing an accurate mechanical counter for rates up to 600 per minute and a less accurate electronic integrator for higher counting rates. Various applications are mentioned.

621.319.4 : 621.793.14 **1365**

Metallized Capacitor Dielectrics.—J. I. Cornell. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 98..157.) A recently developed American product called the 'Solite' capacitor has aluminium electrodes deposited directly on to the paper dielectric by a vaporization process. These capacitors are very small in size, and have long life and a low power factor.

621.319.4.011.4 : 537.224 **1366**

Calculation of the Edge Correction for Capacitors.—Zickner. (*See* 1403.)

621.319.43 **1367**

A Note on Variable Capacitors.—M. Parodi & F Raymond. (*Onde élect.*, Dec. 1946, Vol. 26, No. 237, pp. 477–478.) A formula is derived from which the shape of the moving plates can be calculated for a given capacitance law.

621.39.011 **1368**

Application of Complex Functions to Frequency-Transposition Systems.—F. H. Stieltjes. (*Tijdschr. ned. Radiogenoot.*, Nov. 1946, Vol. 11, No. 6, pp. 221–271. In Dutch with English summary.) Campbell's 'cisoidal oscillations' are used to develop a theory of these systems (i.e., modulators, etc.) which is analogous to normal circuit theory: equivalent circuit diagrams are given which show the behaviour of such systems at a glance. Practical applications are discussed.

621.39.012 **1369**

Functional Schematic Diagrams. S. H. Larick. (*Proc. Inst. Radio Engrs, W. & E.*, Dec. 1946, Vol. 34, No. 12, pp. 1005–1007.) Suggestions for clarifying schematic and circuit diagrams. Stress is laid on the importance of correctly representing the functions of circuits rather than the layout of components.

621.392.2 : 621.314.2 **1370**

Design of 500 kc/s Transformers. R. Lee. Tele-Tech, Jan. 1947, Vol. 6, No. 1, pp. 84–86.) Description of the development of untuned, aminated, iron-cored transformers to cover the requency range of 50 kc/s to 515 kc/s. Construcional technique is briefly indicated and perormance curves are given.

21.392.5 **1371**

Generalization of the Conception of Rejector ilters.—F. Raymond. (*C. R. Acad. Sci., Paris*, 7th Dec. 1943, Vol. 217, No. 26, pp. 680–682.) quadripole with connexions between its input nd output terminals behaves as a rejector filter or the frequencies transmitted by the quadripole ithout damping or phase change.

21.392.52 : 519.27 **1372**

The Wiener RMS (Root Mean Square) Error riterion in Filter Design and Prediction. N evinson. (*J. Math. Phys.*, Jan. 1947, Vol. 25, o. 4, pp. 261–278.) Methods are given for deterining quantitatively the extent to which message nd noise can be separated and for the design of a lter to effect this separation. The problem of multaneous filtering and predicting is considered. he r.m.s. approach used is an approximation to d a simplification of the transcendental case eveloped by N. Wiener.

21.394/.397].645 **1373**

Graphical Solutions for Cathode Followers. L. Krauss. (*Electronics*, Jan. 1947, Vol. 20, o. 1, pp. 116–121.) Design data can be computed ven only the conventional family of plate characteristics and the load, which is regarded as a re resistance.

21.394.645.35 : 621.317.715 **1374**

Contact Modulated Amplifier. Perkin-Elmer Corration. (*See* 1512.)

1.396.611.1 : 531.33 .39 **1375**

On the Stability Conditions of Oscillating Systems. Couffignal. (*See* 1497.)

621.396.611.3 **1376**

Propagation of Waves in Periodic Systems, taking Account of Certain Boundary Conditions. P. Marié. (*C. R. Acad. Sci., Paris*, 29th April 1946, Vol. 222, No. 18, pp. 1039–1042.) An expression is derived, involving electrospherical polynomials of order $(n + 1)$, for the attenuation ratio of a series of $(n + 1)$ oscillatory circuits, loosely coupled by mutual inductance, under certain simplifying assumptions. See also 661 of March.

621.396.611.3.015.3 **1377**

Transient Regimes in Coupled Resonators. P. Marié. (*C. R. Acad. Sci., Paris*, 6th May 1946, Vol. 222, No. 19, pp. 1006–1008.) Continuation of 1376 above. For the general case of *n* identical obstacles and where the condition for iterative reflection is satisfied, the intensity of the signal transmitted in the transient regime is represented by an integral Bessel function which can be expanded in a rapidly converging series of Bessel functions. This result is valid for a chain of feebly oscillating coupled circuits terminated by its iterative impedance.

621.396.611.4 **1378**

Principles aiding the Calculation of Electromagnetic Cavities. J. Bernier. (*C. R. Acad. Sci., Paris*, 29th Nov. 1943, Vol. 217, No. 22, pp. 530–532.) A continuation of 2155 of 1945. From the principle of similitude it follows that if all the geometric dimensions of a cavity are multiplied by *m*, the natural wavelengths, self-inductance, and capacitance will also be multiplied by *m*, while the parallel resistance is divided by $\sqrt{m}$ and the mutual inductance per square centimetre of the coupling loop by *m*. The principle of symmetry enables the modes of vibration of a cavity made up from one with a plane side and its mirror image in that plane side, to be deduced from those of the smaller cavity. The equivalence between two of Maxwell's equations and a principle of minimum energy analogous to the principle of least action, enables the natural frequencies and the fundamental fields of a cavity to be studied by the methods of the calculus of variations. In this way the variations in natural frequencies caused by small deformations of the cavity wall can be determined. The principle of orthogonal trajectories can also be applied.

621.396.611.4.029.64 **1379**

Resonance Cavities used for Ultra-Short Waves. A. Briot. (*Télévis. franç.*, Dec. 1945, No. 8, pp. 7–10.) A mathematical treatment, based on Maxwell's equations, of the general case of cavity resonance, with application to the determination of the natural resonance frequencies of cylindrical cavities.

621.396.615 **1380**

Complete Theory of Valve Oscillators. D. Guindin. (*Rev. sci., Paris*, Aug. 1946, Vol. 84, No. 3255, pp. 165–168.) The grid and anode currents are assumed to be sinusoidal. An approximate formula for the wavelength is derived mathematically, and agrees better with experimental results than that of classical theory which neglects the grid current.

621.396.615 **1381**

A Stabilized Modulated Oscillator. A. E. Hayes.

Jr. (*Radio News*, Jan. 1947, Vol. 37, No. 1, pp. 28–29.) Spurious frequency-modulation in an amplitude-modulated oscillator is eliminated by a secondary circuit producing frequency-modulation which is controlled and switched to oppose it.

621.396.615.14 **1382**

Ring Oscillators for U.H.F. Transmission.—Gootée. (*See* 1623.)

621.396.615.17 : 621.317.755 **1383**

New Timebase Circuit for Cathode-Ray Oscillographs.—(*Elektrotech. Z.*, 20th April 1944, Vol. 65, Nos. 15/16, pp. 138–139.) An auxiliary shunt circuit, with properly chosen time constant, enables the capacitor connected across the time-deflexion plates of the c.r.o. to be charged with sensibly uniform current. A modification of the arrangement gives a linear single sweep.

621.396.619.11/.13 **1384**

Theory of the Frequency Discriminator.—P. Güttinger. (*Bull. schweiz. elektrotech. Ver.*, 7th Sept. 1946, Vol. 37, No. 18, pp. 531–534. Reprint. In German, with French summary.) A general theory is developed. The conditions for linearity are considered from a new point of view. The main problem investigated is the demodulation of f.m. waves, with particular reference to the transformation of f.m. into a.m. with the least possible distortion.

621.396.619.23 **1385**

Overmodulation without Sideband Splatter.—Villard. (*See* 1625.)

621.396.645 : 621.43.019.8 **1386**

Constant-Gain Knock Pickup Amplifier.—Krebs & Dallas. (*See* 1551.)

621.396.662.3 **1387**

Introduction of the Idea of the Coupling Quadripole.—L. Boé. (*Radio en France*, 1947, No. 2, pp. 29–31.) A coupling quadripole is any quadripole with zero open-circuit impedance and infinite short-circuit impedance. It is the basis of nearly all the simplifications possible in systems of quadripoles of the general type.

621.396.662.3 **1388**

General Theory of Decimal Attenuators.—P. Thévenin. (*Radio en France*, 1947, No. 2, pp. 26–29.) The decimal attenuator consists of three quadripoles whose input and output terminals are connected in parallel, the quadripoles comprising three identical resistances R, three identical variable attenuators and respectively 0, 1 and 2 T-type lines of characteristic impedance R and reduction 1/10. Theory shows that such an attenuator, connected between a generator and a receiver, will give ratios between generator output voltage and receiver input voltage varying in steps of 1/1 000 of a value determined by the receiver impedance, from 1.110 to 0.001. Some applications are discussed.

621.396.69 **1389**

Components.—M. Chauvierre. (*Radio en France*, 1947, No. 2, pp. 4–7.) A general critical discussion of present design trends in various countries for valves, circuit components, tuning units and loudspeakers.

621.396.692.029.3 **1390**

Notes on the Construction of Attenuator Resistors.—F. Tournery. (*Radio en France*, 1947, No. 2, pp. 32–33.) Economical methods of construction for all audio frequencies are described.

621.396.694.011.3/.4 **1391**

Study of Electronic Reactance-Variation Devices.—W. Mazel. (*Toute la Radio*, Jan. 1947, Vol. 14, No. 112, pp. 34–38.) Reactance tube circuits are described whose behaviour for reactance-variation depends solely on a proper choice of the values of the resistors and capacitors involved. The operation of such circuits is explained with the aid of graphs and the results obtained with particular circuits are discussed.

GENERAL PHYSICS

53.081 **1392**

On Unities [units] **and Dimensions.**—H. B. Dorgelo & J. A. Schouten. (*Proc. Acad. Sci. Amst.*, Feb. & March 1946, Vol. 49, Nos. 2 & 3, pp. 123–131 & 282–291.) Discussion of the analogy between electric and magnetic quantities, of the relative merits of rationalized and unrationalized Giorgi units and of the expression of quantities dimensionally. Tables are given of units, dimensions and the field equations using the c.g.s., Gauss and Giorgi systems.

530.145.6 **1393**

Physical Interpretation of Wave Mechanics.—P. Destouches-Février & J. L. Destouches. (*C.R. Acad. Sci., Paris*, 6th May 1946, Vol. 222, No. 19, pp. 1087–1089.) A discussion of the basic principles of wave mechanics and of its relation to the quantum theory.

530.145.6 **1394**

On New Relations between the Densities of Mean Values in Dirac's Electron Theory.—G. Petiau. (*Rev. sci., Paris*, June/Dec. 1945, Vol. 83, Nos. 3245/3251, pp. 303–306.)

530.145.65 **1395**

An Interpretation of L. de Broglie's Equations for the Photon.—R. Murard. **Physical Interpretation of L. de Broglie's Equations for the Photon.**—R. Murard. (*C. R. Acad. Sci., Paris*, 29th April & 6th May 1946, Vol. 222, Nos. 18 & 19, pp. 1030–1032 & 1075–1076.) Relativistic theory of systems of particles shows that the photon can be considered as a system of two Dirac corpuscles whose relative motion round their common centre of gravity is evanescent. Regarding the photon as a Dirac corpuscle of positive energy combined with a lacuna in the series of states of negative energy, the relativistic wave mechanics of systems of particles completely justifies L. de Broglie's photon theory.

530.162 + [621.315.6 : 621.396.822 **1396**

The Response of Biased, Saturated Linear and Quadratic Rectifiers to Random Noise.—Middleton. (*See* 1565.)

534.321.9 : 621.315.58 **1397**

The Effect of Ultrasonic Waves on the Conductivity of Salt Solutions.—F. E. Fox, K. F. Herzfeld & G. D. Rock. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 329–339.) The conductivity is increased by an adiabatic compression because of direct pressure influence and temperature increase. Equipment is described for measurements between 200 kc/s and 1.5 Mc/s.

535.14 **1398**

The Photoelectric Effect.—C. Gutton. (*Télévis. franç.*, March 1946, No. 11, pp. 9–10.) A short historical account of the experimental laws which led Einstein to his corpuscular theory of light and thence to the development of wave mechanics by L. de Broglie.

535.343.4 + 621.317.011.5 + 621.396.11.029.64] : 546.171.1 **1399**

The Ammonia Spectrum and Line Shapes near 1.25 cm Wave-Length.—C. H. Townes. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 665–671.) Results are compared with those of Bleaney & Penrose (2622 of 1946) and of Good (3236 of 1946).

