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Editorial

The Velocity of Acoustical and Electromagnetic Waves

IN a recently published textbook on "Electromagnetic Theory"* we read, "The second postulate of Einstein is more remarkable: *The velocity of propagation of an electromagnetic disturbance in free space is a universal constant c which is independent of the motion of its source.* This proposition is evidently quite contrary to our experience with mechanical or acoustical waves in a material medium, where the measured velocity is known to depend on the relative motion of source and observer."

Let us examine this statement of our experience with acoustical waves. It is well known that as a high-speed train approaches an observer at a station, the pitch of the note of the whistle is raised above its normal stationary value, whereas when the train is receding from the station the pitch falls below its normal value. This is not due, however, to any change in the velocity of propagation. If the observer on the station platform made measurements of the velocity of the arriving wave he would find exactly the same result, whether the train was approaching or receding. The change of pitch is due entirely to the compression or extension of the wavelength with the consequent raising or lowering of the frequency. *Here, then, we have relative motion of source and observer but no effect on the measured velocity.* The same applies to other mechanical waves. If, instead of making his measurements on the station platform, our observer makes them in another train, he will then find changes of the measured velocity, but changes depending only on his own velocity and quite independent of the velocity of the source. If he is travelling ahead of the source and at the same speed the pitch will now be the normal, for although the wavelength of the sound has been compressed by the motion of the source, he will observe a reduced velocity of propagation and consequently $f = v/\lambda$ remains unchanged. If the source and observer be on trains moving in opposite directions, the change of pitch will be doubled because, when approaching, the moving whistle is compressing the wavelength, and the observer measures an increased velocity of wave propagation, so that in the formula $f = v/\lambda$ the numerator is increased and the denominator decreased. On receding the reverse is the case. It should be noted, however, that the two contributions to the increase or decrease of pitch are entirely distinct, one being due to the change of radiated wavelength resulting from the motion of the source relative to the medium, whereas the other is due to an observed change of wave velocity resulting from the motion of the observer relative to the medium. If the observer and source be both at rest, relative to the station, but a

* By J. A. Stratton. 1941. P. 75.

powerful wind be blowing along the line, the pitch will again be normal, but measurement will show that the velocity of wave propagation is not normal but is increased or decreased depending on the direction of the wind. *Here, then, we have variation of the measured velocity but no relative motion of source and observer.*

Slightly modifying the author's words we can therefore say that *his* proposition is evidently quite contrary to our experience with mechanical or acoustical waves in a material medium, where the measured velocity is known to be *independent* of the motion of the *source*.

The source determines the wavelength of the radiated wave but, having handed it over to the medium, it has no control of the velocity with which it is propagated through the medium. The velocity measured by an observer is dependent, however, on his motion relative to the medium.

Having thus clarified our ideas on mechanical wave propagation we shall have some difficulty in seeing anything very remarkable in the author's statement of Einstein's second postulate, viz. that the velocity of propagation of an electromagnetic disturbance in free space is independent of the motion of its source. Through his misunderstanding of acoustical wave propagation he has apparently failed to grasp the true import of Einstein's second postulate. We have seen that the observed velocity of an acoustical wave depends on the motion of the observer relative to the medium. If now we attempt to apply this to an electromagnetic wave in free space we find ourselves immediately in the difficulty of having no observable medium against which to measure the motion of the observer. If we postulate a medium we are presumably equally at liberty to postulate a motion for it, and surely the simplest assumption to make is for each observer to assume that the postulated medium is at rest so far as he is concerned. Having postulated the possession of an aura, a man is surely at liberty to assume that he carries it about with him. "Every man his own ether," says Einstein, in effect, and Nature agrees by giving everyone the same answer when they measure the velocity of propagation of electromagnetic waves in free space, notwithstanding their own relative motions.

G. W. O. H.

A.C. Impedance of Chokes and Transformers*

A Measuring Instrument for Production Checks

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(Murphy Radio, Ltd.)

Introduction

THE well-known difficulties experienced in the measurement of the incremental inductance of iron-cored elements are basically due to two reasons:†

1. A.C. and D.C. may be simultaneously in the winding of the test object, but it is essential that these should be separately controlled and measured.

2. The presence of an iron-core renders the inductance of the winding non-linear. It is therefore usual to specify that the applied volts shall be sinusoidal; this results in a current containing odd harmonics only, in the case of pure A.C. excitation, while in general, it will contain both odd and even harmonics when D.C. polarisation obtains as well.

Routine Measurements

Established Practice.—Testing conditions are laid down according to the size and function of the component. The following table (being the generalised test specification of a well-known firm) illustrates how com-

* MS. accepted by the Editor, March, 1941.

† Ref. *Wireless Engineer*, 1367, Vol. 12. Dr. Sims: "Incremental Permeability and Inductance."

ponents may be subdivided into two groups.

The values under columns (c) and (e) are, of course, dependent on the actual type of component in each group.

a	b	c	d	e	f
Range No.	Component	L Inductance in henrys	A.C. Volts	D.C. mA.	Frequency
1	e.g. Intervalve and Pick-up transformers.	30—160	1	None	50 c/s.
2	e.g. Smoothing Chokes, Output Transformers, etc.	1—50	25	5–200	50 c/s.

Accuracy: While admissible errors are not yet specified, it should be remembered that a production tolerance of, say, plus or minus 5 per cent. in L would be considered quite close; these wide limits are due not so much to inherent production difficulties as to the unsatisfactory apparatus for routine measurements. Now, no difficulty arises from (f) and (e) if the mains supply and a good D.C. milliameter are used; similarly (d), the A.C. excitation volts are not too critical; a considerable fluctuation, say, 10 per cent., would have very little effect on L. To find the underlying reason it is necessary to refer to the methods available for measurement.

From the point of view of accuracy, the A.C. potentiometer is the ideal instrument for the measurement of incremental inductance followed by Hay's Bridge as a second best, and ballistic D.C. methods where interest is focused on the iron. But complexity of operation and the technical skill required rule out the first two methods for any but laboratory purposes, while the third is hardly suitable here.

Applications of the volt-ammeter and the comparison method are generally popular in shops and measure the magnitude of impedance rather than inductance. However, the V.-A. method is most unsatisfactory owing to the quadrature effects of shunting by the D.C. source and shunting by the A.C. voltmeter or the series effect of the ammeter. Calibration is by means of a standard resistance box and calculation; but even where great care is taken, errors up to 50 per cent. may arise from these effects.

In the comparison method (Fig. 1), the test component of impedance Z_x is connected in series with a standard variable resistance R, the A.C. source, the D.C. source and resistance S for setting the D.C. In operation, the valve voltmeter is alternately connected across Z_x and R respectively; the latter is adjusted until the valve voltmeter reads the specified voltage in both positions. The method is somewhat slow and cumbersome as the adjustment of the D.C. and R, on the one hand, and the A.C., and S, on the other, completely interlock. Powerful D.C. sources, rated up to 500V, 200 mA and above, are necessitated. Accuracy is not high as the criterion is the equality of two consecutive voltage readings.

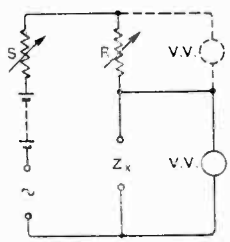

Fig. 1.

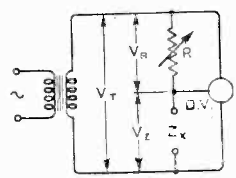

Fig. 2.

With regard to the waveform, it appears that a properly designed radio component is fairly linear under normal test conditions, the iron circuit being gapped where D.C. is carried, so only a moderate amount of harmonic, mainly odd, is to be expected; with a square law valve voltmeter, the wave form error should therefore be negligible. The wave form applied to Z_x will, however, not be sinusoidal even in these circumstances owing to the large A.C. drop in S and R.

Principles of New Design

The instrument to be described was designed to overcome these objections to the largest possible extent and is based on a comparison by the valve voltmeter method. To illustrate its principle, the basic circuit for the 1 volt A.C., and zero D.C. range is shown in Fig. 2.

Z_X and R are connected in series and supplied from a low impedance A.C. source, i.e. the secondary of a mains transformer worked at a maximum B of 12,000 lines/cm.[2] A differential valve voltmeter is connected across R and Z_X and measures the difference between V_R and V_Z, the voltage across R and Z_X respectively. Now obviously $\sqrt{V^2_R+V^2_Z} = V_T$, the volts applied by the source and $V_R = V_Z$ at balance. Thus V_Z would $= \frac{V_T}{\sqrt{2}}$ if Z_X were purely reactive, and a supply of $\sqrt{2}$ volts would ensure a correct ripple supply of 1 volt when the differential valve voltmeter read zero. Now, the worst type of iron-cored choke is not likely to have an in-phase component exceeding ½ the magnitude of the quadrature component, i.e., a power factor of 0.45. In practice, the value of V_T is 1.4V, and under the most unfavourable conditions—i.e., with a power factor of 0.45 — V_Z will be about 20 per cent. low. But as normally a much better power

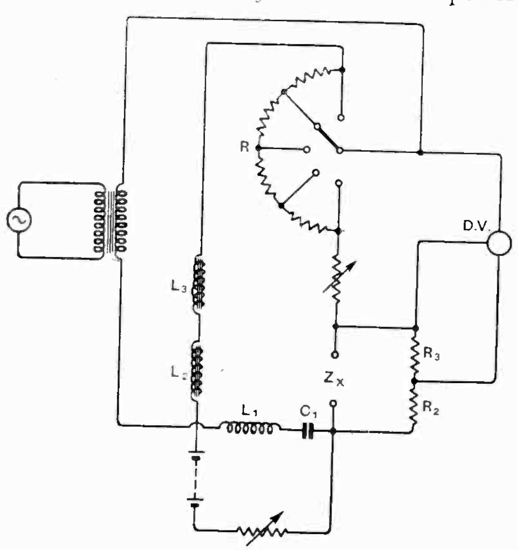

Fig. 3.

factor will obtain V_Z may be considered sufficiently close to 1 volt for all practical purposes. Again, since Z_X may be expected to be fairly linear (no D.C.), the wave form of V_Z will be quite satisfactory.

Fig. 3 illustrates the basic features of the arrangement for range 2 (25V A.C.; D.C. polarisation). The A.C. and D.C. supplies are in parallel; mutual shunting is minimised respectively by the iron-cored chokes L_2, L_3 and the blocking condenser C_1. The air-cored coil L_1 tunes C_1 to 50 c/s so as to minimise the effect on the regulation of the A.C. supply. The arrangement R_2, R_3 forms a high resistance potential divider, chosen so that $\frac{R_3}{R_2+R_3} = \frac{1}{25}$. The voltages compared by differential valve voltmeter are thus V_R and $\frac{V_Z}{25}$.

At balance, $V_R = \frac{V_Z}{25}$, i.e. $R = \frac{Z_X}{25}$ or $Z_X = 25R$.

With $V_T = \sqrt{V^2_Z + V^2_R} = 25$, at balance, $V_Z = 25$V, $V_R = 1$V very nearly. Applying a 1/25th part of V_Z only to the differential valve voltmeter has the following three advantages.