537.12/.13 **1400**

Fundamental Particles.—R. E. Peierls. (*Nature, Lond.*, 30th Nov. 1946, Vol. 158, No. 4022, pp. 773–775.) A descriptive account of current ideas concerning the nature and properties of the fundamental particles of physics, namely the electron, proton, photon, positron, neutron, neutrino, meson and negative proton.

537.12 **1401**

On the Self-Energy of the Electron.—G. Racah. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 406–409.) "Some evidence is given that the self-energy of an electron in the hole theory is finite, but coincides with mc^2 only if e^2/hc satisfies a particular equation."

537.122 **1402**

Determination of the Electronic Charge by the Oil-Drop Method.—V. D. Hopper. (*Nature, Lond.*, 30th Nov. 1946, Vol. 158, No. 4022, pp. 786–787.) Experiments are described which show that in the oil drop determination of e, the hole in the capacitor plates may distort the electric field appreciably and thus introduce an error. The magnitude of this error in previous measurements is discussed.

537.224 : 621.319.4.011.4 **1403**

Calculation of the Edge Correction for Capacitors.—G. Zickner. (*Arch. Elektrotech.*, Jan./Feb. 1944, Vol. 38, Nos. 1/2, pp. 1–16.) An extension of classical work to a large number of specific conductor systems.

537.291 **1404**

On the Back Action [reaction] **of the Electromagnetic Field on a Moving Electron.**—M. Markov. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 2, pp. 159–166.)

537.291 **1405**

The Motion of Positive Ions in the Electric Field n a Gas.—L. Sena. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 2, pp. 179–182.) A relation between the velocity of drift of ions and the ratio of field strength to gas pressure is established on the assumption that charge exchange of the ions is the predominant process in the interaction between ions and atoms.

537.525.5 + 621.396.822] : 621.385 **1406**

Noise and Oscillations in Hot Cathode Arcs.— . D. Cobine & C. J. Gallagher. (*J. Franklin Inst.*, Jan. 1947, Vol. 243, No. 1, pp. 41–54.) A summary was abstracted in 3266 of 1946.

537.525.6 **1407**

Energy Distribution of Electrons in High Frequency Gas Discharges.—T. Holstein. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 367–384.) An equation for the energy distribution is obtained and the limitations of its application are defined. Methods of solution and examples are given.

537.56 : 621.385 **1408**

Ionization Currents in Non-Uniform Electric Fields.—P. L. Morton. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 358–366.) A differential-difference equation for the electron current as a function of the electron energy and distance from the cathode end of a glow discharge is derived and the ionization currents are calculated by a step-by-step method.

538.24 **1409**

Magnets in Permeable Media and Definition of Magnetic Moment.—H. Diesselhorst. (*Elektrotech. Z.*, 6th April 1944, Vol. 65, Nos. 13/14, pp. 119–122.)

538.24 **1410**

Induced Magnetization and Magnetic Moments.—É. Brylinski. (*C. R. Acad. Sci., Paris*, 29th April 1946, Vol. 222, No. 18, pp. 1035–1037.) Consideration of the effects produced in a non-magnetic material, when a magnetic field is applied, shows that the moment of the couple exerted by a uniform field H on a plane closed current is the algebraic sum of the moment caused by the field H and of that due to the field $4\pi I$ which results from the reaction of the material, the magnetic moment remaining independent of the material. On the assumption that all magnetism is due to moving electric charges in vacuo, it is concluded that the volume integral definition of magnetic moment, which leads to a contradiction, should be abandoned.

538.3 : 517.9 **1411**

Applications of the Riesz Potential to the Theory of the Electromagnetic Field and the Meson Field.—N. E. Fremberg. (*Proc. roy. Soc. A*, 31st Dec. 1946, Vol. 188, No. 1012, pp. 18–31.) Riesz's method "yields simple deductions of classical results . . . [and] also the results recently obtained by Dirac regarding the proper energy and proper momentum of an electron." Bhabha's analogous theory of the neutral meson field is also treated.

538.32 **1412**

The Distribution of Currents induced by a Plane Wave on the Surface of a Conductor.—V. Fock. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 2, pp. 130–136.) If λ is small compared with the dimensions and radii of curvature of the conductor, the current distribution near the geometrical shadow can be expressed in terms of an universal function, which is tabulated.

538.566 **1413**

The Propagation of Electromagnetic Waves in Two or More Successive Media and the Diffraction of These Waves Referred to the Study of Cauchy's Problems.—L. Robin. (*Rev. sci., Paris*, Jan/May 1946, Vol. 84, Nos. 3252/3253, pp. 7–14.) A mathematical paper. Earlier work of Delsarte (*Ann. sci. Éc. norm. supér.*, 1936, Vol. 53, pp. 223–273) is confirmed and extended to the case of two homogeneous isotropic media, of given dielectric constant, permeability, and electrical conductivity, separated by a plane interface.

In general the dielectric constants and the permeabilities alone determine whether Maxwell's equations for this problem have a unique solution or no solution ; the conductivities are only involved in certain limiting cases.

539.234 + 621.793.14 **1414**

Phenomena of the Production of Thin Metallic Layers by Vaporization.—H. Stahl & S. Wagener. (*Z. tech. Phys.*, 1943, Vol. 24, Nos. 10/12, pp. 280–287.)

53 **1415**

Reports on Progress in Physics, Vol. X (1944-45). [Book Review]—W. B. Mann (Ed.). Physical Society, London, 442 pp., 30s. (*J. sci. Instrum.*, Dec. 1946, Vol. 23, No. 12, p. 302.) A list of subjects and authors is given.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523 : 621.396.822.029.6 **1416**

Disturbances of Extraterrestrial Origin in the Short Wave Band.—Steinberg & Denisse. (*See* 1575.)

523.5 : 621.396.812 **1417**

On the Detection of Meteors by Radio.—L. A. Manning, R. A. Helliwell, O. G. Villard, Jr., & W. E. Evans, Jr. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 767–768.) Observations were made during the meteor shower of 9th Oct. 1946, using a 15-Mc/s, 100-kW broadcasting transmitter and also a 29-Mc/s c.w. transmitter of 0.7 kW. Signal strength bursts and Döppler whistles were observed on both frequencies and the results indicate that both bursts and whistles may be regarded as evidence of the passage of meteors. The use of c.w. unmodulated transmissions of relatively low power, with frequency about 30 Mc/s, has definite advantages for meteor observation.

523.74 : 621.396.821 **1418**

Radio Effects observed during the Period of Solar Activity from 31st Jan. to 14th Feb. 1946.—Bureau. (*See* 1564.)

523.746 **1419**

On Movements and Origin of Sunspots.—J. Tuominen. (*Observatory*, Dec. 1946, Vol. 66, No. 835, pp. 387–391.)

523.746 : 551.510.535 : 621.396.11 **1420**

Effect of Sunspot Cycles on Long Distance Radio Signals.—H. T. Stetson. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 44–49.) A survey of sunspot activity and critical frequencies over the period 1934–1946. Absorption in the E layer is an important factor in the prediction of usable frequencies.

523.77 **1421**

Solar Ultraviolet Spectrum to 88 Kilometers [above the earth].—W. A. Baum, F. S. Johnson, J. J. Oberly, C. C. Rockwood, C. V. Strain & R. Tousey. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 781–782.) The spectrum below 3 400 Å was photographed by means of a grating spectrograph mounted in the tail fin of a V-2 rocket. The results show a progressive extension of the spectrum into the ultraviolet with increasing height. Detailed analysis of the results is in progress.

523.854 **1422**

The Magnetic Field of the Galaxy.—L. Spitzer, Jr. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 777–778.)

537.591 + 523.165 **1423**

An Investigation of the Absorption of Cosmic Rays in a Strong Magnetic Field at 3 250 m above Sea Level.—A. Alichanian, A. Alichanow, S. Nikitin & A. Weissenberg. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 3, pp. 294–295.) Continuation of work described in 73 of 1946 (Alichanow & Alichanian). Results indicate that a proportion of the soft component is not composed of electrons ; it is suggested that the particles observed may be protons.

537.591 **1424**

Cosmic-Ray Effects at High Altitudes.—C. D. Anderson. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, p. 788.) Summary of Amer. Phys. Soc. paper.

537.591 **1425**

Recent Cloud-Chamber Observations of the Soft Component of Cosmic Rays.—W. Hazen. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, p. 789.) Summary of Amer. Phys. Soc. paper.

537.591 **1426**

The Energy Spectrum of Cascade Electrons.—I. Tamm & S. Belenky. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 660–664.)

537.591 **1427**

The Multiple Production of Neutrons by Cosmic Radiation.—S. A. Korff & B. Hamermesh. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, p. 429.)

537.591 **1428**

The Mass of the Mesotron as determined by Cosmic-Ray Measurements.—D. J. Hughes. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, p. 791.) A review of published results leads to the conclusion "that the spread in mass values exceeds the experimental errors, and that it is extremely likely the mesotron does not possess a unique mass." But see 1429 below. Summary of Amer. Phys. Soc. paper.

537.591 **1429**

The Mass of Cosmic-Ray Mesotrons.—W. B. Fretter. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 625–632.) The range of mesotrons in lead as a function of their momentum was determined by a double cloud-chamber method. The results are consistent with a unique rest mass for mesotrons of 202 times that of an electron. But see 1428 above.

537.591 **1430**

Mass of Cosmic-Ray Mesotrons.—W. B. Fretter & R. B. Brode. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, p. 791.) Summary of Amer. Phys. Soc. paper.

537·591 **1431**

Measurement of Meson Masses by the Method of Elastic Collision. Probable Existence of a Heavy Meson (1000 m_0) in the Cosmic Radiation.—L. Leprince-Ringuet. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 791–792.) Summary of Amer. Phys. Soc. paper.

537·591 **1432**

Some Problems in the Study of Cosmic-Ray Mesons.—B. Rossi. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, p. 788.) Summary of Amer. Phys. Soc. paper.

537·591 **1433**

Origin of Cosmic-Ray Mesons.—M. Schein. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 788–789.) Summary of Amer. Phys. Soc. paper.

537·591 **1434**

On the Determination of the Energy Spectrum and Sign of Primary Cosmic Radiation.—M. S. Vallarta, M. L. Perusquía & J. De Oyarzabal. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 785–786.) Summary of Amer. Phys. Soc. paper.

537·591 **1435**

On the Space Correlation of Particles in Cosmic Rays: Part 2—Correlation between Electrons and Photons.—V. Berestetzky. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 3, pp. 211–216.)

537·591 **1436**

Ionizing Power of Particles of the Hard and Soft Components of the Cosmic Radiation.—N. Dobrotin. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 3, pp. 207–210.)

537·591 **1437**

Attempt of an Analysis of Some Cosmic-Ray Phenomena.—R. P. Feynman & H. A. Bethe. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 786–787.) Summary of Amer. Phys. Soc. paper.

37·591 : 523·7 **1438**

Three Unusual Cosmic-Ray Increases possibly ue to Charged Particles from the Sun.—S. E. Forbush. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 771–772.)

37·591.15 **1439**

Atmospheric Showers and Bursts.—D. Skobeltzyn. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 441–442.)

37·591.15 **1440**

Penetrating (Atmospheric) Showers in Cosmic ays.—V. Veksler, L. Groshev & L. Lazareva. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, p. 440–441.)

37·591.15 **1441**

Penetrating Cosmic Ray Showers at 3 860 m bove Sea Level.—L. Bell, N. Birger & V. Veksler. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 2, pp. 198–99.) Results of observations on the Pamir plateau.

7·591.15 : 539.16.08 **1442**

A Cloud-Chamber Investigation of Penetrating owers.—G. D. Rochester. (*Proc. roy. Soc. A*, 13th Dec. 1946, Vol. 187, No. 1011, pp. 464–479.) "Some 20% of penetrating showers are accompanied . . . by what appear to be electron cascades. . . . These showers may be due to electrons or photons produced in processes which become important at very high energies; e.g., $>10^{11}$eV."

537·591·5 **1443**

Composition of Cosmic Rays at a Height of 3 250 m above Sea Level.—A. I. Alikhanoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1945, Vol. 9, No. 3, pp. 135–144. In Russian.)

550.38 **1444**

On the Question of the Origin of Terrestrial Magnetism.—Y. P. Bulashevich. (*Bull. Acad. Sci. U.R.S.S., sér. géogr. géoph.*, 1944, Vol. 8, Nos. 2/3, pp. 93–95. In Russian.)

551.510.535 **1445**

Sporadic E-Region Ionization at Watheroo Magnetic Observatory 1938-1944.—H. W. Wells. (*Proc. Inst. Radio Engrs, W. & E.*, Dec. 1946, Vol. 34, No. 12, pp. 950–955.) Continuous recordings of the occurrence of the sporadic E_1 layer have been analysed to determine diurnal, seasonal, annual or other regular variations. It is inferred that there is no direct relationship with recurrent solar phenomena or with magnetic disturbances.

551.510.535 **1446**

The Mechanism of Ionospheric Ionization: Part 2.—R. v. d. R. Woolley. (*Proc. roy. Soc. A*, 13th Dec. 1946, Vol. 187, No. 1011, pp. 403–415.) "The available mechanisms for the production of electrons in the three regions of the ionosphere are discussed with special reference to the question whether it is possible to account for the observed electron densities without supposing that the sun emits far more energy in the remote ultra-violet spectrum than would be emitted by a black body at 6 000°. The contributions to electron densities made by metastable states of atoms and molecules are examined. It is concluded that the observed electron densities may be accounted for without requiring high solar energy in the ultra-violet if the effective recombination coefficient in the F_2 region is 10^{-11}. The F_2 region is supposed formed by the ionization of atomic oxygen, and the E region by the ionization of molecular oxygen. The electrons forming the F_1 region are supposed to be provided by metastable N_2 or by NO." For part 1 see 416 of February.

551.510.535 : 621.396.11 **1447**

The Role of the Ionosphere in the Propagation of Radio Waves.—R. Jouaust. (*Bull. Soc. franç. Élect.*, June/July 1946, Vol. 6, No. 60, pp. 348–354.) A survey of present knowledge. Regular daily observations on the ionosphere have been carried out at the National Radio Laboratory, Bagneux, since April 1946. The programme envisaged is the extension of the observations to all the hours of the day and night and the progressive provision of further recording stations in France overseas.

551.594 **1448**

A New Theory of Atmospheric Electricity.—D. S. Kothari & L. S. Lothari. (*Sci. Culture*, Dec. 1946, Vol. 12, No. 6, pp. 261–263.) A discussion of Frenkel's theory (2186 of 1946) showing that it offers a qualitative explanation of some puzzling phenomena. It may have wider application to dust storms and the electrification of powders injected into gases.

551.594 : 551.574 **1449**
Influence of Water Drops on the Ionization and Electrification of Air.—J. Frenkel. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 2, pp. 151–158.)

614.825 : 551.594.221 **1450**
The Image of Objects produced by Lightning and Impulse Discharge in Atmosphere.—G. Spiwak & J. Kardash. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 3, pp. 252–256.) Laboratory reproduction of the imprinting by lightning of images of nearby objects on struck bodies.

LOCATION AND AIDS TO NAVIGATION

621.396.677 **1451**
Various Papers on Directive Aerials.—See Aerials section for papers prepared for the I.E.E. Radiolocation Convention, 1946.

621.396.9 : 623.454.25 **1452**
Radio Proximity-Fuze Development.—Hinman & Brunetti. (*See* 1555.)

621.396.932 **1453**
Radar Specifications for the Merchant Navy.—(*Onde élect.*, Dec. 1946, Vol. 26, No. 237, pp. 481–487.) The specifications for navigational radar issued by the Service des Phares français and by the London conference on radar navigational aids, May and June 1946, are given, and also that of the London conference for anti-collision radar.

621.396.932.078 + 621.396.664 **1454**
Radio Controlled Buoys.—A. F. Hopkins, Jr., & F. A. B. Smith. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 84–86.) A simple v.h.f. remote control selective relay system, originally used for rapid black-out of unattended buoys. Its application is being extended to foghorns and similar navigational aids only required occasionally.

621.396.933 : 621.38.001.8 **1455**
Analyzing Present Position of Electronic Aids for Airplanes.—G. Shea. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 34–41 . . 138.) A discussion of the many " problems encountered in flight together with recommended electronic solutions which have been offered the PICAO delegates ". See also 112 of January and 428 of February.

621.396.96 **1456**
Identification, Friend or Foe — Radar's Sixth Sense.—L. E. Stuart. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 60–67.) Technical details of the U.S. Navy's auxiliary system of pulsed transmission and reception for the positive identification of aircraft.

621.396.96 **1457**
Low-Altitude Radar Bombsight.—J. W. Rieke. (*Bell Lab. Rec.*, Jan. 1947, Vol. 25, No. 1, pp. 13–16.) An account of the AN/APQ-5 equipment and its operation.

621.396.96 : 518.5 **1458**
The Ballistic Computer.—Juley. (*See* 1494.)

MATERIALS AND SUBSIDIARY TECHNIQUES

535.37 : 535.61-15 **1459**
Decay in Brightness of Infra-Red Sensitive Phosphors.—R. T. Ellickson & W. L. Parker. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 290–299.)

538.221.029.64 **1460**
Theory of the Dispersion of Magnetic Permeability in Ferromagnetic Materials at Microwave Frequencies.—C. Kittel. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 281–290.) An explanation of the experimental facts is proposed, based on a consideration of the equations of motion of a domain boundary in a applied magnetic field for frequencies such that the skin depth of the magnetic field is smaller than the thickness of the domain. A criticism is given of theories of ferromagnetic resonance.

546.287 **1461**
Silicone Oils — Part 2: Their Applications.—D. F. Wilcock. (*Gen. elect. Rev.*, Dec. 1946, Vol. 49, No. 12, pp. 28–33.) For part 1 see 750 of March.

546.46.78 : 548.2 **1462**
The Crystal Structure of Magnesium Tungstate.—N. J. Dunning & H. D. Megaw. (*Trans. Faraday Soc.*, Dec. 1946, Vol. 42, No. 292, pp. 705–709.)

549.514.51 : 548.24 **1463**
Artificial Electrical Twinning in Quartz Crystals.—J. J. Vormer. (*Tijdschr. ned. Radiogenoot.*, Nov. 1946, Vol. 11, No. 6, pp. 215–219. In Dutch with English summary.) Electrical twinning can easily be produced below 573°C at well-defined places in AT-, CT- and GT-cut quartz plates. Such twinning may occur at points where leads have been soldered to the metal coatings. In some cases this type of twinning can be corrected by suitable heat treatment, but attempts to correct natural electrically-twinned quartz met with little success.

620.193.21 : 669.721 **1464**
Magnesium : Corrosion Resistance under Accelerated Atmospheric Conditions.—R. R. Rogers, D. A. Tetu & H. Livingstone. (*Metal Ind., Lond.*, 3rd Jan. 1947, Vol. 70, No. 1, pp. 9–10.) Magnesium and its alloys offer good resistance to corrosion except in marine atmospheres, in which case protective coatings of paints are desirable.

621.3.032.53 : 533.5 **1465**
Glass-to-Metal Seals.—G. D. Redston & J. E. Stanworth. (*J. Soc. Glass Tech.*, April 1945, Vol. 29, No. 132, pp. 48–76.) Stress-optical bench photoelastic measurements on standard sandwich seals over a wide temperature range are discussed. Axial stresses for bead seals at room temperature were determined by the method of Hull and Burger.

621.3.032.53 : 533.5 **1466**
Glass-to-Metal Seals, with Particular Reference to Current Lead-In Seals in Vacuum Devices.—R. W. Douglas. (*J. Soc. Glass Tech.*, April 1945, Vol. 29, No. 132, pp. 92–110.) A procedure for avoiding extreme stresses in manufacture or operation is described.

621.3.032.53 : 533.5 **1467**
Sealing Glasses.—A. E. Dale & J. E. Stanworth. (*J. Soc. Glass Tech.*, April 1945, Vol. 29, No. 132,

pp. 77–91.) A general discussion of the physical properties and chemical compositions of common sealing glasses and their applications. A method of classification is suggested.

621.314.63 **1468**

Remarks on the Operation and Construction of Barrier Layer Rectifiers.—M. Leblanc. (*Bull. Soc. franç. Élect.*, Aug./Sept. 1946, Vol. 6, No. 61, pp. 444–452.) Discussion of various theories proposed to explain the differing properties of metals, semiconductors and insulators, with particular reference to conductivity. It is concluded that a dry rectifier consists of two crystalline lattices in which the concentration of the electrons is very different, separated by an insulating layer having a thickness of the order of a hundred atomic layers. Electrons crossing this layer obey the laws of wave mechanics. In metals, the free electrons do not obey the classical statistical laws because of their small mass; they form a degenerate gas to which the Sommerfeld-Fermi theory applies. In semiconductors the concentration of free electrons is so low that the electronic gas ceases to be degenerate and classical laws apply. Copper oxide, copper sulphide, and selenium rectifiers are discussed with special reference to the nature and mechanism of the dielectric separating layer.

621.314.63 **1469**

Applications of Dry Rectifiers.—J. M. Girard. (*Bull. Soc. franç. Élect.*, Oct. 1946, Vol. 6, No. 62, pp. 522–556.) The principles involved in rectifiers of the barrier-layer type are discussed and an account is given of the characteristics of selenium and copper-oxide rectifiers and of their commercial production. Many widely differing applications are described, ranging from apparatus giving many tens of thousands of amperes at low voltage to apparatus giving hundreds of thousands of volts at low currents of the order of tens of milliamperes.

621.315.22 : 669.715 **1470**

Cable Sheathing in Aluminium.—(*Light Metals*, Sept. 1946, Vol. 9, No. 104, pp. 474–498.) A critical survey of the possibility of replacing lead by aluminium, based on published German work. See also 1471 below.

621.315.22 : 669.715 **1471**

Insulated Cables and Wire in Aluminium.—(*Light Metals*, Dec. 1946, Vol. 9, No. 107, pp. 648–684.) A continuation of 1470 above. A survey of practice in various countries including France and Italy; the possibility of replacing copper by aluminium is considered with particular reference to the methods of cable joining.

621.315.61 : 537.228.1 **1472**

The Dielectric Properties of Ferroelectric (Seignette electric) Crystals and Barium Titanate.—V. Ginsburg. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 2, pp. 107–115.) A discussion based on thermodynamical consideration of a phase transition from a non-pyroelectric to a pyroelectric crystal.

621.315.61 : 546.4 **1473**

High Dielectric Constant Materials.—B. Wul [B. M. Vul]. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 2, pp. 95–106.) Another account in English of the experimental work noted in 3639 of 1946.

621.315.61 : 547 **1474**

Contribution to the Knowledge of Electrotechnical Organic Insulating Materials.—H. Stäger, B. Frischmuth & F. Held. (*Schweiz. Arch. angew. Wiss. Tech.*, Dec. 1946, Vol. 12, No. 12, pp. 372–390.) Research on the relation between the molecular structure of resinous substances, and the dielectric losses in layered insulating materials is described. The dielectric losses in such materials can be reduced by esterization of the cellulose hydroxyl substances used as binders; this also alters the mechanical properties of the materials. The losses in materials using glass as binder are dependent on the alkali content of the glass. With alkali-free glass the losses are considerably lower than with a cellulose-type binder and the mechanical properties are improved.

621.315.61 : 621.396.67.029.64 **1475**

Dielectric Housings for Centimetre-Wave Antennae.—Birks. (*See* 1343.)

621.315.611.011.5 + 537.226.3 **1476**

The Relation between the Power Factor and the Temperature Coefficient of the Dielectric Constant of Solid Dielectrics: Part 2.—M. Gevers. (*Philips Res. Rep.*, Aug. 1946, Vol. 1, No. 4, pp. 279–313.) A review of available data, given by various authors. The data differ so widely that a relation between the power factor and temperature coefficient cannot be deduced. For part 1 see 125 of January.

621.317.333.8 : 621.392.015.33 **1477**

Insulation for High-Voltage Pulse Networks.—C. D. Owens. (*Bell Lab. Rec.*, Jan. 1947, Vol. 25, No. 1, pp. 28–31.) Breakdown tests on various materials, with point-to-point and point-to-plate electrodes, show correlation between arc resistance properties and ability to withstand high pulse voltages. Mica and glass-bonded mica were found best for arc resistance.

621.357.6 **1478**

Electroforming: Parts 1–3.—E. A. Ollard. (*Metal Ind., Lond.*, 3rd, 17th & 31st Jan. 1947, Vol. 70, Nos. 1, 3 & 5, pp. 6–8, 51–53 & 86–88.) A survey of moulds and moulding materials, conducting surfaces, types of metal, solution formulae, etc., for piece part production by electrodeposition. To be continued.

621.775.7 **1479**

Metallurgy of Powders; Study of Compressed Kovar.—Nguyen Thienchi. (*C. R. Acad. Sci., Paris*, 29th April 1946, Vol. 222, No. 18, pp. 1046–1047.) Kovar ingots were prepared from carefully purified Co, Ni and Fe, with no Mn. Rings from these ingots welded perfectly to a glass having an expansion coefficient of 5×10^{-6}. X-ray photographs show that in the case of the ingot obtained by h.f. heating, the alloy is well formed, with the same crystalline structure as kovar of American origin. The structure of that obtained by heating to 1 050°C for 10 hours is less definite, the diffraction lines being appreciably more diffuse.