1. The differential valve voltmeter remains the same for ranges 1 and 2.

2. The dimensions of the D.C. source may be kept far more moderate than would otherwise be the case.

3. Only an insignificant voltage drop occurring across R_1, the waveform of V_Z will be good even with an appreciable amount of distortion present in Z_X. V_R will admittedly not be sinusoidal then, but the effect of this is minimised by the square-law rectification characteristic of the differential valve voltmeter.

It should be noted that R takes the form of fixed resistors selected by a switch and a rheostat. The method of feeding in the D.C. is such as to make the amount of interlock between the adjustment of D.C. and R negligible.

A Practical Instrument

Fig. 4 is a circuit diagram of the complete instrument, including power supplies for the differential valve voltmeter, D.C. polarisation and A.C. ripple voltages.

S_1 is a wafer-type switch for selecting the range, separate fixed and variable resistors being provided on each range. The voltages across the component under test—which is connected to terminals XX—and the comparison resistor are applied to the grids of the low slope triodes V_1, V_3. The D.C. return path of these grids is via the 5 and 0.2

megohm leaks. It will be seen that these shunt the comparison resistor and the test coil. However, the error thus reduced is negligible on range 2, rising to 2 per cent. at the extreme high end of range 1.

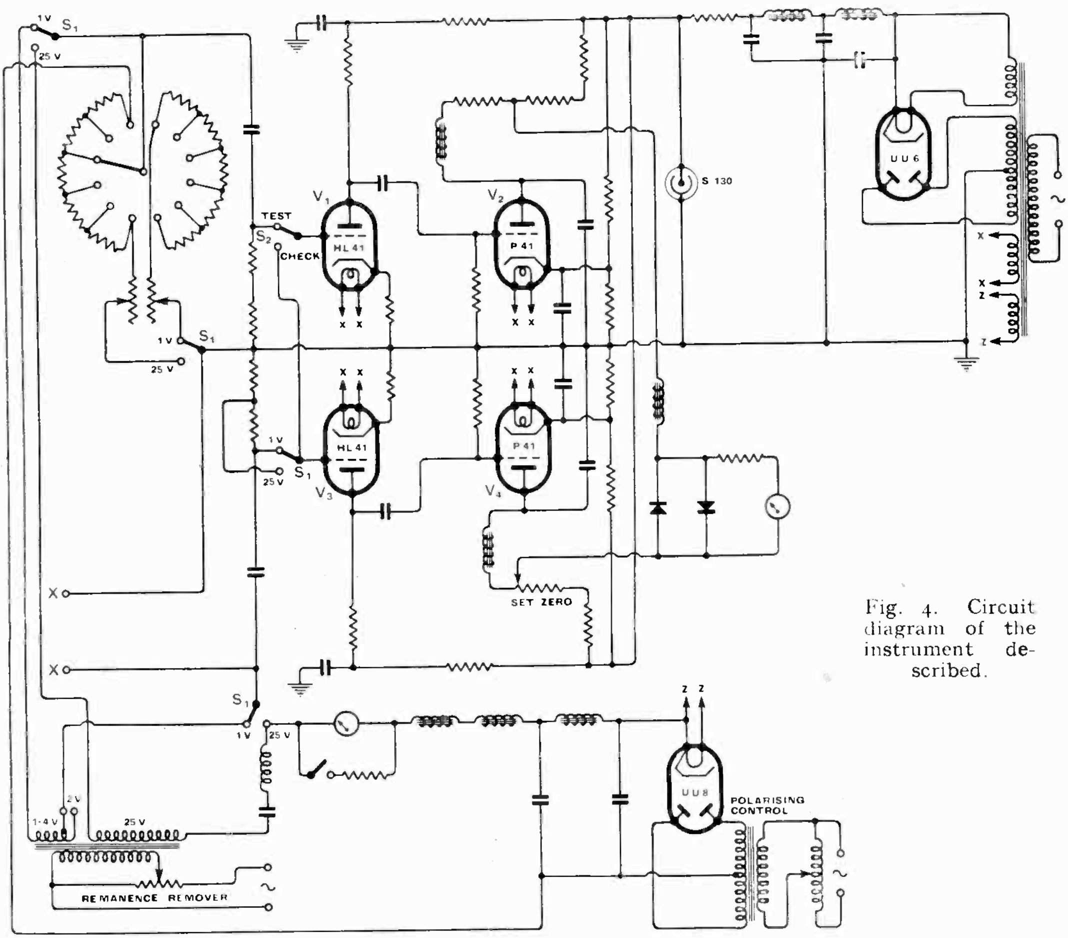

Fig. 4. Circuit diagram of the instrument described.

The differential valve voltmeter itself consists of two symmetrical halves, i.e. a pair of linear amplifiers R.C. coupled to a pair of anode-bend rectifiers, terminating in a bridge circuit.

In designing the differential valve voltmeter it was stipulated that an error of 1 per cent. in the test object should be easily discerned on the meter which takes the place of a bridge detector; actually, an error of 0.1 per cent., corresponding to a voltage difference of 1mV at the input to differential valve voltmeter, could still be detected. This result was achieved by applying about 3V A.C. to the grids of V_2 and V_4. The latter are biased to a point on their $I_A - V_a$ characteristic such that voltage peaks considerably in excess of the peak value of a 3V r.m.s. sine wave will still lie on the curved portion of the characteristic. The meter is protected against overload by a two-way rectifier which does not affect the sensitivity at or near balance. The sensitivity at mid-scale equals 10μA for 1 per cent. difference. However, this device makes imperative the use of good A.C. filtering in the anodes and a large A.C. impedance in the meter arm, as shown; the reason is that owing to phase, high sensitivity and the position of the point of operation on the bend of the characteristic, conditions for A.C. and D.C. balance differ, the second being the required state. For similar reasons, the stabilised H.T. supply of 130V must be very generously smoothed, leads carrying A.C. must be kept short and screened and corresponding components on each side of the differential valve voltmeter must be made equal within about 1 per cent. The tolerance for the ratio of 25 of the potentiometer at the grid of V_3 should not exceed 0.1 per cent. for satisfactory working. Valves V_2 and V_4 should also be selected for closely equal emissions.

An important feature of the differential valve voltmeter is the " test-check " switch S_2: it serves to set the meter zero in conjunction with the 500 ohms " set zero " potentiometer.

While it is convenient to adjust the comparison resistors and calibrate the comparison rheostat on a Wheatstone bridge (multiplying results by 25 for range 2), the detector-meter is calibrated in per cent. by connecting a standard rheostat at the test terminals. The auxiliary 2V winding on T_1 is useful for this purpose.

The polarising D.C. is controlled by means of an auto-transformer. The potentiometer on the primary side of T_1 is provided to allow of the removal of remanence in a test coil where necessary by reducing the A.C. to zero; but it should be returned to the maximum position when measurements are taken.

Results

A representative number of iron-cored radio components were measured on the instrument described and on a Hay's Bridge. Care was taken to ensure similar testing conditions in each method by making the iron " cyclic " setting the D.C. to the same value and, in the case of the bridge, adjusting the A.C. to 1V or 25V respectively with the aid of a separate valve voltmeter.

Wave form.—A cursory examination was made by applying a cathode-ray oscillograph to the live end of the comparison resistor and the test coil respectively. The wave form appeared to be the same in all cases, i.e., purely sinusoidal across the resistance and slightly distorted across the coil. This distortion was estimated to be due to 3-5 per cent. 3rd harmonic and traced back to the mains. No conclusion can therefore be drawn regarding the distortion of the A.C. feed circuit, except that it is not serious.

Voltage.—The test voltage at balance was measured with a separate valve voltmeter and found to be within plus or minus 5 per cent. of the specified value, except for one coil with the very poor power factor of 0.6.

Impedance. — Comparison between the direct value given by the instrument and the root of the sum of the squares of the in-phase and quadrature components given by the bridge showed agreement well within plus or minus 1.5 per cent. an exception again being made by the coil with a power factor of 0.6.

Conclusion

The results of wave form and voltage measurements are encouraging. Optimism is justified by the agreement of the impedance measurements with the bridge. Sources of error in the latter are in the wave-form distortion which is much more serious there than in the instrument described, the peak valve voltmeter employed for adjusting the ripple volts and possibly the D.C. meter. The authors are therefore inclined to place more reliance on the comparison instrument than on the bridge.

This comparison instrument, being quick and simple in operation and electrically robust, is most convenient for production checks. When pre-set the per cent. indicator is a useful asset.

As a laboratory instrument, it might be objected that it gives insufficient information. However, there are many cases where impedance rather than inductance enters into the design; e.g., in " smoothing " chokes, the chief criterion is the impedance at 100 c/s. A useful variation of the instrument would therefore incorporate a 100 c/s supply of good regulation and wave form. Raising the frequency from 50 c/s is also advisable for other reasons, as 50 c/s is not a representative working frequency of the components likely to be tested.

Acknowledgments

Thanks are due to J. E. Marshall, M.Eng., for valuable suggestions during design of the instrument and to Murphy Radio, Ltd., for permission to publish this article.

Inductance Linearized Time Base

By F. C. Williams, D.Sc., D.Phil., A.M.I.E.E., and Alan Fairweather, M.Sc., Grad.I.E.E.

(Concluded from page 231 of the June 1941 issue)

PART II

3. Design Data and Procedure

The significant formulae are, from (38) (*b*), (19) (*c*) and (44) (*b*):

$$\delta = 1 - \cos\frac{1}{2}\left[\sqrt{\frac{C}{L}}\frac{V_2}{I_m}\right] \quad \ldots \quad (58)$$

$$f = \frac{I_m}{CV_2} \quad \ldots \quad \ldots \quad \ldots \quad (59)$$

$$R'' = \left[1 - \frac{1}{2}\frac{V_2}{E}\right]\left[\frac{E}{I_m}\right] \ldots \quad \ldots \quad (60)$$

and the important variables are $\sqrt{\frac{L}{C}}$, $\frac{V_2}{E}$ and $\frac{E}{I_m}$. It is convenient, therefore, to write (58) and (59) in the form:

$$\delta = 1 - \cos\frac{1}{2}\left[\sqrt{\frac{C}{L}}\frac{E}{I_m}\right]\frac{V_2}{E} \quad \ldots \quad (61)$$

$$\text{and}: f = 1\Big/\left[C\frac{E}{I_m}\frac{V_2}{E}\right] \quad \ldots \quad \ldots \quad (62)$$

Let:

$\sqrt{\frac{C}{L}} = \alpha$, the reciprocal of the element reactance.

$\frac{E}{I_m} = \beta$, the mean resistance.