621.793 : 666 **1480**

Metallizing Glass and Ceramic Materials.—A. J. Monack. (*Glass Ind.*, Jan. 1947, Vol. 28, No. 1, pp. 21–25..44.) A detailed account of metallizing methods using (*a*) mechanical films, (*b*) metallic paints, (*c*) metal spraying, (*d*) cathode sputtering or evaporation in vacuo, (*e*) chemical reduction.

621.793.14 + 539.234 **1481**

Phenomena of the Production of Thin Metallic Layers by Vaporization.—Stahl & Wagener. (*See* 1414.)

669.018 : 621.775.7 **1482**

Fernico from Metal Powders.—E. E. Burger. (*Gen. elect. Rev.*, Dec. 1946, Vol. 49, No. 12, pp. 22–24.) Fernico, an alloy of Fe, Ni and Co, is produced from powdered materials by sintering. Its thermal expansion coefficient is almost the same as that of Corning glass 705AO, permitting seals to be made of almost any size or shape. Its electrical resistance is about 43 $\mu\Omega/\text{cm}^3$.

669-167 **1483**

The Structure and Appearance of Metal Surfaces.—J. H. Nelson. (*Metal Treatm.*, Winter 1946/1947, Vol. 13, No. 48, pp. 279–285.)

669.3 + 669.35 **1484**

Copper and Copper Alloys : a Survey of Technical Progress during 1946.—E. Voce. (*Metallurgia, Manchr*, Dec. 1946, Vol. 35, No. 206, pp. 78–84.) Discusses the production of copper, its up-grading by distillation, the casting and properties of various alloys, corrosion and oxidation and some aspects of physical metallurgy.

669.738 : 620.193.15 **1485**

Comparison of Electroplated Finishes under Humidity (K 110) Test.—(*Metallurgia, Manchr*, Dec. 1946, Vol. 35, No. 206, pp. 63–64.) Illustrations of results obtained by F. Taylor in work on cadmium plating described in 779 of March.

678.1.02 **1486**

Colloidal Carbon.—W. H. Cadman. (*J. R. Soc. Arts*, 27th Sept. 1946, Vol. 94, No. 4727, pp. 646–663.) A description of the methods of manufacture and the properties of carbon-black, with special reference to its use in the rubber industry.

679.5 **1487**

Polythene.—F. A. Freeth. (*Engineering, Lond.*, 25th Oct. 1946, Vol. 162, No. 4215, pp. 388–389.) Abridged English text of a lecture delivered at the 20th Congress of the Société de Chimie Industrielle.

679.5 **1488**

Contribution to the Knowledge of the Softening of Polyvinyl Chloride.—H. Stäger & F. Held. (*Schweiz. Arch. angew. Wiss. Tech.*, Sept. 1946, Vol. 12, No. 9, pp. 278–288.)

679.5 : 620.193.21 **1489**

The Behaviour of Thermosetting Plastics exposed to the Weather.—G. O. Grimm. (*Schweiz. Arch. angew. Wiss. Tech.*, Oct. 1946, Vol. 12, No. 10, pp. 311–322.) An account of tests, lasting over two years, on rods subjected to bending loads and on a wide range of mouldings exposed in the open. The materials were chiefly of the phenol and urea types, with various fillers. Short tests and weathering tests, with or without mechanical loading, do not give comparable results. Deterioration of materials exposed to the weather is greatly increased by simultaneous mechanical loading.

MATHEMATICS

51 : [5 + 6 **1490**

Advanced Instruction in Practical Mathematics.—A. Erdélyi & J. Todd. (*Nature, Lond.*, 16th Nov. 1946, Vol. 158, No. 4020, pp. 690–692.) A discussion of proposals for the foundation of an Institute for Practical Mathematics, with suggestions regarding staff and the functions of such an institution. These should include instruction in advanced mathematical techniques not usually included in university curricula, the provision of short courses for engineers and others and of post-graduate courses for mathematicians, the promotion of research and the preparation of monographs. See also leader in same issue, pp. 683–684, *Nature, Lond.*, 4th May 1946, Vol. 157, No. 3992, pp. 571–573, and *Nature, Lond.*, 21st Dec. 1946, Vol. 158, No. 4025, pp. 916–917.

512.831 : 621.392.1 **1491**

Matrix Methods in Transmission-Line and Impedance Calculations.—Watson. (*See* 1329.)

517.65 **1492**

The Finite Parts of Integrals and the Laplace-Carson Transformation.—J. Gilly. (*Rev. sci., Paris*, June/Dec. 1945, Vol. 83, Nos. 3245/3251, pp. 259–270.)

518.5 **1493**

Calculations and Electronics.—(*Electrician*, 8th Nov. 1946, Vol. 137, No. 3571, pp. 1279–1280.) A short account of the various features to be incorporated in the A.C.E. (automatic computing engine) designed by the National Physical Laboratory.

518.5 : 621.396.96 **1494**

The Ballistic Computer.—J. Juley. (*Bell Lab. Rec.*, Jan. 1947, Vol. 25, No. 1, pp. 5–9.) For A.A. fire control.

518.6 : 621.317.329 : 621.385 **1495**

Electrostatic Field Plotting.—Balachowsky. (*Bull. Soc. franç. Élect.*, April 1946, Vol. 6, No. 58, pp. 181–186.) Starting from one electrode, a second equipotential surface is plotted very close to the electrode. Laplace's equation is then used to calculate successive equipotentials until the neighbourhood of the second electrode is reached. The shape of this electrode can thus be found for any assigned value of its potential. Practical difficulties of the method are discussed. Similar graphical integration methods may be applied to problems involving the telegraphy equation.

519.28 : 52/59 **1496**

Choice of a 'Reality Index' for Suspected Cyclic Variations.—W. Gleissberg. (*Nature, Lond.*, 21st Dec. 1946, Vol. 158, No. 4025, pp. 915–916.) A discussion of the cyclic variations apparent in some natural phenomena which are not purely periodic in nature. A 'reality index' to indicate the degree of reality of such variations is defined and its use is demonstrated by an example taken from sunspot observations.

531.33/.39 : 621.396.611.1 **1497**

On the Stability Conditions of Oscillating Systems.—L. Couffignal. (*Rev. sci., Paris*, May 1945, Vol. 83, No. 3244, pp. 195–210.)

MEASUREMENTS AND TEST GEAR

620.199 : 621.315.614.6 **1498**

High-Speed Life Test for Capacitor Paper.—H. A. Sauer. (*Bell Lab. Rec.*, Jan. 1947, Vol. 25, No. 1, pp. 17–19.)

621.317.083.71 **1499**

Remote Indication of Measured Quantities using a Resistance Element and a Crossed-Coil Indicator.—J. Lorenz. (*Arch. tech. Messen*, Oct. & Nov. 1940, Nos. 112 & 113, pp. T109–110 & T121–122.)

621.317.323.027.21 **1500**

Measurement of H.F. Voltages of the Order of a Microvolt.—P. Mourmant. (*Radio en France*, 1947, No. 2, pp. 15–19.) Indirect methods are preferred. Practical difficulties and methods of standardization, and the stability of the heterodyne and measurement receivers are discussed.

621.317.33 : 621.385.3.032.2 **1501**

Inter-Electrode Capacitances of Triode Valves and Their Dependence on the Operating Condition.—S. C. Mitra & S. R. Khastgir. (*Indian J. Phys.*, June 1946, Vol. 20, No. 3, pp. 81–99.) Inter-electrode capacitances are measured by a double-beat method and their variation with filament and anode current for three different anode voltages with no grid bias are studied. Results for eight commercial valves are given and discussed.

621.317.336 : 621.396.67 **1502**

The Measured Impedance of Cylindrical Dipoles.—King. (*See* 1338.)

621.317.336.6 : 621.392.029.64 **1503**

Standing Wave Meter.—H. E. Kallmann. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 96–99.) A detailed description of an automatic standing wave detector of moderate accuracy designed for quick adjustments of microwave equipment. Power from a constant source is injected into a U-shaped waveguide. Power reflections caused by mismatch are measured automatically by a device which gives a direct meter indication of standing-wave ratio.

621.317.35 **1504**

The Cinematic Analyzer.—E. Aisberg. (*Radio Craft*, Dec. 1946, Vol. 18, No. 3, pp. 18–19..66.) This frequency analyser comprises a receiver and mixer, a wide band-pass amplifier tuned to 460 kc/s, a converter stage, an oscillator tuned to 877 kc/s and frequency-modulated over ± 50 kc/s by a vibrating reed wobbler, and a selective amplifier tuned to 417 kc/s. The output from the latter is applied to the vertical deflexion plates of a c.r.o., the 60 c/s sweep being synchronized with the supply to the wobbler. Applied frequencies between 410 and 510 kc/s thus appear as peaks on the screen, the height of the peaks indicating the signal amplitude. In addition to this direct application to i.f. stages, the apparatus can also be used for the study of receiver r.f. stages, selectivity curves and a.f. stages.

621.317.35 **1505**

Wave and Pulse Counter.—R. Blitzer. (*Radio Craft*, Dec. 1946, Vol. 18, No. 3, pp. 25, 49.) The incoming wave is amplified, clipped and reduced to sharp pulses, which are applied to the grid of a thyratron.

621.317.372.029.64 **1506**

Apparatus for Measurement of Centimetre Waves : Q-Meter and Wattmeter.—A. G. Clavier & R. Cabessa. (*Onde élect.*, Nov. 1946, Vol. 26, No. 236, pp. 421–429.) In the Q-meter a positive-grid valve, with anode voltage varied periodically (e.g., at 210 c/s), is used to create a variable electromagnetic field ; this in turn excites the resonant cavity, the Q of which is to be measured. A crystal detector is used to measure the field in the resonant cavity, the detector current being applied after amplification to the vertical plates of a c.r.o. ; the horizontal sweep is derived from the voltage used for modulation. The resonance curve thus obtained enables Q to be found. $Q = F_0/\Delta F$, where F_0 is the mean frequency, corresponding to the peak of the resonance curve, and ΔF is the width of the curve where the amplitude is half the maximum. A double-beat method can also be used. The apparatus described enables measurements of Q to be made from 2 000 to about 50 000 with an accuracy of the order of 10%. It has been used for measuring, at λ 8 cm, the attenuation constants of coaxial cables or of circular guides with E_{01} or H_{11} waves. The wattmeter comprises (*a*) a measurement line of characteristic impedance 90 Ω and of adjustable length, which is inserted between the u.h.f. source and the apparatus to be measured ; (*b*) a bolometer probe carried on a slider movable along the measurement line and (*c*) rack-mounted measurement equipment. The length of the line and the position of the bolometer are adjusted to obtain a system of stationary waves, the bolometer being at a current loop. Powers from 50 mW to 150 W can be measured with the apparatus on wavelengths between 8 and 14 cm with an accuracy of about ± 15%.

621.317.38 **1507**

Definitions and Measurement of Apparent Power and Energy.—A. Iliovici. (*Bull. Soc. franç. Élect.*, Dec. 1945, Vol. 5, No. 54, pp. 367–377.) Applicable to polyphase circuits.

621.317.7 **1508**

Manufacture of Electrical Measuring Instruments in India.—B. B. Bhowmik. (*Sci. Culture*, Dec. 1946, Vol. 12, No. 6, pp. 275–279.) A brief historical survey, with suggestions for future developments in the production of jewelled bearings, hair springs, pivots, magnets, etc.

621.317.7 : 621.385 **1509**

Portable Precision Valve Tester.—F. Haas. (*Toute la Radio*, Jan. 1947, Vol. 14, No. 112, pp. 59–61.) A description, with circuit diagrams and constructional details, of an instrument for measuring valve slope, cathode insulation, emission, and for testing filament continuity and insulation between electrodes.

621.317.7.082.78 **1510**

Electronic Magnetometer.—J. H. Rubenstein. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 156–164.) Compact, with sensitive pickup head. Suitable for remote indication of the change of position of a small permanent magnet attached to any moving object.

621.317.7.082.78.085.31 **1511**

Electronic Position Pickup.—D. W. Moore, Jr. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 100–101.)

An earth-inductor compass formed by mounting an armature on a piezoelectric crystal. A small permanent magnet is mounted on the pointer whose position is to be transmitted.

621.317.715 : 621.394.645.35 **1512**

Contact Modulated Amplifier.—Perkin-Elmer Corporation. (*Rev. sci. Instrum.*, Dec. 1946, Vol. 17, No. 12, p. 560.) Notice of manufacture of the amplifier described in 2629 of 1946 (Liston, Quinn, Sargeant & Scott). It is designed to replace sensitive suspension galvanometers; various applications are indicated.

621.317.715.085.39 **1513**

A Simple Galvanometer Amplifier with Negative Feedback.—D. G. Prinz : J. S. Preston. (*J. sci. Instrum.*, Dec. 1946, Vol. 23, No. 12, pp. 301–302.) Comment on 3670 of 1946, and Preston's reply.

621.317.725 **1514**

A Very High Impedance R.M.S. Voltmeter for Iron Testing.—D. C. Gall & F. C. Widdis. (*J. sci. Instrum.*, Dec. 1946, Vol. 23, No. 12, p. 287.) A valve amplifier, with high input impedance, which "has no voltage gain but a high power gain, giving in effect a very high impedance to the a.c. voltmeter which it operates. The ratio of input to output is linear."

621.317.727.025 **1515**

Alternating Current Potentiometer.—S. Holmqvist. (*Ericsson Rev.*, 1946, Vol. 23, No. 4, pp. 297–307.) The required a.c. quantities are transformed thermally into d.c. voltages, which are measured with d.c. potentiometers. Circuit diagrams are given for power, current and voltage measurement.

621.317.73 **1516**

A Visual Null Indicator for Impedance Bridge Measurements at Radiofrequencies.—P. J. Brine & J. W. Whitehead. (*Rev. sci. Instrum.*, Dec. 1946, Vol. 17, No. 12, pp. 537–539.) Greater accuracy in balance is obtained by applying the detector amplifier output to one pair of plates of a c.r. tube, and the modulated output of the r.f. oscillator to the other pair. A straight line trace indicates balance. Using this indicator with a General Radio Type 916A bridge, impedance measurements to an accuracy of 0.2 Ω can be made in the presence of interference levels more than 40 db above 1 μV.

621.317.79 : 621.397.62 **1517**

Television Synchronizing Signal Generating Units : Part 1.—R. R. Batcher. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 50–54..144.) Describes picture and synchronizing test equipment for studio, laboratory and receiver production lines.

621.317.794 **1518**

The Organic Thermistor Bolometer.—C. D. Niven. (*Canad. J. Res.*, Nov. 1946, Vol. 24, Sec. A, No. 6, pp. 93–102.) Tests of a bolometer using a cellophane film painted with aquadag show it to be much inferior to the inorganic thermistor developed at the Bell Telephone Laboratories, particularly as regards drift and speed of response.

621.396.611.4 : 538.569.4 **1519**

Theory of a Microwave Spectroscope.—W. E. Lamb, Jr. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 308–317.) A discussion of (*a*) the measurement of the exponential decay of the radiation in an untuned echo box between pulses of radio-frequency power, and (*b*) the steady-state response of a large untuned cavity.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

518.5 **1520**

Calculations and Electronics.—(*See* 1493.)

537.533.7 **1521**

Imperfections of Shape in Electron-Optical Instruments.—F. Bertein. (*C. R. Acad. Sci., Paris*, 13th Jan. 1947, Vol. 224, No. 2, pp. 106–107.)

539.16.08 **1522**

Design of a Proportional Counter for Gamma-Rays.—B. B. Benson. (*Rev. sci. Instrum.*, Dec. 1946, Vol. 17, No. 12, pp. 533–536.)

539.16.08 **1523**

A Universal Radiation Measurement Apparatus, Its Description, Operation and Possible Applications.—R. Reiter. (*Z. InstrumKde*, April/June 1944, Vol. 64, Nos. 4/6, pp. 105–121.) An instrument for use with counters, having a special capacitor arrangement and suitable not only for single impulse counting but for reading the relative values of large radiation quantities from galvanometer deflexions. Various applications include the recording of the intensity characteristics of X rays and of all kinds of corpuscular radiation.

550.837 : 621.39 **1524**

The Development of Electrical and Radio Methods of Geophysical Prospecting.—V. Fritsch. (*Radio Tech., Vienna*, June/July 1946, Vol. 22, Nos. 2/3, pp. 139–146.) A review of present-day d.c., a.f. and h.f. methods, with applications to ore, coal and oil prospecting, water detection, investigation of building sites, and lightning protection.

621.317.39 : 531.768 **1525**

Acceleration Measurement by Wireless Methods.—G. Loeser. (*Z. InstrumKde*, Jan./March 1944, Vol. 64, Nos. 1/3, pp. 30–46.)

621.317.7.082.78.085.31 **1526**

Electronic Position Pickup.—Moore. (*See* 1511.)

621.317.794 : 535.61-15 **1527**

A Fast Superconducting Bolometer.—D. H. Andrews, R. M. Milton & W. DeSorbo. (*J. opt. Soc. Amer.*, Sept. 1946, Vol 36, No. 9, pp. 518–524.) For detection of infra-red signals. A ribbon of CbN is used at an operating temperature of about 15° K which can be maintained with the aid of liquid hydrogen and nitrogen for several hours. The primary response time is about 5×10^{-4} sec at about 3 000 c/s while the noise level is 5×10^{-4} μW. The apparatus has a secondary response time of 5×10^{-2} sec at about 140 c/s.

621.318.572 **1528**

Modern Geiger-Muller Counters.—Graves. (*See* 1364.)

621.365 **1529**

Electronic Heating.—M. Doucerain. (*Bull. Soc. franç. Élect.*, Oct. 1946, Vol. 6, No. 62, pp. 498–509.) Describes applications to the heat treatment of wood, rubber and plastic materials. H.F. heating should not in all cases be substituted for other methods when these are more economical.

621.365.5.029.5 **1530**

High Frequency Induction Heating.—E. May. (*Machinery, Lond.*, 9th & 23rd Jan. 1947, Vol. 70, Nos. 1787 & 1789, pp. 45–49 & 109–110.) Abstract of a paper read before the Institution of Production Engineers.

621.38 : 6 **1531**

Industrial Electronics.—H. A. Thomas. (*Elect. Times*, 23rd Jan. 1947, Vol. 111, No. 2883, pp. 104–106.) Summary of I.E.E. paper and discussion.

621.38.001.8 **1532**

The Application of Electronics.—W. Wilson. (*Beama J.*, Dec. 1946, Vol. 53, No. 114, p. 440.) Discusses applications in both light and heavy engineering. Abstract of paper in *Machinery Lloyd*, 19th Oct. & 2nd Nov. 1946, Vol. 18, Nos. 21A & 22A, pp. 37–43 & 37–47.)

621.38.001.8 **1533**

Opinion Meter.—(*Electronics*, Jan. 1947, Vol. 20, No. 1, p. 198.) To integrate the votes of large groups. Each voter sets a hand device, connected to the meter, to the degree of positive or negative opinion he holds.

21.38.001 : 620.18 **1534**

The "Talysurf" Surface Meter.—(*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, p. 351.) A lescription of a stylus type of instrument manu-actured by Taylor, Taylor & Hobson for measuring he textures of surfaces. High magnifications of urface irregularities are produced electrically und displayed graphically.

21.383.001.8 **1535**

Electronic Spectroscopy.—G. C. Sziklai & A. C. Schroeder. (*J. appl. Phys.*, Oct. 1946, Vol. 17, No. 10, pp. 763–767.) Double differentiation of he signal from a photocell, to which a saw-tooth oltage is applied, enables the spectral distribution f the light incident on the cell to be observed on a .r.o. The method is directly applicable to colour atching.

21.383.001.8 : 614.715 **1536**

Photoelectric Dust Meter.—G. F. Barnett & L. Free. (*Electronics*, Dec. 1946, Vol. 19, No. 12, p. 116–119.) A photocell in an illuminated air uct continuously measures the quantity of light eflected by dust particles passing through the ystem. Applications include testing and rating he efficiency of air-cleaning devices.

21.384.6 + 537.291 **1537**

Resonance Acceleration of Charged Particles.— M. McMillan. (*Phys. Rev.*, 1st/15th Nov. 1946, ol. 70, Nos. 9/10, p. 800.) Discussion of phase ability leads to a simple solution of the problem keeping the particles in step with the accelerating eld for a very large number of cycles. Descriptions f the 300 MeV synchrotron and the 184-inch nchro-cyclotron now under construction at erkeley will be given later, with a discussion of ture possibilities, leading to the eventual attainent of the billion-volt range. Summary of Amer. hys. Soc. paper.

621.384.6 **1538**

Electron Radiation in High Energy Accelerators.—J. Schwinger. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 798–799.) A discussion of the limitation to the attainment of very high energy electrons, in devices such as the betatron and synchrotron, due to the radiative energy loss accompanying the circular motion of the electrons. Summary of Amer. Phys. Soc. paper.

621.384.6 **1539**

Development of Electron Accelerators.—(*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 170 . . 184.) A brief description of the principles of operation of linear accelerators, cyclotrons, synchrotrons and betatrons. Their limitations are explained. Medical applications are indicated.

621.384.6 **1540**

Preliminary Studies on the Purdue Microwave Electron Accelerator.—R. O. Haxby, E. S. Akeley, A. Ginzbarg, R. N. Smith, H. W. Welch & R. M. Whaley. (*Phys. Rev.*, 1st/15th Nov. 1946, Vol. 70, Nos. 9/10, pp. 797–798.) Summary of Amer. Phys. Soc. paper.

621.384.6 **1541**

The Betatron.—W. Bosley. (*J. sci. Instrum.*, Dec. 1946, Vol. 23, No. 12, pp. 277–283.) An historical account of its development and some details of particular instruments.

621.384.6 **1542**

The Theory of the Synchrotron.—D. Bohm & L. Foldy. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 249–258.)

621.384.6 **1543**

Magnetic Fields due to Dee Structures in a Synchrotron.—A. F. Clark. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, p. 444.) Method of measurement of the out-of-phase fields due to eddy currents in the metal dee. Summary of Amer. Phys. Soc. paper.

621.385.833 + 537.533.72 **1544**

Properties of Some Electrostatic Lenses.—H. Bruck & L. Romani. (*Cah. Phys., Paris*, Oct. 1944, No. 24, pp. 15–28. Reprint.) The cardinal elements and the spherical and chromatic aberrations of a series of independent electrostatic lenses are determined from their constructional parameters. The term 'independent lens' is used to distinguish such lenses from immersion lenses. Study of the effect of diaphragms or near objects leads to some new results. All the results are obtained from experimental values of the potential measured in an electrolytic bath with sloping base.

621.385.833 **1545**

Effect limiting the Possibilities of the Electron Microscope.—L. de Broglie. (*C. R. Acad. Sci., Paris*, 29th April 1946, Vol. 222, No. 18, pp. 1017–1019.) Movement of the object due to impacts from the irradiating source may result in reduced image sharpness, particularly when the source uses particles more massive than electrons. This effect is discussed.

621.385.833 **1546**

Supplementary Bibliography of Electron Microscopy.—M. E. Rathbun, M. J. Eastwood & O. M.

Arnold. (*J. appl. Phys.*, Oct. 1946, Vol. 17, No. 10, pp. 759–762.) References not included in the list of Marton & Sass (1008 of 1946).

621.386.1 **1547**

X-Ray Generators at 1 000 and 2 000 kV.—J. Saget. (*Bull. Soc. franç. Élect.*, Aug./Sept. 1946, Vol. 6, No. 61, pp. 476–479.)

621.386.1 : 620.179.1 **1548**

Applications of Recent X-Ray Inspection Equipment.—J. L. Bach. (*Machinery, Lond.*, 21st Nov. 1946, Vol. 69, No. 1780, pp. 663–665.)

621.386.84 **1549**

Radiography and Microradiography by Secondary Electrons.—A. Saulnier & J. J. Trillat. (*Rev. sci., Paris*, May 1945, Vol. 83, No. 3244, pp. 211–214.) Penetrating X rays from a tube operated at 150 kV or more are passed through a sheet of lead 0.2 mm thick and the secondary emission from the lead is used to obtain radiograms of thin objects, such as butterfly wings, onion skin, etc., interposed between the lead and a sheet of photographic paper.

621.39 : 578.088.7 **1550**

Electroencephalographic Technique from an Engineer's Point of View.—W. G. Egan. (*Proc. Inst. Radio Engrs, W. & E.*, Dec. 1946, Vol. 34, No. 12, pp. 1000–1004.) A general description of equipment and of a new type of electrode. Methods of improving calibration accuracy and recorder performance are suggested.

621.396.645 : 621.43.019.8 **1551**

Constant-Gain Knock Pickup Amplifier.—R. P. Krebs & T. Dallas. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 87–89.) "Cathode-follower input, special feedback circuit, and simplified phase inverter stage provide flat frequency response from 8 to 20 000 cycles with a gain of 160 000 for portrayal of knock patterns of internal combustion engines on a cathode-ray oscilloscope."