$\frac{V_2}{E} = \gamma$, the voltage utilisation factor.

and further, let:

$$\alpha\beta = \epsilon$$

Hence (61), (62) and (60) may be written:

$$\delta = 1 - \cos\frac{1}{2}\epsilon\gamma \quad \ldots \quad \ldots \quad (63)$$

$$f = \frac{1}{C\beta\gamma} \quad \ldots \quad \ldots \quad \ldots \quad (64)$$

$$R'' = \left[1 - \frac{\beta}{2}\right]\gamma \quad \ldots \quad \ldots \quad (65)$$

subject to five limitations which have already been noted at various stages in the analysis, viz., three theoretical ones:

from (31) *et seq.*: $\delta \ngtr 1$ (*a*)

from (38) *et seq.*: $\frac{1}{2}\epsilon\gamma \ngtr \frac{\pi}{2}$ (*b*)

from (24) *et seq.*: $\gamma \ngtr 2$ (*c*)

and two practical ones:

from (39) *et seq.*: $\alpha \nless 10^{-4}$ (*d*)

from (18) (*b*) *et seq.*: $f \ngtr 0.5 . 10^6$ (*e*)

} (66)

The precise process of design will depend on particular circumstances, but the procedure envisaged by the authors is as follows: an adequate graphical representation of (63), (64) and (65), to facilitate rapid computation, may be obtained from five curve sheets, viz.:

(*a*) δ : δ versus γ for various ϵ
α versus β for various ϵ

(*b*) f : f versus γ for various $C\beta$
C versus β for various $C\beta$

(*c*) R'' : R'' versus γ for various β

where the ranges of the various quantities are determined by the facilities at the designer's disposal. The method is then as follows: for a given design β is known and certain δ, γ and f are specified; it is required

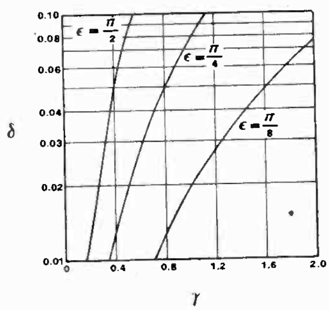

Fig. 7.

to ascertain L, C and R''. If absurd values result, the design is not practicable, and must be abandoned, or the original specifica-

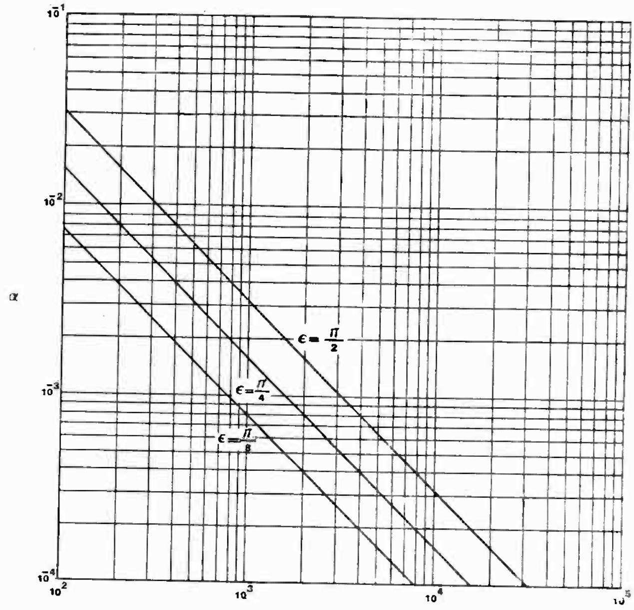

Fig. 8.

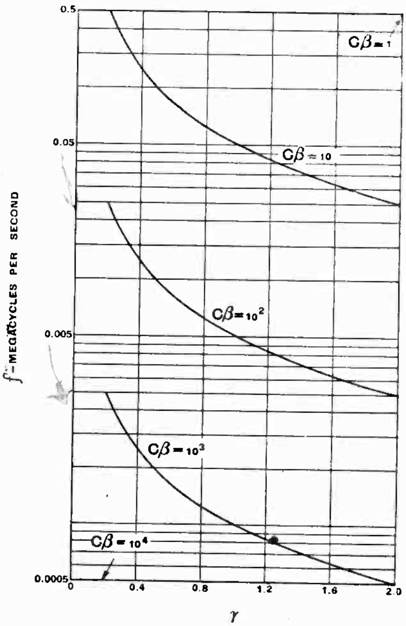

Fig. 9.

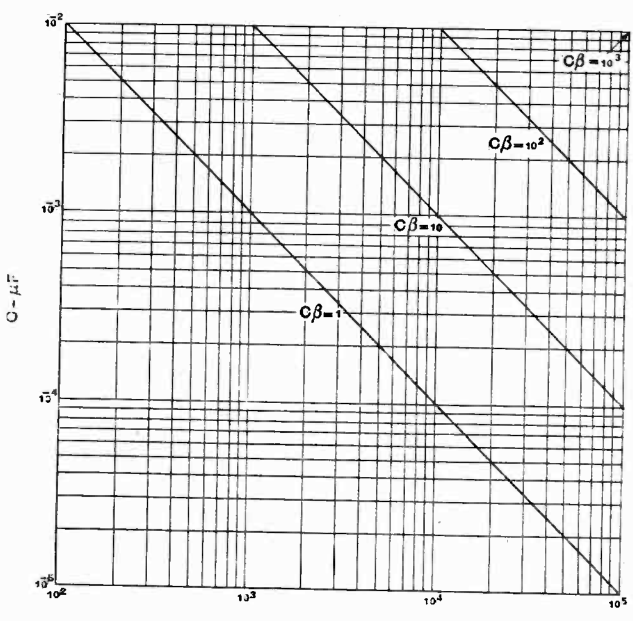

Fig. 10.

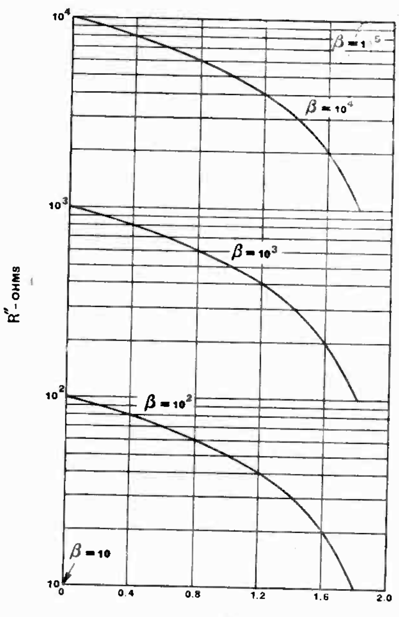

Fig. 11.

tion modified. The steps are:

(*a*) for α

(i) δ and γ—hence ϵ (Fig. 7).
(ii) β and ϵ—hence α (Fig. 8).

(*b*) for C

(i) f and γ—hence $C\beta$ (Fig. 9).
(ii) β and $C\beta$—hence C (Fig. 10).

(*c*) for L

α and C—hence $L\left(\alpha = \sqrt{\frac{C}{L}}\right)$

(*d*) for R''

β and γ—hence R'' (Fig. 11).

4. Experimental Check

The circuit shown in Fig. 12 was set up, using components as indicated in the figure. A tapping key K was arranged to permit sudden application of a paralysing negative bias to the thyratron grid.

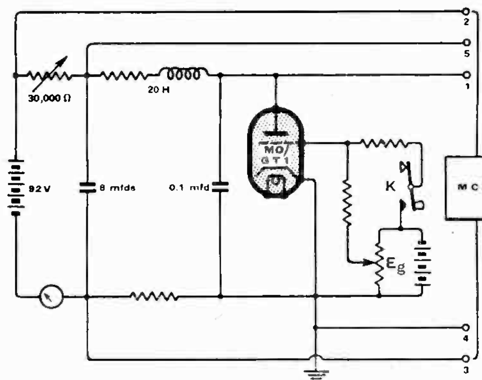

Fig. 12.

The first experiment was devoted to demonstrating that the time base strokes were, in fact, symmetrical segments of sine curves as predicted. For this purpose, an oscillograph with a slow running time base was connected across the 0.1 μF condenser, and the circuit set oscillating at a high frequency by reducing E_g. The camera shutter was set to give an exposure of $\frac{1}{5}$th sec., and, shortly after opening it, the key K was closed: this prevented further thyratron operation, and it may be seen, from oscillogram 1 in Fig. 13, that a damped sinusoidal oscillation ensues. The content of the blur between the start and the closing of K is shown in oscillogram 2. The frequency of the damped oscillation was estimated from oscillogram 1 as 130 cycles/sec.; the resonant frequency is 113 cycles/sec.

Further oscillograms were taken using the recently described multi-channel amplifier (*Bib.* 3). A small resistance was introduced to provide a p.d. proportional to the current I. The earth point was connected to the earth point on the amplifier, and the points marked 1, 2, 3 and 4 were connected to the four live terminals. Thus, there were simultaneously visible on the oscillograph, curves of:

1. V_1 the voltage across C,
2. The battery voltage,
3. the current I,
4. the zero potential line.

The difference between 2 and 4 serves to calibrate the oscillogram for voltage, and illustrates the extent to which the available voltage is utilised in the stroke; 4 is also the zero for the current curve 3.

The voltage E' from 5 to earth and the mean current I_m were measured.

Oscillogram 3 shows the result with $V_2 > E$ and verifies that such values are possible.

The strokes appear to be segments of sine curves, and the current curve appears to be made up of the caps of sine curves based on the zero line, as predicted. Since the current curve consists of sine curve caps, $\cos \frac{\omega T}{2}$ is measurable from the oscillogram, and is equal to the ratio of minimum to maximum ordinate of the current curve measured from the zero line. A value of repetition frequency f can thus be found, since $\omega = \frac{1}{\sqrt{LC}}$. A second value can be obtained from (18) (*a*) viz.:

$$I_m = \frac{C(V_2 - V_1)}{T}$$

V_2 and V_1 being measured from the figure. Finally, the frequency was measured with a heterodyne oscillator. The three values are shown in the table. The scale of the current curve is too small to permit highly accurate determination by the first method, and the second gives high values since the discharge by the thyratron is not instantaneous as assumed in the theory. $\frac{V_1 + V_2}{2}$ is measur-

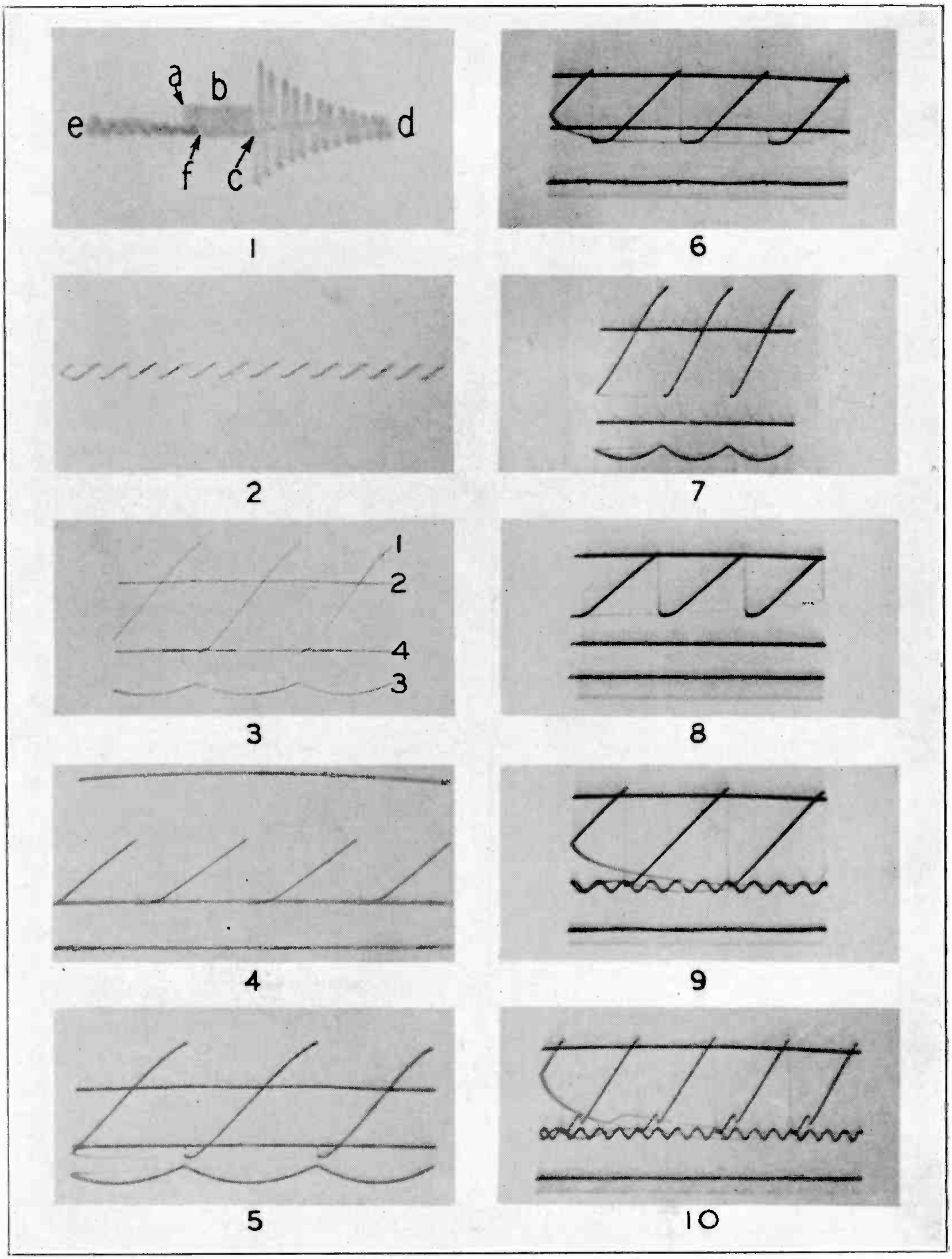

Fig. 13.

able from the oscillogram, and E' has been measured: the two figures, which should be equal, are seen to agree quite well.

Oscillogram 4 shows the result of reducing V_2: the linearity improves, and the current and frequency both increase. Within the limits of observation, the current becomes constant, and hence the linearity perfect: the calculated linearity is about 2 per cent. Accordingly, two values of f only are available here—see the table.

It may be noted from this oscillogram that a short period of constant V follows discharge, and that the linear rise of V is, therefore, delayed. This is due to ionisation in the thyratron, which takes an appreciable time to die away. Also, the value of V_1 is zero, whereas, normally, the thyratron requires a minimum of 12 volts to maintain ionisation. This again is thought to be due to a "reservoir" of ions formed during the initial period of the discharge: these flow to the electrodes at a lower potential than that necessary to maintain ionisation, reduce V to zero, and hold it there until the supply is exhausted. That the voltage actually falls to zero was checked with a "trough" voltmeter,* as it was at first thought possible that the observation was spurious, and due to unsuspected shortcomings of the multi-channel amplifier. Doubtless both effects would vanish if a thermionic trigger device replaced the thyratron.

Oscillograms 5, 6, 7 and 8 show similar pairs with different values of V_1, achieved by inserting bias in the thyratron cathode lead. In each case the theory is adequately

* A "trough" voltmeter is a device to measure the minimum value of a unidirectional undulating voltage. It comprises a diode peak voltmeter suited to the peak measurement of the voltage considered, but having the diode connections reversed and having sufficient bias to cause conduction at voltages slightly in excess of the minimum voltage.

KEY TO FIG. 13

Osc.No.	Data									
1	Sequence	a	b			c	d | e			f
	→	Start	Blur—see Osc. No. 2			Bias Applied	Flash back			Finish
2	Content of portion b of Osc. No. 1.									
	E (+ volts)	E_b (∓ volts)	E' (+ volts)	$(V_1+V_2)/2$ (+ volts)	I_m (mA)	δ (%)	f (c/s) I curve	f (c/s) I_m	f (c/s) H.O.	Synch. (c/s)
3	95.0	0	72.0	73.5	8.0	—	500	540	450	Nil
4	89.0	0	22.0	22.3	14.5	98.3	—	3,260	3,000	Nil
5	95.0	+ 25.0	73.5	72.5	8.5	90.0	385	433	405	Nil
6	89.0	+ 25.0	30.7	34.0	23.0	95.0	—	1,850	1,700	Nil
7	97.5	− 26.5	89.0	85.0	4.9	—	402	420	390	Nil
8	88.0	− 26.5	61.0	57.5	16.0	97.0	—	2,650	2,250	Nil
9	92.0	0	50.0	50.0	14.0	93.0	—	1,400	1,500	6,000
10	Included to show interesting failure of circuit occurring with particular values of synchronising and bias.									

NOTES 1. f (I curve) indicates frequency computed from $\cos\frac{\omega T}{2}$ (measured from I curve) and $\omega\left(=\frac{1}{\sqrt{LC}}\right)$

2. $f(I_m)$ indicates frequency computed from I_m $\left(I_m = \frac{C(V_2 - V_1)}{T}\right)$, V_2 and V_1 being measured from V curve).

3. f (H.O.) indicates frequency measured with the aid of a heterodyne oscillator.

4. Values have been omitted where it was not possible to compute them from the oscillograms.

5. E_b = thyratron cathode bias.

supported by the figures given in the table: where the frequency cannot be estimated from the current curve the calculated linearity is quoted.

Oscillogram 9 shows the apparatus running synchronised with a 6,000 cycles/sec. signal, and 10 shows an interesting locking failure which occurred with particular combinations of bias and synchronising amplitude.

Although linearities better than 1 per cent. are not shown, they were achieved, but required the use of lower values of V_2, for I_m cannot be increased beyond a certain limit (about 30 mA here) without continuous conduction in the thyratron ensuing. Similarly, if the L/C ratio was further increased, the range of I over which conduction was not either zero or continuous became very small. Doubtless a more rapid trigger device would extend these limits. Linearities of 2–3 per cent. are, however, easily achieved with a swing of 100V, and these are probably sufficient for most practical purposes.

5. Conclusions

In subsection 2.35, (37) *et seq.*, certain inferences were drawn regarding the behaviour of δ and T under different conditions. It appears, therefore, that since, for given linearity, T varies only as $\sqrt{L}$ and/or $\sqrt{C}$, circuits of this kind are not suited to wide frequency range use or to use at low frequencies. And, further, that if L and C be fixed, δ deteriorates with T^2.

The chief advantage of the circuit, over the simpler CR type, lies in the high voltage utilisation factor, and it would appear to have application only in cases where a small frequency range is required, and a low voltage, heavy current source is available. The only practical arrangement is the improved circuit, since this is the only really stable form.

6. Note on Earlier Work

This paper would be incomplete without some reference to an earlier paper, by F. de la C. Chard (*Bib.* 4), describing a similar circuit. The description of the circuit operation there given is purely qualitative and, in the Authors' opinion, entirely incorrect.

One point is, however, worthy of particular note. It will be seen in his oscillogram 4, and in the oscillograms of Fig. 13 of the present paper, that the observed current differs from the predicted current in that a brief peak of current occurs between adjacent time wave caps. Chard ascribes this peak to "follow-on" current from the supply through the thyratron, whereas it appears to be due to charging current drawn by the self-capacitance of the inductance during flash-back.

7. Acknowledgment

The research described in this paper was carried out partly in the Electrotechnics Department of the Victoria University of Manchester, and partly in the Signalling Apparatus Laboratory of the Post Office Engineering Research Station. The Authors' thanks are due, therefore, to Professor Willis Jackson, D.Phil., D.Sc., M.I.E.E., and to W. G. Radley, Esq., B.Sc., Ph.D., M.I.E.E., for facilities provided.

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3. Williams, F.C. and Beattie, R. K. "A Multi-Channel Oscillograph Amplifier." *Wireless Engineer*, March, 1939, No. 186, Vol. 16, p. 126.
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Birthday Honours

COL. A. STANLEY ANGWIN, D.S.O., M.C., B.Sc. (Eng.), M.I.E.E., Post Office Engineer-in-Chief, was created a Knight Bachelor in the recent Birthday Honours. It was in June 1939 that he succeeded to the post of Engineer-in-Chief. He joined the Post Office Engineering Department in 1906 and when after the Great War he returned to civilian life he went to the Wireless Section of the Engineer-in-Chief's office. He contributed largely to the design and construction of the major Post Office wireless stations in this country and that at Cairo, and also to the inauguration of the transatlantic telephone service. Sir Stanley has been chairman of the Wireless Section of the Institution of Electrical Engineers and is now a vice-president of the Institution. He is a member of the Government's Television Advisory Committee and has represented the Post Office at a number of international conferences.

Mr. Frank Gill, O.B.E., M.I.E.E., who is chairman of Standard Telephones and Cables and the International Marine Radio Company, was created a Knight Commander of the Order of St. Michael and St. George in the Birthday Honours for services in the development of the telephone industry and of international telephony. Sir Frank is a past president of the Institution of Electrical Engineers.

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 Deflecting Condenser

To the Editor, "The Wireless Engineer"

SIR,—There is a growing tendency to recognise the importance of the exit field in determining the apparent conductance between the plates of a deflecting condenser. The issue was for some time confused by the fact that, in the case of deflector plate length 1 greatly exceeding the separation d, the correct formula had been given by Hollmann and Thoma[1] on incorrect premises. The matter was set right by Recknagel. Mr. Rodda's note in the April issue of *The Wireless Engineer*[2] has prompted me to re-examine my own calculations which did not at first agree with those of Recknagel.[3] I now find that for long deflector plate such that the stray fields at entry and exit may be considered short in comparison, my calculations also give the Recknagel formula, moreover the calculation is no longer restricted to small deflections. Mr. Rodda's proof is based on a solution of Dirichlet's problem using the Green's function. A non-mathematical proof will be given below.

Hollmann[4] has devised a highly ingenious model which will enable a number of tests to be made on a macroscopic scale, and which, he claims already confirms negative conductance predicted on Recknagel's theory when $\omega\tau = 5\pi/2$. Since in Hollmann's model the balls, once they leave the tilting board, have no further connection therewith, and since there is no transition layer effect, we should, contrary to Hollmann's opinion, expect Benner rather than Recknagel damping to be observed. When the frequency is held constant and the transit time varied, the Benner damping is seen to be a maximum[5] when $\omega\tau = (2n + 1)\pi$, where $n = 0, 1, 2. \ldots$ Thus Hollmann's observation of maximum damping when $\omega\tau = \pi$ could receive explanation on either formula. When $\omega\tau = 2\pi$, Hollmann's oscillogram shows the damping alternately increasing and decreasing as the transit time fluctuates, there is no definite indication of negative damping, and the Benner formula suffices here also. With regard to the negative damping which Hollmann's oscillogram taken at $\omega\tau = 5\pi/2$ indeed appears to reveal, a crisis arises since the Benner formula shows no negative damping, and the Recknagel formula only shows negative damping as a result of the transition layer at the exit of the condenser, to which, as indicated above, there is no counterpart in the mechanical case. It would not appear from the photographs that there would be any trouble due to the balls bouncing, nor is it likely that Hollmann was using insufficient numbers of balls. These points are merely mentioned in connection with an attempt to remove the paradox which has arisen.