621.396.932.078 + 621.396.664 **1552**

Radio Controlled Buoys.—Hopkins & Smith. (*See* 1454.)

621.43 **1553**

Improved Electronic Engine Indicator.—A. H. B. Walker. (*Engineering, Lond.*, 18th Oct. 1946, Vol. 162, No. 4214, pp. 361–364.)

621.791.3 : 621.365.5 **1554**

High-Speed Assembly of Radiators by Induction Soldering.—(*Machinery, N.Y.*, Dec. 1946, Vol. 53, No. 4, pp. 166–167.)

623.454.25 : 621.396.9 **1555**

Radio Proximity-Fuze Development.—W. S. Hinman, Jr., & C. Brunetti. (*Proc. Inst. Radio Engrs, W. & E.*, Dec. 1946, Vol. 34, No. 12, pp. 976–986.) A description of fuses for smooth-bore projectiles. The oscillating detector, amplifier, power supply unit and safety arrangements are described in some detail, together with methods of production and testing.

PROPAGATION OF WAVES

538.566 **1556**

The Propagation of Electromagnetic Waves in Two or More Successive Media and the Diffraction of These Waves Referred to the Study of Cauchy's Problems.—Robin. (*See* 1413.)

621.396.11 : 523.746 : 551.510.535 **1557**

Effect of Sunspot Cycles on Long Distance Radio Signals.—Stetson. (*See* 1420.)

621.396.11 : 551.510.535 **1558**

The Role of the Ionosphere in the Propagation of Radio Waves.—Jouaust. (*See* 1447.)

621.396.41.029.64 **1559**

Calculation of Multiplex U.H.F. Radio-Telephony Links [100–5 000 Mc/s].—H. Chireix. (*Bull. Soc. franç. Élect.*, Aug./Sept. 1946, Vol. 6, No. 61, pp. 415–424.) In three parts. The first part discusses the effect of various types of aerial on received power for given power radiated, and the effect of aerial and receiver height using the height-gain formulae of Eckersley (1660 of 1937) and of van der Pol & Bremmer (3245 of 1937, 35 and 3102 of 1938). The second part is a discussion of the noise factor of various systems, single and multiplex, with various types of modulation, with and without relays. The ranges considered are of the order of 50 km; i.e., up to approximately optical range. In the third part long-distance communication is discussed for a range of 200 km, and the possibility of using various reflector systems as 'passive relays' is considered.

621.396.8.029.62 **1560**

The World above 50 Mc/s.—E. P. Tilton. (*QST*, Jan. 1947, Vol. 31, No. 1, pp. 50–54..116.) Reports of amateur transmissions on frequencies of 50 Mc/s and above with a special reference to the first transatlantic communication on 50 Mc/s using F_2-layer reflection.

621.396.812.029.56 **1561**

Short Skip on Five Metres.—O. J. Russell. (*Short Wave Mag.*, Jan. 1947, Vol. 4, No. 11, pp. 670–675.) Analysis of 5 m propagation data suggests the presence of a short but persistent skip effect of 60 miles, possibly accounted for by a very low ionized layer at a height of 5–10 miles.

621.396.812 + 538.569.4]029.64 : 551.57 **1562**

Water Vapor Absorption of Electromagnetic Radiation in the Centimeter Wave-Length Range.—G. E. Becker & S. H. Autler. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 300–307.) An experimental investigation of absorption in water vapour in the region of the longest wavelength rotational absorption line, which has been shown to be centred at about 1.34 cm wavelength. The basis of the method is the determination of the Q of an 8-ft cubical copper cavity, maintained at 45°C, the air pressure being one atmosphere, and the partial pressure of water vapour being varied between 1 and 55 mm Hg. The absorption line is broadened as the water vapour density is increased. The wavelength range 0.7 cm to 1.7 cm was explored. The atmospheric attenuation of 1.34 cm waves is given as 0.025 db per km for 1 gm water vapour per cubic metre. A summary was given in 3719 of 1946.

621.396.812.029.74 **1563**

Research in England on the Propagation of Ultra-Short Waves.—Bras. (*Bull. Soc. franç. Élect.*, Aug./Sept. 1946, Vol. 6, No. 61, pp. 480–495.) A review of the work already abstracted in 512 and 514–518 of February.

621.396.821 : 523.74 **1564**

Radio Effects observed during the Period of Solar Activity from 31st Jan. to 14th Feb. 1946.—R. Bureau. (*C. R. Acad. Sci., Paris*, 11th March 1946, Vol. 222, No. 11, pp. 597–599.) Atmospherics were recorded on various wavelengths from 24 000 m to 150 m and field strengths of the Geneva station on 48.66 m as a method of observing chromospheric activity. Sudden fade-outs of the decametre wave signal frequently coincided with sudden increases in intensities of atmospherics on 11 000 m; 24 000 m waves were less susceptible to disturbance. Disturbances of long duration on the decametre wavelengths indicate that solar activity is not limited to chromospheric eruptions.

RECEPTION

621.315.6 : 621.396.822] + 530.162 **1565**

The Response of Biased, Saturated Linear and Quadratic Rectifiers to Random Noise.—D. Middleton. (*J. appl. Phys.*, Oct. 1946, Vol. 17, No. 10, pp. 778–801.) Rectification of broad-band and semi-broad-band noise gives roughly the same spectral distribution as that of the input, but narrow-band noise causes an infinite number of separate noise bands, centred about harmonics of the central frequency. Clipping of any sort always spreads the spectrum and reduces the output power. The behaviour of linear and quadratic rectifiers is qualitatively similar in most cases. The powers in the d.c. and continuous portions of the output spectrum are independent of the spectral shape of the incoming noise.

21.396.619.11/.13 **1566**

Frequency and Amplitude Modulation.—R. schenbrenner. (*Radio en France*, 1947, No. 2, p. 8-14.) A theoretical discussion of a method f comparison, with experimental verification. With no signal, background noise is worse in the m. receiver. When signals are being received, it actically disappears in the f.m. receiver, but mains unchanged in the a.m. receiver. Reception music was much better with the f.m. receiver. de-band effects are also discussed.

1.396.62 **1567**

The Radio L.L. Synchrovox 645A Receiver.—*Radio en France*, 1947, No. 2, pp. 23–25.) Comete technical description with performance aracteristics.

1.396.62 **1568**

Converting the BC-348-Q.—P. M. Kersten. *ST*, Jan. 1947, Vol. 31, No. 1, pp. 19–21..104.) odifications necessary to make a surplus receiver itable for amateur use.

1.396.621.54 **1569**

Method of Plotting Tracking Error.—E. B. enzies. (*Electronics*, Jan. 1947, Vol. 20, No. 1, 128–130.) A beat frequency method.

1.396.722(4)" 1939/45 " **1570**

Radio Technique in Europe during the War : t 2.—H. Baumgartner. (*Radio Tech., Vienna*, June/July 1946, Vol. 22, Nos. 2/3, pp. 104–109.) An account of the general features of various German, Swedish and Austrian broadcasting receivers, including small mains sets and portables, and a fuller description, with circuit diagram, of an Austrian super-midget mains set.

621.396.812 : 523.5 **1571**

On the Detection of Meteors by Radio.—Manning, Helliwell, Villard & Evans. (*See* 1417.)

621.396.822 : 621.383 **1572**

Calculated Frequency Spectrum of the Shot Noise from a Photo-Multiplier Tube.—Sard. (*See* 1628.)

621.396.822 : 621.396.621.53 **1573**

Noise-Figure Reduction in Mixer Stages.—M. J. O. Strutt. (*Proc. Inst. Radio Engrs, W. & E.*, Dec. 1946, Vol. 34, No. 12, pp. 942–950.) An analysis is given of random noise in mixer stages and its effect on proper circuit design and feedback. Conditions for optimum gain in a diode mixer stage are shown to be identical with those for minimum noise. Noise figures for triode and multi-grid mixer stages are related to those of a comparable triode amplifier.

621.396.822 : [621.396.694 + 621.396.615.142 **1574**

Shot Effect and the Receiving Sensitivity of Transit-Time Valves of Different Types.—F. Lüdi. (*Helv. phys. Acta*, 21st Sept. 1946, Vol. 19, No. 5, pp. 355–374.) The fundamental Schottky equation is extended and applied to calculations of the receiving sensitivity, neglecting the noise of the input resistance and assuming half the received power to be available at that resistance. The calculations show that for all transit-time types of valve the equivalent input resistance, (i.e., the valve noise) is much greater than the resistance noise. The results for the different types are summarized and compared with one another and with triode sensitivity. From this it appears that only heterodyne reception is capable of giving a satisfactory sensitivity for microwaves.

621.396.822.029.6 : 523 **1575**

Disturbances of Extraterrestrial Origin in the Short Wave Band.—J. L. Steinberg & J. Denisse. (*Rev. sci., Paris*, 15th Sept. 1946, Vol. 84, No. 3257, pp. 293–294.) Historical survey of galactic and solar noise, from Jansky's observations in 1932 to the recent work of Reber, Southworth, Appleton and Hey. Recent theoretical work on noise in valves and aerials and from interstellar matter is briefly discussed.

621.396.828.1 : 621.394.141 **1576**

Shorting Gate Noise Suppressor [for morse reception].—(*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, p. 55.) With no signal, incoming and set noise, after amplification, limiting and rectification, are used to control a tone generator. The excess voltage due to the signal operates a gating circuit which cuts out the tone completely. The result is silence during the signal and a note of constant amplitude during spacing, which can be used for operating printers or automatic equipment. For another account see *Electronics*, Jan. 1947, Vol. 20, No. 1, p. 150.

STATIONS AND COMMUNICATION SYSTEMS

534.861 **1577**

The Acoustic Problems of Broadcasting.—Braillard. (*See* 1307.)

621.395.44.029.62/.64 **1578**

A Microwave Relay System.—L. E. Thompson. (*Proc. Inst. Radio Engrs, W. & E.*, Dec. 1946, Vol. 34, No. 12, pp. 936–942.) The system is based on double frequency modulation in which the carrier is frequency modulated by a sub-carrier, which is frequency or phase modulated by the intelligence. The signal/noise ratio and distortion in such a system are discussed and compared with those of a single frequency modulation system. An experimental two-way radio link is described in which double frequency modulation is used with carrier and sub-carrier frequencies of about 3 000 Mc/s and 1 Mc/s respectively. The link consists of three sections, each about 30 miles long, and two frequency channels are used for the complete two-way circuit. At each relay station the transmitters in both directions are on the same channel frequency, the two receivers operating on the other channel frequency.

621.395.623.8 **1579**

United Nations Broadcasting and Sound System.—(*See* 1315.)

621.396.1 **1580**

Planning the Amateur Bands.—(*Short Wave Mag.*, Jan, 1947, Vol. 4, No. 11, pp. 680–681.) A suggested division of each amateur band into c.w. and telephone zones.

621.396.1 **1581**

The Moscow Conference on Telecommunications.—Loyen. (*Onde élect.*, Dec. 1946, Vol. 26, No. 237, pp. 479–480.) A short review of the objects and recommendations of the conference from 28th Sept. to 21st Oct. 1946. See also 871 of March.

621.396.41.029.64 **1582**

Calculation of Multiplex U.H.F. Radio-Telephony Links [100–5 000 Mc/s].—Chireix. (*See* 1559.)

621.396.619 **1583**

Modern Modulation Systems.—P. Güttinger. (*Bull. schweiz. elektrotech. Ver.*, 15th June 1946, Vol. 37, No. 12, pp. 326–332. Reprint. In German with French summary.) Systems requiring a wide frequency band, such as f.m. or pulse-time modulation, are discussed and various combined systems are tabulated.

621.396.619.11/.13 **1584**

Frequency and Amplitude Modulation.—Aschenbrenner. (*See* 1566.)

621.396.619.16 **1585**

Pulse Technique.—R. Lemas. (*Télévis. franç.*, Jan. 1946, No. 9, pp. 14–17.) A general description of various methods.

621.396.65 **1586**

Considerations on Multiplex Links by Hertzian Cables [i.e., radio links].—J. Maillard. (*Onde élect.*, Nov. 1946, Vol. 26, No. 236, pp. 418–420.) A general discussion, from the economic point of view, of the relative merits of modulation and pulse systems for multiplex operation of radio links. It is concluded that pulse systems present definite advantages, since the economy of a multiplex radio link is determined much less by the performance of the link itself (i.e., signal/noise ratio, frequency band used) than by the cost of the accessory equipment.

621.396.65.029.64 **1587**

The Principal Factors affecting Radio-Multiplex Telecommunication Systems on Ultra-Short Waves.—V. A. Altovsky. (*Onde élect.*, Nov. 1946, Vol. 26, No. 236, pp. 401–417.) A detailed discussion of the problems involved in the design and setting up of multiplex radio-telephony links on wavelengths from 30 cm to about 1 cm, including (*a*) the requirements of the service and criteria of quality, (*b*) choice of modulation, (*c*) choice of frequency and (*d*) number of relay stations. Design details are given for a 200-channel telephony link to connect Paris and Lyons (about 300 miles), using a 6 cm wave and a 20 Mc/s f.m. band. Some particulars are also given of actual installations in the U.S.A. and France and of the No. 10 equipment used during the war in Europe by the British army.

621.396.712 **1588**

Status of Broadcasting Overseas.—A. Huth. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 56–58 . . 146.) Discusses the effect of the war on the transmitter and receiver situation in countries outside the U.S.A.

621.396.931 **1589**

Railroads plan Greater Use of Radio for Communications.—J. Peterson. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 78–83 . . 153.) Discusses existing equipment and future developments.

621.396.931.029.62 **1590**

Tests confirm Efficiency of 72 Mc/s for Mobile Radio.—G. H. Underhill. (*Elect. World, N.Y.*, 1st Feb. 1947, Vol. 127, No. 5, pp. 48–51.) Field tests in a typical eastern mountainous area indicate that the performance of a 72-Mc/s system is much better than would be expected from line-of-sight considerations. The Central Hudson Gas and Electricity Corporation is now installing a 75.66-Mc/s system.

621.396.932 : 621.396.5 **1591**

Multi-Channel Radiotelephone for Inland Waterways.—G. G. Bradley. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 74–77 . . 149.) The special problems of ship-to-shore radio telephone communication on the Great Lakes are discussed, and equipment recently designed for this service is described.

SUBSIDIARY APPARATUS

620.197.122 **1592**

Pressure Sealing Zip Fastener.—(*J. sci. Instrum.*, Oct. 1945, Vol. 22, No. 10, p. 198.) The fastener is waterproof and prevents the escape of air or gases by means of overlapping rubber lips attached to each side of the line to be sealed.

621.314.6 + 621.319.4 + 621.383] : 669.018 **1593**

Light Alloys in Metal Rectifiers, Photocells, and

Condensers.—Continuing the series in *Light Metals* mentioned in 1226 of April and back references.

(xvii) Jan. 1946, Vol. 9, No. 96, pp. 9–21.
Discusses the manufacture of fixed-paper capacitors, with particular reference to the properties, handling, and processing of the aluminium foils employed.

(xviii) March 1946, Vol. 9, No. 98, pp. 144–151.
The manufacture of fixed paper capacitors is further considered, with special reference to the manipulation of the foil and the impregnation of the paper. See also pp. 163–166 of the same issue.

(xix) April 1946, Vol. 9, No. 99, 215–220.
Discusses the final stages in the production of fixed capacitors.

(xx) May 1946, Vol. 9, No. 100, pp. 231–235.
Discusses the materials employed in the sealing and potting of fixed paper capacitors.

(xxi) June 1946, Vol. 9, No. 101, pp. 318–325.
Practical considerations of the final production stages of capacitor manufacture.

621.314.63 **1594**
Applications of Dry Rectifiers.—Girard. (*See* 1469.)

621.316.722.078.3 **1595**
Improvement of Various Arrangements for Voltage Stabilization.—J. Benoit. (*C. R. Acad. Sci., Paris*, 13th Dec. 1943, Vol. 217, No. 24, pp. 597–599.) A bridge arrangement of resistors and accumulator batteries, with a neon stabilizing tube in one of the arms, is described. This gives much smaller voltage variations than the usual stabilovolt arrangements. Similar improvement is possible for any voltage stabilizer whose internal impedance is not egligible.

21.316.722.078.3 : 537.525.3 **1596**
Characteristics of the Pre-Corona Discharge and ts Use as a Reference Potential in Voltage Stabilizers.—S. C. Brown. (*Rev. sci. Instrum.*, Dec. 1946, Vol. 17, No. 12, pp. 543–549.) Studied particularly in terms of current and voltage characteristics. he use of a diode to give a constant reference otential depends on the high sensitivity of current o changes in voltage. Factors to be considered in esign are discussed. A summary was noted in 758 of 1946.

21.522.4 **1597**
Tests on a Metal Self-Fractionating Oil Diffusion ump.—H. Wachter & J. W. A. van der Scheer. *. tech. Phys.*, 1943, Vol. 24, Nos. 10/12, pp. 287–91.) An account of tests on an American pump, F 250, made by Distillation Products, Rochester, Y. The pump is of relatively small dimensions, s a speed of about 250 litres/sec and with a rotary cking pump will reach a pressure of 6×10^{-7} tor.

TELEVISION AND PHOTOTELEGRAPHY

1.397.262 **1598**
Television System with Mixed Amplitude and equency Modulation, for the Transmission on a ngle Carrier Wave of the Video, Synchronizing and dio Signals.—M. Chauvierre. (*Radio en France*, 45, No. 4, pp. 38–44.) Successive modulation in plitude and in frequency of the carrier wave es two independent channels for video and chronism signals. Line synchronism corresponds to a frequency variation in one sense with respect to the carrier and image synchronism to a frequency variation in the opposite sense, so that a phase inversion followed by a limiter gives absolute separation of the two synchronizing signals. Application of a.f. modulation gives a complete television system on a single carrier wave; such a system has been realized in practice with a transmitter of several watts.

621.397.262 **1599**
Television System with Single Carrier Wave and Frequency and Amplitude Modulation.—F. Vaglio. (*Radio en France*, 1945, No. 4, pp. 46–47.) Proposes a television system with simultaneous amplitude and frequency modulation of a single carrier wave.

621.397.3.012.3 **1600**
Vertical and Horizontal Definition in Television Systems.— J. A. Widemann. (*Télévis. franç.*, Dec. 1945, No. 8, pp. 2–4.) An abac is given from which the two definitions can be found for any system of television, given the number of lines and of images and the cut-off frequency.

621.397.331 **1601**
Considerations on the Bedford Velocity-Modulation Television System.—P. J. Freulon. (*Télévis. franç.*, Dec. 1945, No. 8, p. 11.) For original paper of Bedford & Puckle, see 1934 Abstracts, p. 506.

621.397.5 **1602**
Two Systems of Color Television.—D. G. Fink. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 72–77.) A general discussion on the relative merits of the sequential and simultaneous systems. Both provide good fidelity of colour transmission, without flicker, if bandwidth, frame frequency, etc., are suitably chosen. As simultaneous colour transmission can be reproduced in black-and-white by existing receivers, the transition to colour television will be easier on this system. For examples of each system see 2051 and 2363 of 1946 and 1240 of April.

621.397.5 : 537.291 **1603**
Theory of the Electric Deflexion of Electron Beams.—J. Picht & J. Himpan. (*Elektrotech. Z.*, 17th May 1944, Vol. 65, Nos. 19/20, pp. 196–197.) Summary of a paper abstracted in 3091 of 1941.

621.397.5 : 621.391.63 **1604**
TV [television] on Modulated Light-Beam.—(*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 96..98.) Describes the transmission of video signals over short distances by means of a light-beam carrier system employing a cathode-ray tube as the modulated light source and a multiplier-type photocell receiver.

621.397.5 : 621.396.67 **1605**
Line-of-Sight Aerials [antennes de vision].—Tabard. (*See* 1339.)

621.397.61 **1606**
Television Transmission Centre, Paris.—H. Delaby. (*Télévis. franç.*, March 1946, No. 11, pp. 4–8.) A general account of the present Eiffel Tower equipment, with proposed extensions to relay stations.

621.396.615.17 : 621.316.729 : 621.397.5 **1607**

A Simplified Generator for Synchronizing Signals.—(*Radio en France*, 1947, No. 2, pp. 39–42.) Circuit and constructional details of simple and comparatively inexpensive equipment.

621.397.62 **1608**

The Main Types of Faults in a Television Receiver.—R. Aschen. (*Télévis. franç.*, Jan. & Feb. 1946, Nos. 9 & 10, pp. 4–5..21 & 6.)

621.397.62 **1609**

Large Television Screens and Their Evolution.—Hemadinquer. (*Télévis. franç.*, March 1946, No. 11, pp. 17–18..27.) Outlines the development of large-surface multi-cell screens.

621.397.62 **1610**

Television for Today : Part 7—Video Detector Circuits.—M. S. Kiver. (*Radio Craft*, Dec. 1946, Vol. 18, No. 3, pp. 29..61.) Discusses full-wave detection circuits, the use of peaking-coil filters and polarity.

621.397.62 **1611**

Pye [television] **Receiver Type B16T.**—(*Radio en France*, 1947, No. 2, pp. 43–48.) A general description, with circuit details.

621.397.62 **1612**

Carrier-Difference Reception of Television Sound.—R. B. Dome. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 102–105.) Use of a common i.f. amplifier for video and sound signals eliminates the effects of local oscillator hum and frequency drift. The overall i.f. bandwidth is greater than the carrier difference frequency, and by the use of absorption trap circuits, the sound i.f. level is kept below the minimum level expected from the picture carrier. The two signals are then separated. A receiver incorporating this system is reliable in performance, and costs are reduced.

621.397.62 : 621.317.79 **1613**

Television Synchronizing Signal Generating Units : Part 1.—Batcher. (*See* 1517.)

TRANSMISSION

621.316.726.078.3 : 621.396.619.13 **1614**

Carrier Stabilization in Frequency-Modulated Transmitters.—G. Guanella. (*Brown Boveri Mitt.*, Aug. 1946, Vol. 33, No. 8, pp. 193–197.) Several automatic control methods are briefly described, with block diagrams. (*a*) An a.c. voltage of lower frequency is derived by heterodyning with a stable reference frequency and is used for control through a frequency discriminator. (*b*) Modulation of a stable two-phase voltage by a fraction of the carrier voltage gives a rotating field which is used for retuning. (*c*) Modulation of a two-phase voltage, with differentiating and heterodyning, gives a control voltage proportional to frequency error. (*d*) The carrier frequency is compared directly with a suitable harmonic of a reference oscillator.

621.394.61 **1615**

New 10-kW Transmitter for Telegraphy.—E. Guyer & M. Favre. (*Brown Boveri Mitt.*, Aug. 1946, Vol. 33, No. 8, pp. 175–178.) The frequency range is 5.5–21 Mc/s with stability to one part in 10^5. The transmitter is designed for 3-phase 230/380 V 50-cycle supply and is capable of 450 w.p.m. A modulator attachment permits use for telephony.

621.396.61 : 621.394/.395].61 **1616**

Modern 1-kW Transmitter.—E. Meili. (*Brown Boveri Mitt.*, Aug. 1946, Vol. 33, No. 8, pp. 172–174.) A description, with illustrations, of a short-wave transmitter for λ 12.8–90 m and adaptable for either telephony or telegraphy. A Franklin oscillator with quartz control gives frequency stability of $\pm 2 \times 10^{-6}$.

621.396.61 : 621.396.619.13 **1617**

Engineering a 250 Watt BC Transmitter for F.M.—L. C. Killian & F. Hilton. (*Tele-Tech*, Jan. 1947, Vol. 6, No. 1, pp. 68–70.) Using the cascade phase-shift system.

621.396.61.029.54/.58 **1618**

The R.A.F. T.1154 Transmitter.—(*Short Wave Mag.*, Oct. 1946, Vol. 4, No. 8, pp. 499–501.) A brief description of a 100-W telegraphy/telephony aircraft transmitter with three frequency ranges: 200–500 kc/s, 3.0–5.5 Mc/s and 5.5–10 Mc/s.

621.396.61.029.58 **1619**

A 7/14-Mc/s Transmitter.—(*Short Wave Mag.*, Oct. 1946, Vol. 4, No. 8, pp. 481–483.) General description and performance of a 70-W amateur transmitter. See also *Short Wave Mag.*, July 1946, Vol. 4, No. 5, pp. 312–313.

621.396.61.029.58 **1620**

Five-Band 25-Watt Transmitter.—B. Randell. (*Short Wave Mag.*, Jan. 1947, Vol. 4, No. 11, pp. 664–669.) A combination of crystal oscillator and power amplifier which can be used either as a low-power transmitter or as an efficient exciter for a high-power r.f. amplifier. Data are included for operation on wavebands from 1.7 Mc/s to 28 Mc/s.

621.396.61.029.63 **1621**

Decimetre-Wave Transmitter giving 50-W Aerial Power.—R. Schweizer. (*Brown Boveri Mitt.*, Aug. 1946, Vol. 33, No. 8, p. 222.) A general description, with photographs but no operational details, of a transmitter with stabilized anode and heater voltages, suitable for field-strength measurements.