A very simple statement of deflecting condenser theory enabling one to see without mathematics why we get a conductance vanishing with the frequency may not be out of place here. At first sight it might appear strange that we have the apparent ability to swing an electron beam without doing work upon it. It may help therefore to point to a parallel case in the field of astronomy. A comet coming towards the sun from a great distance gains (except when the orbit is hyperbolic) kinetic energy at perihelion at the expense of mutual gravitational potential energy. When the comet recedes all the newly acquired kinetic energy is lost.

We shall neglect the stray field on the entry side and suppose that electrons enter the condenser having zero kinetic energy in the y direction. Before leaving the condenser each electron acquires a kinetic energy T. Owing to electron inertia effects, the potential energy U lost by the electron differs in general from T. At the exit of the condenser the stray field (comprising a retarding longitudinal component and a diminishing transverse component) is in reality of finite extent, but in Recknagel's analysis an abrupt fall to zero over a transition layer of infinitesimal thickness is virtually assumed. As a consequence, negligible transit time is taken in traversing the layer from which it follows that the loss of kinetic energy therein (whether in the y or x direction) is exactly equal to the potential energy gained. But since there is no electric field beyond the discontinuity the potential energy gained must be that previously lost while within the confines of the condenser, namely U. Hence the kinetic energy lost in the transition layer is also U, so that the electron gains on balance the kinetic energy $T - U$. The value of U is approximately $(eV/d)y$, while $T = \frac{1}{2}m\dot{y}^2$. When summation is effected over all electrons momentarily present, we obtain the desired formula without difficulty.

The transit time function involved is identical with that obtained by the writer and others for the longtitudinal case (diode, neglecting space charge)[5], so that at first sight it might appear as though an electron atmosphere would endow similar conducting properties in whatever direction the conductors are disposed relative to the beam. Only in the particular case $l = 2d$, however, do the formulae become equal. In general the ratio of transverse to longitudinal conductance is $l^2/4d^2$. Thus for a long condenser for which we have arranged end plates at entry and at exit (with holes to admit the beam) the transverse conductance would greatly exceed the conductance at the end plates, but it would doubtless be possible to arrange the dimensions so that transverse and longitudinal conductance were the same should any particular object in so doing suggest itself.

Of course, the simple conception of an abruptly terminating transverse field is not realised in practice, moreover it is not true that the electrons possess zero transverse velocities on entry. The resulting formula for the transverse conductance when stray fields increasing or decreasing linearly are assumed are somewhat complicated, and for the parabolic stray fields favoured by Hollmann, and applied by him successfully to the calculation of the deflection on the screen of the tube, the formulae are more complex still. In the limiting case when the two stray fields predominate the transit time in the condenser being reduced to negligible proportions, the conductance approximates to Benner's form. Thus the effect of extended stray field is to inhibit negative conductance.

If, on the other hand, stray fields were literally zero everywhere in the longitudinal direction we could not get the Recknagel conductance as there would be no transition layer. We should instead get the Benner conductance. In particular, the writer some time ago applied Fourier's integral theorem to evaluate the effect of a square topped pulse of electric field applied transversely to the path of an electron. Benner's conductance factor was obtained. These are some of the considerations which will indicate that before accepting the new conductance formula a critical survey of the problem has been made, and that the new formula must only be taken to apply approximately to a practical case.

Fordcombe, Kent. W. E. BENHAM.

REFERENCES

[1] Hollmann, H. E., and Thoma, A., *Hochf:tech. u. Elek:akus.*, 49, 145, 1937. See also *Wireless Engineer*, pp. 198 and 370, April and July, 1938.
[2] p. 154.
[3] Recknagel, A. *Zeitschr.f. tech. Phys.*, No. 3, Vol. 19, 1938, p. 74.
[4] *Proc. Inst. Rad. Eng.*, No. 2, Vol. 29, Feb. 1941, p. 70; gives literature. See particularly Figs. 6 and 7.
[5] Benham, W. E., *Wireless Engineer*, p. 598, Dec. 1939. See Fig. 3 and text, also Fig. 4.

Measurements of Shot and Thermal Noise

To the Editor, "The Wireless Engineer"

SIR,—We have noted with interest the article by Mr. D. A. Bell in *The Wireless Engineer* of March, 1941, on the measurement of noise using a linear diode for the measurement of mean square output. In spite of the linearity shown between the increase of the square of the rectified current and the noise current in the comparator diode, there are certain discrepancies between the indicated value of his "mean square noise ratio" (F^2) and those which are obtained when using a thermal device for indicating the output. The discrepancy is particularly large in the case of the EE50 secondary emission valve, for which Bell indicates an F^2 of 0.65 and an equivalent grid noise resistance of 500 ohms.

It is possible to make an estimate of the value of F^2 for any valve from a knowledge of the operating currents. For the EE50, which operates with a high mutual conductance at a relatively low cathode current (less than 3 mA.), the value of F^2 for the primary current stream will be of the order of 0.2. Partition effects at the screen grid which abstracts approximately one-fifth of the cathode current will increase F^2 to 0.36. The final value of F^2 applicable to the anode current is obtained by multiplying by the secondary emission coefficient and by a factor of the order of 1.2 which allows for the spread of this coefficient about its mean value. For the EE50, the coefficient necessary to obtain a slope of 14 mA/V. at an anode current of 10 mA. is of the order of 4 or 5. The final value of F^2 will then be approximately 2. Measured values taken in these laboratories using a vacuum thermojunction as an output indicator show even higher values of the order of 3 to 5, the corresponding equivalent grid noise resistance being 3,000 to 5,000 ohms.

It is difficult, without detailed knowledge of Mr. Bell's circuit, to suggest a cause for the discrepancy in his measurements, but a possibility lies in the assumption that a current stream containing charges of varying effective magnitude, as is obtained by amplification by secondary emission, will give rise to the same effects on a linear rectifier as will a current stream of charges of uniform magnitude as in the case of the comparison diode.

The derivation of the expression given for the equivalent grid noise resistance is not stated. The complete expression for this is

$$R_n = \frac{e}{2KT} \cdot F^2 \cdot \frac{I_a}{G^2}$$

where e = the electronic charge = 1.59×10^{-19} coulombs.
K = Boltzmann's constant = 1.37×10^{-23} joules/degree.
T = Room temperature = 293° Kelvin.
I_a = actual anode current.
G = mutual conductance.

When the numerical values are inserted, the expression becomes

$$R_n = 20 \frac{F^2 \; I_a}{G^2}$$

in which no approximations are involved. The figures given by Bell for equivalent grid noise resistance should, therefore, be increased by one-third to obtain equivalence with his stated values of F^2.

For and on behalf of the
G.E.C. Research Laboratories,
W. H. ALDOUS.
E. G. JAMES.

Book Received

Vacuum-Tube Voltmeters.—By John F. Rider. Intended as an exposition of the numerous types of valve voltmeter, this book, which is of American origin, deals with the subject practically rather than theoretically. There are eleven chapters and a comprehensive bibliography. Whilst the book contains details of considerable original work undertaken by the author, he states in his foreword that it is a "symposium of all the work which has been done in many countries upon vacuum-tube voltmeters." The following types of valve voltmeter are described and their practical applications dealt with: diode, triode, slide-back, rectifier-amplifier, tuned, A.F. and logarithmic. Pp. 179+xi. 113 Figs. John F. Rider, Publisher, Inc., 404 Fourth Avenue, New York City, U.S.A. Price in the U.S.A. $1.50.

The Institute of Physics

PROFESSOR SIR LAWRENCE BRAGG was recently elected chairman of the Institute of Physics. The following were also elected to take office on October 1st: Vice-President, Professor W. Makower; hon. treasurer, Major C. E. S. Phillips; hon. secretary, Professor J. A. Crowther.

Half-wave Modulation*

By C. E. G. Bailey, B.A., A.M.I.E.E.

SUMMARY.—It is shown that the intelligibility of speech received over a communication channel is not seriously depreciated by transmitting one half only of the wave form. The amount of this depreciation is measured: when allowance is made for it, calculations show that a given radio communication requirement which is limited in range by the effect of noise on intelligibility may be more economically solved by designing the transmitter to transmit half the speech wave. The saving amounts to 44 per cent. reduction in power, 17 per cent. reduction in peak emission, and the omission of much apparatus.

1. Origin of the Investigation

DURING experiments with a small telephony transmitter which suffered from insufficient peak emission from the cathodes of the output valves, it was noticed that transmitted speech was perfectly clear in spite of the fact that a thermo-ammeter in the aerial circuit showed a decreased reading during modulation, and that the R.F. output with sinusoidal modulation input appeared on a cathode-ray oscillograph much as shown in Fig. 3(c) under "modulation envelope."

1.1. Now much less is required of a "communication" telephony transmitter than of a broadcast entertainment transmitter. At its maximum range its signal must compete with the thermal noise or Schottky noise from the first stages of a sensitive receiver, and a satisfactorily high proportion of the messages spoken into the transmitter must be understood without repetition. Intelligibility becomes the end, fidelity only a means. Any distortion of the speech-wave reduces intelligibility, but if the intelligibility is then fully restored by some other factor, such as improved signal/noise ratio, then nothing has been lost.

1.2. It therefore occurred to the writer that communication transmitters might be more economically designed to handle one half of the speech wave only. There are two ways in which this can be done: all levels from the carrier upward can be removed, as in Fig. 3(c), or radiation may be suppressed during half of the audio-frequency wave, as in Fig. 3(d). These two sorts of modulation will be termed "downward" and "upward" modulation respectively.

* MS. accepted by the Editor, March, 1941.

1.3. The problem resolved itself into three parts; first to assess the price paid for the distortion in terms of intelligibility, then to allocate a sufficient increase in signal/noise ratio to restore the lost intelligibility, and finally to compare a transmitter modified to satisfy the first two parts of the problem with a conventional transmitter of equal range.

The difference between "upward" and "downward" modulation is significant in the third part of the problem, but not in the first two. For after detection the audio-frequency wave-form from either envelope is simply the reverse of that from the other. Furthermore, the intelligibility of both forms of modulation can be investigated without bringing any radio frequencies into the picture; for the original audio-frequency wave may be distorted by a half-wave rectifier to give the same result as half-wave modulation followed by linear detection.

2. Experimental Results

The processes of modulation and detection were accordingly by-passed by using the apparatus shown in block schematic form in Fig. 1. The apparatus used is specified in the following list:

- *A* Transverse-current carbon microphone (Philips Type 4210).
- *B*. Mixer box consisting of transformer and volume control (Philips Type 4228).
- *C*. Resistance-coupled stage using two triodes (Mullard Type EBC3) in push-pull, giving 20 db. gain.
- *D*. Distorter stage consisting of two diodes in parallel (Mullard Type EB4) shunted by 20,000 ohms.
- *E*. Toggle switch to cut out *D*.

F. Attenuator pad introducing 20 db. loss. (The sequence of *C* and *F* ensured that the input to the diodes was sufficient to suppress one half of the wave at all levels, while not overloading the amplifier *H*.

G. Amplifier giving random noise at adjustable level.

H. 2-stage amplifier with inverse feed-back (Philips Type 12595).

K. Speaker (Philips Type 2136.)

The frequency characteristic air-to-air of the sequence *ABCFHK* is shown in Fig. 2 and it will be seen that it is adequate for intelligibility.

2.1. For those not familiar with the technique of intelligibility measurements, it may be useful to explain that tests were made by pronouncing standard meaningless syllables or "logatomes" into the micro-phone in groups of 50. An operator worked switch *E* in such a manner as to give 25 distorted and 25 undistorted logatomes, distributed in an arbitrary manner, during a group. The results of the observers were then checked for accuracy, and the accuracy of a given group of 25 was expressed as a percentage, called the "articulation." The results of a series of groups were then averaged and the probable error found in the usual way. This method, tiresome as it is, produces consistent results in less time than does that of repeating words or sentences.

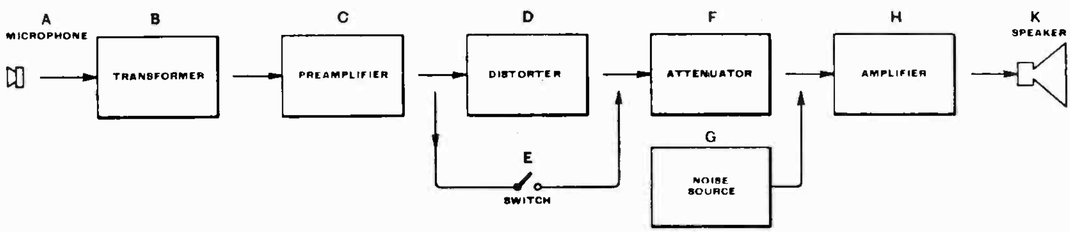

Fig. 1.

These results are, however, interpretable in terms of word of sentence intelligibility (Reference 1, 2). It is interesting to note that 50 per cent. articulation corresponds to about 95 per cent. sentence intelligibility.

2.2. It was verified by oscillograph in initial tests that the audio waves were being clipped cleanly in half: and the quality of music so reproduced was excruciating. But sentence intelligibility was perfect, and logatome articulation so high (about 95 per cent.) that accurate comparison would have involved the repetition of a very large number of logatomes.

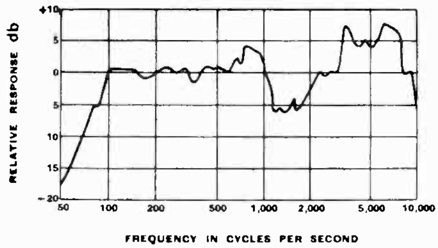

Fig. 2.

The intelligibility was accordingly reduced to about 50 per cent. by superimposing noise from the source *G* (Fig. 1). This had the advantage that the loss of intelligibility could be directly compared with that from a reduction in signal/noise ratio by the following reasoning.

Steinberg (Reference 2) measured the articulation of speech at various intensity levels in the presence of noise also at various intensity levels and with various frequency distributions. When the frequency distribution of the noise was reasonably uniform over the range of the important speech frequencies (for example, when it varied smoothly over a range of 20db. between 100 c/s and 4,000 c/s), the curves connecting the articulation with the relative signal strength in decibels were parallel. They were also nearly linear between the limits of 20 per cent. and 80 per cent. articulation. If the signal/noise ratio be fixed, then by adjusting the absolute level of signal and of noise simultaneously, we can find a level which gives an optimum intelligibility. It is a matter of common experience that to understand a message, the voice should be reproduced neither too loudly nor too softly.

But this optimum, according to Steinberg, is exceedingly flat, and at any reasonable loudness the articulation depends only on the signal/noise ratio. Between the limits of 20 per cent. and 80 per cent. articulation, where the curves are linear, we may therefore write,

$$\Delta \text{ (articulation)} \propto \Delta \text{ (signal/noise db.)} \quad \text{.. .. .. ..} \quad (2.21)$$

where the operator Δ signifies a finite change made in the variables. From Steinberg's curves we may fill in the constant as follows :

$$\Delta \text{ (per cent. articulation)}$$
$$= 3.3\,\Delta \text{ (signal/noise db.)} \quad \text{..} \quad (2.22)$$

2.3. 1850 logatome observations gave the result that the articulation was reduced by distortion by 14.6 per cent. with a probable error of 1.3 per cent. Formula (2.21) indicates that this could be restored by an improvement in signal/noise ratio of 4.4 db.

In order to verify this point, the switch E was arranged to include an attenuation pad giving 4.4 db. loss in the " undistorted " position. The result showed 0.8 per cent. articulation in favour of the distorted transmission with a probable error of 1.6 per cent. This verification can be considered satisfactory.

3. Effect on Transmitter Design

These results may be summarised by saying that a " communication " transmitter whose functions are defined in 1.1, is equally satisfactory if

(1) its carrier is 100 watts, or

(2) its carrier is raised by 4.4. db. to 275 watts, and one half of the modulation is removed. This can be done by leaving either " downward modulation " or " upward modulation."

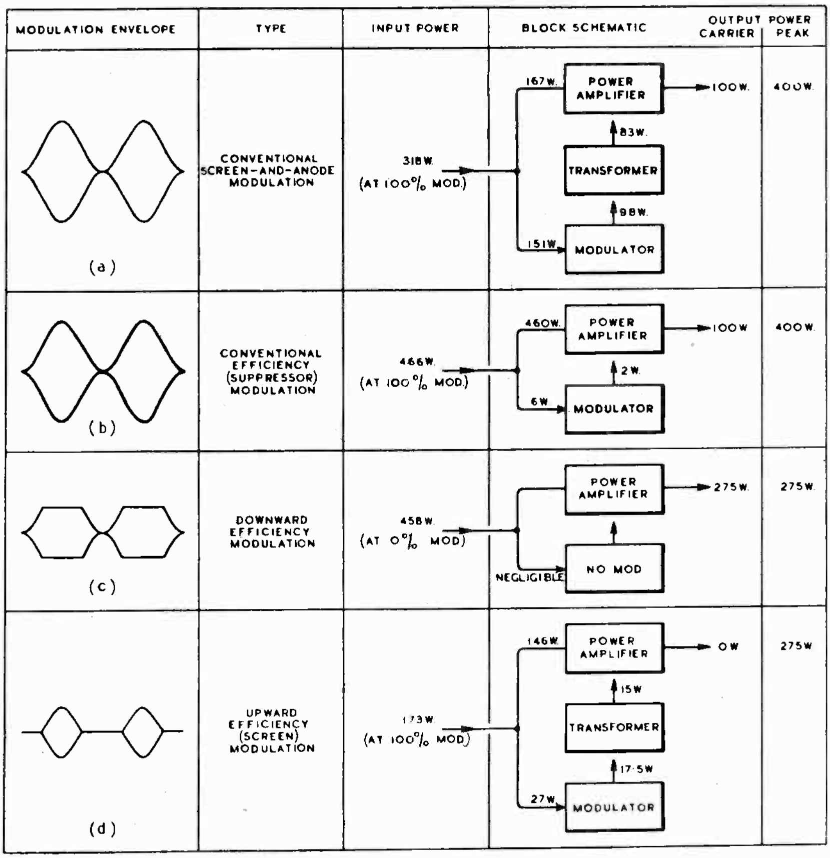

Fig. 3.

3.1. Let us now examine the relative power inputs required by transmitters (1) and (2)

An examination of 5 Mullard pentodes of recent design shows that as Class C final stages with or without anode modulation their overall power efficiency, including screen consumption but neglecting cathode consumption, is 60 per cent. A similar examination of 5 modulator triodes using the efficient Class AB arrangement with cathode coupling, including the anode power of the driver stages, gives an average efficiency of 50 per cent. A few similar practical data enable one to construct the comparative table of Fig. 3 showing four transmitters of equal range. Attention has been concentrated on the peak input, since this determines the size of transformers, generators, smoothing equipment and so on.

3.2. The first two of these transmitters use conventional modulation. Transmitter (*b*) uses low-power modulation on the suppressor grid: following Ladner and Stoner (Ref. 3) we describe this as an example of "efficiency modulation." It requires more power than transmitter (*a*) but its type is often used because the modulator section is so simple. Transformer losses are insignificant and so are not shown.

3.3. Changing transmitter (*b*) to downward efficiency modulation results in transmitter (*c*). The final stage now runs in Class C: the modulator requires negligible power, since the only power absorbed in modulation in transmitter (*b*) goes to produce positive peaks. Thus downward efficiency modulation presents no great advantages. A single point in its favour is that less peak cathode emission is required in this transmitter than in transmitters (*a*) and (*b*). Because peak input power is so important, the watts in (*c*) have been calculated for the condition of zero modulation. It is obvious that the power input decreases during modulation.

3.4. Upward modulation shows, however, several advantages (transmitter *d*). The input is lower than transmitter (*a*) with 100 per cent. modulation. The saving in peak input power is significant by itself, but the improvement is still more marked when the average power consumption is an important factor.

Screen-grid modulation has been taken for the type of efficiency modulation in example (*d*), because the ordinary transmitter valve is severely limited by screen-grid dissipation if the suppressor grid is biased to cut-off for long periods.

The combined anode and screen dissipation is 92 watts in transmitter (*d*) and 100 watts in transmitter (*a*). Thus final amplifier valves may be the same. The peak emission required in transmitter (*d*) is 0.83 times that in transmitter (*a*). Finally, the modulator becomes much simpler and uses smaller components.

4. Acknowledgments

The author wishes to acknowledge his thanks to the Directors of the Mullard Radio Valve Company for permission to publish this paper.

REFERENCES

1. Harvey Fletcher, "Speech and Music," Van Nostrand, 1929.
2. Steinberg, *Journ. Acous. Soc. Am.*, I, 1929, p. 130.
3. Ladner and Stoner, "Short Wave Wireless Communication," Chap. X (Chapman and Hall, 1938).

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

DIRECTIONAL WIRELESS

532 654.—Navigational radio indicator in which variable damping-means are provided to compensate for the different conditions in calm and rough weather.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 12th October, 1938.

532 854.—D.F. apparatus for automatically indicating the true bearing of a distant transmitter relative to compass North.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 15th October, 1938.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

532 337.—Maintaining the output from an A.C. valve constant in spite of changes in the load.

Siemens Bros and Co. and P. A. Chittenden. Application date 27th July, 1939.

532 521.—Method of blocking-out static and similar impulsive interference from a wireless receiver which at the same time will pass signals modulated up to 100 per cent. of the carrier-wave.

Murphy Radio and H. A. Fairhurst. Application date 23rd June, 1939.

532 640.—Remote-control system for a wireless receiver in which one or more change-over switches

are operated by the closure of a distant circuit.
Philips Lamps. Convention date (Germany) 21st September, 1938.