621.396.61.029.64 **1622**

Projectors of Centimetre Waves.—H. Gutton. (*Onde élect.*, Dec. 1946, Vol. 26, No. 237, pp. 459–466.) Calculation of the radiation from projectors is based on Huyghens' principle. Three types of projector are discussed: electromagnetic horns reflectors and dielectric aerials as used by the Germans during the war.

621.396.615.14 **1623**

Ring Oscillators for U.H.F. Transmission.—T. Gootée. (*Radio News*, Jan. 1947, Vol. 37, No. 1, pp. 48–50..122.) An even number of 4 or more triodes of the same type are arranged in a ring and tuned by resonant lines to obtain greatly increased power output, 16 triodes giving about 8 times that of a pair in push-pull.

621.396.619.13 : 621.396.712 **1624**

New F.M. Broadcast Transmitters.—(*Bell Lab. Rec.*, Jan. 1947, Vol. 25, No. 1, pp. 20–23.) Three transmitters are illustrated and briefly described, rated at 1, 3 and 10 kW respectively. The last two consist of the 1-kW unit, together with power amplifiers. A frequency synchronization system is employed to control the carrier frequency.

621.396.619.23 **1625**

Overmodulation without Sideband Splatter.—O. G. Villard, Jr. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 90–95.) Full circuit details of a balanced modulator for incorporation in an a.m. phone transmitter, to produce modulation in excess of 100% without causing adjacent channel interference.

VALVES AND THERMIONICS

537.291 + 538.691 **1626**

The Paths of Ions and Electrons in Non-Uniform Crossed Electric and Magnetic Fields.—N. D. Coggeshall. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 270–280.) The force equations for a charged particle moving in such fields can be integrated by a very simple procedure under certain conditions. These conditions are satisfied when motion takes place in a median plane symmetrically situated relative to magnetic pole faces and electrostatic electrodes. Numerical integration can be used when the analytical difficulties are too great, or when the fields are only known empirically. A summary was noted in 3882 of 1945.

537.291 : 621.396.615.142 **1627**

Theory of Small Signal Bunching in a Parallel Electron Beam of Rectangular Cross Section.—E. Feenberg & D. Feldman. (*J. appl. Phys.*, Dec. 1946, Vol. 17, No. 12, pp. 1025–1037.) The non-uniform distribution of charge in the bunched beam gives rise to a field which opposes the bunching process so that a kinematic solution may be validly applied only for a limited length of the drift space. An accurate solution of the bunching process requires the integration of the dynamical and field equations which, for ‘ small signal ’ conditions, reduce to a linear homogeneous system. Solutions are obtained which are classified as non-solenoidal or solenoidal according as the motion produces or does not produce a high frequency charge density within the beam. The physical problem is solved by taking a suitable linear combination of both solutions, a large part of the solution for practical conditions being of the solenoidal type.

621.383 : 621.396.822 **1628**

Calculated Frequency Spectrum of the Shot Noise rom a Photo-Multiplier Tube.—R. D. Sard. (*J. ppl. Phys.*, Oct. 1946, Vol. 17, No. 10, pp. 768–777.) general expression for the power spectrum of the hot noise produced by a secondary-emission ultiplier tube is applied to the RCA 931 family. t is deduced that the noise intensity should be onstant from zero up to about 100 Mc/s, begin to all off appreciably between 100 and 1 000 Mc/s nd become very weak at higher frequencies.

21.385 **1629**

Beam Production in Radial Beam Tubes, Beam ower Tubes, and Other Low Voltage Electronic evices.—A. M. Skellett. (*Rev. mod. Phys.*, July 946, Vol. 18, No. 3, pp. 379–383.) In the magnetic ocus radial beam valve, the beam is focused entirely y an external magnetic field of between 50 and 50 gauss and in the power tube by the action of e grid wires. Other tubes operating at 300 V less include the ‘ magic eye ’ tuning indicator nd the orthicon pickup tube in television systems.

621.385 : 621.371.329 : 518.6 **1630**

Electrostatic Field Plotting.—Balachowsky. (*See* 1495.)

621.385 : 621.317.7 **1631**

Portable Precision Valve Tester.—Haas. (*See* 1509.)

621.385.1.032.1.011.2 **1632**

Impedance of Gasfilled Tubes traversed by a High-Frequency Discharge.—P. Mesnage. (*C. R. Acad. Sci., Paris*, 10th July 1944, Vol. 219, No. 2, pp. 55–56.) Measurements were made with the tubes placed axially in inductance coils tuned to the frequency in use. Two types of discharge were found. In one the resistance is sensibly independent of the exciting field ; in the other the resistance is a decreasing function of the field. The imaginary part of the impedance may have either sign and is equivalent to a capacitance for gases and to an inductance, decreasing with increasing field, for metallic vapours.

621.385.18.029.64 **1633**

Physical Processes in the Recovery of TR Tubes.—H. Margenau, F. L. McMillan, Jr., I. H. Dearnley, C. S. Pearsall & C. C. Montgomery. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 349–357.) Techniques are described for the measurement of the time of elimination of ions on termination of the discharge in TR tubes. The capture of electrons by gas molecules is found to be the principal factor in recovery.

621.385.3 **1634**

Development of a Water-Cooled Transmitting Triode of 50-kW Anode Dissipation.—F. Jenny. (*Brown Boveri Mitt.*, Aug. 1946, Vol. 33, No. 8, pp. 211–214.) The cathode consists of 12 tungsten wires, arranged for single-, three- or six-phase a.c. heating. The anode is of special electrolytic copper. Details of evacuation, test procedure and results are described.

621.385.3.029.63 **1635**

A Medium-Power Triode for 600 Megacycles.—S. Frankel, J. J. Glauber & J. P. Wallenstein. (*Proc. Inst. Radio Engrs, W. & E.*, Dec. 1946, Vol. 34, No. 12, pp. 986–991.) An account of an air-cooled triode for delivering 25 kW peak pulse power at 600 Mc/s and of a water-cooled version for generating continuous waves giving up to 500 kW at the same frequency.

621.385.3.032.2 : 621.317.33 **1636**

Inter-Electrode Capacitances of Triode Valves and Their Dependence on the Operating Condition.—Mitra & Khastgir. (*See* 1501.)

621.385.38 **1637**

The New Thyratron, Sub-Miniature Type RK61 “ Raytheon ” and Its Applications.—(*Radio en France*, 1947, No. 2, p. 7.) Characteristics of a tube about 8 mm in diameter and 40 mm long.

621.385.38 : 537.525.6 **1638**

Initiation of Discharge in Arcs of the Thyratron Type.—C. J. Mullin. (*Phys. Rev.*, 1st/15th Sept. 1946, Vol. 70, Nos. 5/6, pp. 401–405.) From an equation derived for the anode current as a function of time during the initiation of the discharge, estimates of ionization time can be made which are of the correct order of magnitude.

621.385.4.029.6 **1639**

Resnatron may aid Radio.—(*Sci. News Lett., Wash.*, 1st Feb. 1947, Vol. 51, No. 5, p. 67.) The resnatron, used largely during the war for jamming on frequencies between 350 and 600 Mc/s, will give 140 kW at 450 Mc/s. Its special features are briefly described. See also 1732 and 3822 of 1946.

621.385.832 **1640**

A Cathode-Ray Tube for viewing Continuous Patterns.—J. B. Johnson. (*J. appl. Phys.*, Nov. 1946, Vol. 17, No. 11, pp. 891–900.) "A cathode-ray tube is described in which the screen of persistent phosphor is laid on a cylindrical portion of the glass. A stationary magnetic field bends the electron beam on to the screen, while rotation of the tube produces the time axis. When the beam is deflected and modulated, a continuous pattern may be viewed on the screen."

621.396.615.141.2 + 621.385.16 **1641**

Energy Build-Up in Magnetrons.—L. P. Hunter. (*J. appl. Phys.*, Oct. 1946, Vol. 17, No. 10, pp. 833–843.) An analysis neglecting the mechanism of conversion of the d.c. input into the r.f. output power. The magnetron is represented by its equivalent circuit. The law of build-up is derived from energy considerations and the dependence of starting time on load calculated. "The starting time is affected slightly by the initial noise level and becomes infinite below a minimum *Q*. For high *Q* values the starting time can be varied only by changing the energy stored in the line." A summary was noted in 291 of January.

621.396.615.141.2 **1642**

Self-Regulating Field Excitation for Magnetrons.—H. C. Early & H. W. Welch. (*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 184..188.) Stable magnetron operation is obtained by causing the anode current to excite the magnetic field.

621.396.615.141.2 **1643**

Background Noise and Audio Frequency Oscillations in Magnetrons.—É. Selzer. (*C. R. Acad. Sci., Paris*, 3rd April 1944, Vol. 218, No. 14, pp. 589–591.) Background noise is reduced considerably by accurate adjustment of parallelism of the field and the anode axis, but is not completely eliminated. Numerous bands of a.f. oscillations have been observed. Displacement of the operating point along the characteristic produces a continuous change of the frequency of these bands, which is increased by increase of the applied magnetic field. These results are discussed.

621.396.615.141.2 **1644**

Construction of Magnetrons of Great Symmetry and with Anodes Not Split. Study of Their Static Properties.—É. Selzer. (*C. R. Acad. Sci., Paris*, 20th March 1944, Vol. 218, No. 12, pp. 499–501.) Anodes of large diameter, about 9 cm, are turned from solid copper and sealed to two glass domes carrying the cathode system. Results of experiments with such magnetrons are discussed.

621.396.615.142 **1645**

From Transit-Time Effect to Transit-Time Valves: Parts 1 & 2.—L. Ratheiser. (*Radio Tech., Vienna*, Aug./Sept. & Oct. 1946, Vol. 22, Nos. 4/5 & 6, pp. 189–196 & 283–292.) Simple explanations are given of transit-time effects and the interaction between electrons and a.c. fields. The development of modern u.h.f. valves is traced from Barkhausen-Kurz retarding-field types to velocity-modulation valves. To be continued.

621.396.615.142 : 537.291 **1646**

[Electron] **Bunching in Velocity-Modulation Valves.**—J. Voge. (*C. R. Acad. Sci., Paris*, 1st July 1946, Vol. 223, No. 1, pp. 25–27.) A general treatment, taking into account electronic fields and showing one case where these fields do not modify the law of bunching obtained by neglecting them.

621.396.615.142.2 **1647**

Theory of Single-Circuit Clystrons.—S. Gvosdover & V. Lopukhin. (*J. Phys., U.S.S.R.*, 1946, Vol. 10, No. 3, pp. 275–284.) The mathematical solution of the interaction of an electron beam and the field of a cavity resonator is given. The amplitude and frequency of the resulting oscillations are determined in terms of the size and shape of the cavity and of the applied potentials. The small effects of the space charge are taken into account. The theory is applied to the single-resonator klystron or monotron.

621.396.615.142.2 **1648**

Mechanical Klystron for Demonstration.—(*Electronics*, Jan. 1947, Vol. 20, No. 1, pp. 138, 142.) A rocking motion imparted to a water jib causes bunching of the water droplets similar to electron bunching in the klystron.

621.396.694.011.3/.4 **1649**

Study of Electronic Reactance-Variation Devices.—Mazel. (*See* 1391.)

621.396.822 : [621.396.694+621.396.615.142 **1650**

Shot Effect and the Receiving Sensitivity of Transit-Time Valves of Different Types.—Lüdi. (*See* 1574.)

MISCELLANEOUS

001.891 (94) **1651**

Scientific Research in Australia.—(*Engineering, Lond.*, 3rd–24th Jan. 1947, Vol. 163, Nos. 4225–4228, pp. 5–6, 42–43, 53–54 & 89–90.) The nineteenth annual report of the Council for Scientific and Industrial Research covering a wide range of engineering and allied subjects, including for the first time the work of the Radiophysics Division.

001.98 **1652**

The False Preconceived Notion.—W. Burridge. (*Brit. med. J.*, 5th Oct. 1946, No. 4474, p. 516.) A letter suggesting that in the assessment of conflicting but apparently equally valid hypotheses, the element to reject is that on which all are in agreement, since this is likely to be the false preconceived notion which has engendered the contradictory conclusions.

016 : 05 **1653**

World List of Scientific Periodicals.—(*Nature, Lond.*, 30th Nov. 1946, Vol. 158, No. 4022, p. 785.) The third edition, to include all scientific and technical periodicals that appeared during 1900–1947, is in preparation.

061.6 **1654**

The British National Physical Laboratory.—H. Buckley. (*Sci. Mon., N.Y.*, Jan 1947, Vol. 64, No. 1, pp. 50–52.) A general account of the organization and functions of the Laboratory. The importance of the association with industry is stressed.