533 072.—Design of condenser used for ganging the signal and local-oscillator circuits in a superhet.
Radio Gramophone Development Co. and G. J. Redfern. Application date 12th October, 1939.

533 136.—Remote-tuning control system, operated over the power-supply lines, for a wireless receiver.
Hazeltine Corporation (assignees of L. F. Curtis and J. F. Farrington). Convention date (U.S.A.) 22nd October, 1938.

533 242.—High-frequency multiple receiving system with an automatic sharp-tuning voltage derived simultaneously from two of the intermediate-frequency channels.
Telefunken Co. Convention date (Germany) 21st October, 1938.

533 253.—Method of damping an oscillatory circuit by a resistance whose value depends upon a control voltage, particularly for automatic selectivity control.
Philips Lamps. Convention date (Germany) 25th October, 1938.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

532 110.—Saw-toothed oscillation generator for television scanning in which the discharge circuits are isolated from the supply source for the greater part of each cycle, to prevent distortion effects.
A. A. Thornton (communicated by Philco Radio Corporation). Application date 13th June, 1939.

532 718.—Single-valve circuit for separating the frame and line synchronising impulses in a television receiver.
Standard Telephones and Cables and D. N. Corfield. Application date 28th July, 1939.

533 301.—Electromagnetic deflection system for a cathode-ray television receiver in which two crossed coils are fed in series for one direction of deflection and in parallel for the other.
Standard Telephones and Cables and C. N. Smyth. Application date 9th August, 1939.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

533 485.—Construction of Class B and Class C amplifiers with an impedance inverting network for modulating a carrier frequency or amplifying a modulated frequency.
Philips Lamps. Convention date (Netherlands) 10th November, 1938.

533 500.—Means for modulating an electron stream either by varying its velocity or charge density.
The British Thomson-Houston Co. Convention date (U.S.A.) 1st June, 1938.

533 613.—Means for grouping or associating a number of valve amplifiers, without undesirable capacity effects, in a multi-channel wave-transmission system.
Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 17th November, 1938.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

532 717.—Electrode arrangement for focusing the electrons on to the collecting anode of a secondary-emission tube.
Standard Telephones and Cables and A. I. Vangeen. Application date 28th July, 1939.

532 886.—Process for "settling" the fluorescent screen of a cathode-ray tube and for preventing "avalanching" of the material when the tube is tilted.
Marconi's W.T. Co. (assignees of H. W. Leverenz). Convention date (U.S.A.) 30th July, 1938.

532 920.—Electrode arrangement for controlling and guiding the path of the electrons in a secondary-emission tube.
Standard Telephones and Cables; D. S. B. Shannon and P. K. Chatterjea. Application date 26th September, 1939.

532 984.—Cathode-ray tube in which the deflecting plates are connected through a circuit resonant to the applied wavelength to increase their input impedance, particularly for very high frequencies.
E. J. Alway. Application date 28th September, 1939.

SUBSIDIARY APPARATUS AND MATERIALS

532 066.—System for maintaining continuity of service, in spite of valve failure, say in an unattended repeater station along a submarine or other cable.
Siemens Bros. and Co.; D. P. Long; C. L. Peters; and L. S. Crutch. Application date 15th August, 1939.

532 340.—Mounting bar designed to allow the examination of delicate organic preparations in an electron microscope.
F. Krause. Application date 29th July, 1939.

532 417.—Unitary arrangement of the radio equipment of an aeroplane.
Marconi's W.T. Co. and C. S. Cockerell. Application date 29th August, 1939.

532 502.—Apparatus for subjecting matter, or the human body, to the action of high-frequency fields of the order of 300 Mc/s.
The General Electric Co. and E. C. S. Megaw. Application date 1st September, 1939.

532 798.—Electrical system for exploring the nature and content of the sub-soil.
Cie. Gen. de Geophysique (assignees of J. J. Jakosky and Ihlumberger Well-Surveying Corporation). Convention date (U.S.A.) 13th July, 1938.

532 922.—Interference-eliminator unit for attachment to a domestic labour-saving device.
Electrolux (assignees of Akt. Elektrolux). Convention date (Germany) 3rd October, 1938.

532 925.—Preparing a piezo-electric crystal oscillator of Rochelle salt having a high Q or selectivity factor and a substantially-constant temperature coefficient.
Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 19th October, 1938.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

1816. WAVE-GUIDE ACTION OF PARALLEL CONDUCTORS IN TUBULAR ARRANGEMENT [Experimental Investigation on "Cylindrical" Guide made up of 3, 4, 6, or 8 Parallel Wires].—G. Hara & S. Son. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, pp. 233–234.)

"Such wave-guide action is advantageous from the standpoint of economy of material, and also possesses an advantage for multi-channel communication, using each pair of conductors."

1817. GENERAL CONSIDERATION FOR TRAVELLING ELECTROMAGNETIC FIELDS PRODUCED IN A LONG HOLLOW TUBE [Wave Equations and the Characteristics of Plane Waves: General Analysis of Magnetic Transverse Waves: Relations of Constants in Hollow Conducting Tubes of Various Shapes of Cross Section: General Equations of Electromagnetic Field Components].—H. Iwakata. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 127–134.)

1818. ELEMENTARY THEORY OF THE SPHERICAL CAVITY RESONATOR.—Berg. (*See* 1843.)

1819. "ELECTROMAGNETIC THEORY" [including Wave Guides, Standing Waves in Spheres, etc: Book Review].—J. A. Stratton. (*Journ. Applied Phys.*, April 1941, Vol. 12, No. 4, p. 353.)

1820. STEADY-STATE SOLUTIONS OF ELECTROMAGNETIC FIELD PROBLEMS: I—FORCED OSCILLATIONS OF A CYLINDRICAL CONDUCTOR: II—OF A CONDUCTING SPHERE: III—OF A PROLATE SPHEROID.—Stratton & Chu. (*See* 1888.)

1821. DIFFRACTION MEASUREMENTS AT ULTRA-HIGH FREQUENCIES [55 & 110 Mc/s: Natural Horizontal Knife-Edge provided by 437 ft-High Ridge].—H. Selvidge. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, pp. 10–16.)

Field-strength patterns agreed fairly well with simple theory. Horizontally polarised waves were diffracted more than vertically polarised: "this would seem to indicate that when u.h.f. coverage is desired in deep valleys, or behind any obstacle, such as a building, which presents roughly a horizontal knife-edge, horizontal polarisation may be profitably employed."

1822. MOUNTAIN EFFECTS AND THE USE OF RADIO COMPASSES AND RADIO BEACONS FOR PILOTING AIRCRAFT.—Busignies. (*See* 1911.)

1823. ECHO MEASUREMENTS IN LONG-DISTANCE TRANSMISSION AND THEIR RELATION TO ZENITHAL REFLECTIONS [Correction].—Eyfrig. (*Hochf:tech. u. Elek:akus.*, Feb. 1941, Vol. 57, No. 2, p. 60.) *See* 1587 of June: in footnote 1 the year "1940" should have read "1939".

1824. A LONG-RANGE FIELD-INTENSITY-RECORDING PROGRAMME FOR STUDYING PROPAGATION CONDITIONS [for F.C.C.].—C. A. Ellert & K. A. Norton. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, p. 37: summary only.)

1825. THE FORMATION OF THE STRATOSPHERIC D LAYER BY ABSORPTION OF THE HYDROGEN LINE 1215 AU.—R. Penndorf: Williams. (*Naturwiss.*, 28th March 1941, Vol. 29, No. 13, p. 195.)

Williams's investigations on the absorption of this radiation led him to the conclusion that it would be completely absorbed by the time it reached a height of about 80 km (1317 of 1940). The present writer, however, considers that his own newly calculated values for the pressures in the stratosphere (*Meteor. Zeitschr.*, Feb. 1941, Vol. 58) are more reliable: using these, the value of 0.04 mm Hg for the partial pressure of oxygen, at which (according to Williams) the absorption in air begins, is reached at a height of 61 km. "The radiation in question ionises the O_2 molecule, which splits up and yields a particularly strongly ionised layer below 60 km. This result agrees with measurements, for Appleton suggested in 1928 (*U.R.S.I. Proc.*, 1927, Fasc. 1, Vol. 1, pub. 1928: *also* 1930 Abstracts, p. 446) that the strongly absorbing layer, which he named the D layer, lay at a height of 60 km." Moreover, the various results of Mitra and his colleagues and of Colwell & Friend all unite in indicating a strongly ionised layer below 60 km, appearing particularly on the occasion of solar eruptions.

The writer then uses Williams's measurements to calculate the probable thickness of the layer: he finds that the radiation is half absorbed by the time it reaches a height of 50 km and (an extrapolated value is used here) is reduced to one tenth—that is, is practically completely absorbed—at 44 km. "This interval of 60–45 km agrees with the observations of the D layer on occasions of chromospheric eruptions." The right-hand side of Fig. 1 shows graphically the amounts of energy absorbed in passage through 1 km at various heights from 45 to 60 km: "even this rough calculation yields a Chapman layer such as is demanded by the strict theory. The maximum of the layer lies at 51 km; at about 50 km height something like 5 times as much is absorbed as in the interval from 55 to 60 km, referred to the unit height of 1 km."

Mitra, Bhar, & Ghosh (3429 of 1939) have explained the D layer, according to Pannekoek's theory, by the first ionisation potential of oxygen (12.2 eV). "It seems to be an advantage in our calculation that no special assumptions are made, all that is used being Williams's absorption measurements on the one hand and the pressure-distribution in the atmosphere, as given by Penndorf, on the other." It is, however, assumed that neither N^+, N^+_2, O^+, nor O^+_2 possesses appreciable absorption in this part of the spectrum. The writer considers that a certain amount of ionisation according to the Mitra, Bhar, & Ghosh mechanism may be present always and that his own calculations may concern only the supplementary (fade-out) ionisation, happening to occur at the same height. "In any case the question of the absorption of electric waves during solar eruptions, at heights below 60 km, seems to us to be satisfactorily explained."

1826. Spectroscopy in the Vacuum Ultra-Violet [Survey].—J. C. Boyce. (*Reviews of Mod. Phys.*, Jan. 1941, Vol. 13, No. 1, pp. 1–57.)

1827. A Prophecy Fulfilled [concerning Association of Solar-Constant Fluctuations with Rotation Period: Results in 1929/30].—C. G. Abbot. (*Science*, 11th April 1941, Vol. 93, pp. 350–351.)

1828. Sunspot Disturbances of Terrestrial Magnetism [Storm of 24th March 1940 and Its Effect on Power Systems].—W. F. Davidson. (*Elec. Engineering*, Feb. 1941, Vol. 60, No. 2, pp. 72–75.)

1829. Nature of Solar Hydrogen Vortices [Support for Hydrodynamic Theory].—R. S. Richardson. (*Nature*, 10th May 1941, Vol. 147, p. 579: summary only.)

1830. The Motion of Gases in the Sun's Atmosphere: Part I—On the Mechanism of Formation of Solar Dark Markings.—A. K. Das. (*Indian Journ. of Phys.*, Oct. 1940, Vol. 14, Part 5, pp. 369–386.)

"The proposed mechanism appears to be quite general and helps the understanding of certain other solar phenomena [to be considered in later papers] which are not very easily understandable on the basis of existing solar theories."

1831. On Space Closure of Periodic Orbits in the Field of a Magnetic Dipole [in connection with Cosmic Radiation & Aurora].—O. Godart. (*Journ. of Math. & Phys.* [of M.I.T.], April 1941, Vol. 20, No. 2, pp. 207–217.)

1832. Measurement of Atmospheric Ozone by a Quick Electrochemical Method.—F. A. Paneth & E. Glückauf. (*Nature*, 17th May 1941, Vol. 147, pp. 614–615.)

"We hope to employ the method for a systematic study of the occurrence of ozone in the troposphere and lower stratosphere." Data already collected at ground level show an increase of about 100% in the average ozone content from Nov. 1940 to March 1941, constituting an obvious parallelism with spectrographic measurements of the total ozone in the atmosphere and seeming to confirm the views about a correlation between tropospheric and stratospheric ozone.

1833. On the Measurement of Earth Conductivity [on 357 m & 1571 m Waves].—J. Grosskopf & K. Vogt. (*T.F.T.*, Vol. 29, 1940, pp. 164–172: *Hochf:tech. u. Elek:akus.*, Jan. 1941, Vol. 57, No. 1, pp. 28–29—long summary.)

A.—Various measuring methods: the field-strength method: the buried parallel-wires method: the dipole method, using a rotatable dipole to measure the angle of inclination of the field arriving after propagation over the plane ground. B.—Theory of this last method, based on Zenneck's 1907 work: first for homogeneous ground (never really encountered in practice) and then for stratified ground consisting of two layers, following Hack's 1908 treatment. In the special case where the conductivity of the lower medium is infinite, the phase displacement ϕ (Fig 1) is 90° and the width of the now vertical ellipse is proportional to the thickness of the upper medium. If the lower-medium conductivity is not infinite but is very great compared with that of the upper medium, for instance if a badly conducting upper layer has a water layer below it, the phase angle again approaches 90°. But "if, over a comparatively badly conducting lower layer, a better conducting layer is found, the important factor is the thickness of this upper layer. With very small thicknesses the conditions are determined by the constants of the lower layer; with larger thicknesses, by the constants of the upper layer."

C.—Measuring equipment and measurements. A dipole, $1\frac{1}{2}$ m in length and rotatable about horizontal and vertical axes, is mounted in a test truck at a height of 2.5 m above the ground, and connected by a length of cable to a receiver which can be switched at will to a signal generator and calibrated line, for checking purposes. The dipole is first set horizontally and rotated about its vertical axis to determine the plane of incidence of the incoming signals. The dipole is then set in this plane and swung in it about its horizontal axis, giving a reception diagram such as that of Fig. 3, from which the inclination of the axes to the horizontal, and the ratio a/b of the axes, are derived directly, and yield by calculation the phase displacement ϕ. Particular care is taken to allow for the effect of the position of the connecting cable, the effect of the truck, and the influence of the height of the dipole mid-point above the ground.

Measurements were made on a 357 m wave at distances up to 50 km: at two points the 1571 m signals from the Deutschlandsender were used, the greatest distance being 150 km. The values obtained for the ratio a/b naturally varied considerably according to the nature of the ground at the various points: they ranged between 39.7 and 6.30 (the Deutschlandsender values were 43.8). The inclination of the major axis to the vertical ranged from $-0.6°$ to $+12.1°$. The phase displacement ϕ was usually greater than 45°—a sign that the ground had the properties of a stratified system. The conductivity σ was calculated (by the formula $\sigma = \frac{1}{4} f.(a/b)^2$ electrostatic units) even for such cases, where no real single conductivity could exist: what was obtained must be regarded as an "effective" conductivity. It lay between 9×10^{-15} and 1.5×10^{-13} electromagnetic units.

Fig. 4 shows the behaviour of the field-ellipse major axis at various points along the path of a wave encountering the "Glider Hill" in Trebbin. Along the horizontal stretch before reaching the slope, the field leans 6.0° ahead of the vertical: climbing the slope it increases this forward lean only slightly, to 6.7°: along the flat plateau at the top, the tilt increases to 8.3°: but as the wave descends the far slope the tilt becomes 12.1°—that is, the field leans 6.3° ahead, not of the vertical, but of the normal to the hill surface: on the level ground at the far side the forward tilt of 6.0° is restored. This discrepancy between the behaviours on the upward and downward slopes is explained by supposing that the waves partly penetrate the hill and partly bend round it.

1834. The Effect of the Earth's Curvature on Ground-Wave Propagation [Summary of Present Knowledge, and Curves for Rapid Calculation of Ground Wave over Spherical Earth, for Arbitrary Ground Constants, Antenna Heights, & Polarisation].—C. R. Burrows & Marion C. Gray. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, pp. 16–24.)

1835. Hyperbolic Functions of Complex Variables [in Transmission-Line Theory: a Helpful Interpretation].—S. G. Lutz. (*Elec. Engineering*, Feb. 1941, Vol. 60, No. 2, pp. 95–96.)

1836. The Transient Electromagnetic Processes occurring at the Receiving Point when a Constant Electromotive Force is applied to a Line.—V. I. Kovalenkov. (*Automatics & Telemechanics* [in Russian], No. 2, 1940, pp. 7–17).

Continuing previous work (33 of January), a line of length l is considered, loaded with (a) a resistance R_l (Fig. 1) and (b) an electromagnetic receiver of resistance R_l and impedance L_l (Fig. 2). As a first approximation it is assumed that l is sufficiently large, *i.e.* the attenuation is sufficiently high, for the second reflection of the wave from the receiving end to be neglected. On this assumption formulae are derived for determining the receiver input voltage U_{l1} and current i_{l1}, within the time interval t_0 and $3\,t_0$, where t_0 is the instant at which the receiver is reached for the first time by the wave (upper quarter of p. 9 for case *a* and bottom quarter of p. 13 for case *b*). It is pointed out that although similar formulae could be derived for subsequently reflected waves, the complications so introduced would not be justified by practical requirements. Moreover a study of the building up of i_{l1} shows that the formulae derived could be used for any l, however small (at least in the case of a 5 mm iron wire), since the receiving relay will operate before the second reflection takes place.

1837. Electromagnetic Waves in Transformer Coils treated by Maxwell's Equations [Rigorous Solution for Waves in Thin Single-Layer Coil with Concentric Ground Electrode at Short Distance: Surge Impedance is independent of Frequency for Low Frequencies, decreases gradually at Very High Frequencies, Boundary Wavelength depending on Insulating Distances].—R. Rüdenberg. (*Journ. Applied Phys.*, March 1941, Vol. 12, No. 3, pp. 219–229.)

"As an important result of the rigorous theory we have found that, under the stated conditions, tightly-wound coils perform, up to a boundary frequency, along their wires with respect to travelling waves exactly like smooth lines. In the direction of their axis, however, they perform nearly statically . . ." For previous work *see* 305 of February.

1838. On the Problem of Wave-Motion for the Wedge of an Angle.—A. N. Lowan. (*Phil. Mag.*, May 1941, Vol. 31, No. 208, pp. 373–381.) For previous work *see* 3061 of 1939.

1839. The Reflection and Refraction of Photons [on the Writer's Vibratory Electron Doublet Theory].—Taylor Jones. (*Phil. Mag.*, May 1941, Vol. 31, No. 208, pp. 394–404.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1840. The Effective Separation of Points discharging Atmospheric Electricity [with Deductions as to Continuous Rain-Clouds, etc.].—J. A. Chalmers. (*Phil. Mag.*, May 1941, Vol. 31, No. 208, pp. 363–372.)

1841. REMARKS ON MY PAPER "ELECTROMAGNETIC FORCE EFFECTS OF LARGE CURRENTS IN THE INTERIOR OF CONDUCTORS, AND THEIR CALCULATION."—P. Bachert. (*E.T.Z.*, 26th Dec. 1940, Vol. 61, No. 52, p. 1204.) *See* 1772 of 1940.

1842. A MODERN SYSTEM FOR UPPER-AIR INVESTIGATION BY RADIO [including the Radiosonde produced by J. P. Friez & Sons].—L. E. Wood & R. Chappel. (*Proc. I.R.E.*, Dec. 1940, Vol. 28, No. 12, pp. 575–576: summary only.)

PROPERTIES OF CIRCUITS

1843. ELEMENTARY THEORY OF THE SPHERICAL CAVITY RESONATOR.—T. G. Owe Berg. (*Hochf:tech. u. Elek:akus.*, Feb. 1941, Vol. 57, No. 2, pp. 56–60.)

"The following theory . . . was developed by the writer in the autumn of 1939, in connection with the earlier work of Hansen and of Richtmeyer [63, 2295, & 3420 of 1939]. It was the writer's intention to give, in comparison with these papers, an elementary theory using simple mathematical methods. In the meantime, however, a number of papers on the subject have appeared [Borgnis, 61 of January & back references; Müller, 1379 of 1940; and Jouguet, 3419 (and 3873) of 1939], which could not be taken into account by the writer. But the present representation of the theory of the cavity resonator may supplement these works in many respects. We consider a metallic evacuated sphere in a vacuum, in the interior of which electromagnetic oscillations are excited, for example by the demodulation of a velocity-modulated electron ray [Varian & Varian, 2773 of 1939]. We limit ourselves to the case where the excitation of the oscillations results from a radial electric field, for instance from the radial passage of a velocity-modulated ray, so that the magnetic field strength can be put equal to zero. For this spherical cavity we desire to determine the lowest resonance frequency and the corresponding damping of the natural oscillation."

The Maxwellian equations expressed in spherical coordinates take the form shown in eqns. 4 and 5 (putting $\epsilon = \mu = 1$), from which eqn. 6 is obtained when the magnetic field strength is put equal to zero. In three successive sections the solutions of eqns. 5 and 6 are found for inside the cavity (eqn. 14), in the metallic wall (eqn. 18), and outside the sphere (eqn. 19). In the case where the external radius of the sphere r_a is infinity, so that the wall is so thick that of the oscillations in the internal space nothing whatever penetrates the outer surface, in eqn. 18 C must be put equal to zero, in eqn. 19 F must be equal to zero: eqn. 20 then changes to eqn. 22. On account of the small depth of penetration of the ultra-high-frequency radiation, the case $r_a = \infty$ can be considered a good approximation for practical purposes, and eqn. 22 is therefore used in order to obtain the fundamental resonance frequency ω_0 and the damping constant b. Only approximate solutions are possible, and it must be assumed that σ is large. From eqns. 23 & 24 it is found that for a 10 cm wave the term $b/2\omega_0$ is of the order of 10^{-4} or less: neglecting it, therefore, in comparison with unity, the following formulae are obtained: $\lambda = 2.29\ r_i$ (where r_i is the internal radius of the sphere) and $b = 0.496 \times 10^{-3}\ \omega_0\sqrt{\omega_0/2\pi\sigma}$ or, in terms of the specific resistance ρ and of the wavelength in centimetres, $b = 1.71 \times 10^{6} \times (1/\lambda)\sqrt{\rho/\lambda}$. The curve of Fig. 1 shows the damping b of a resonator of copper ($\rho = 0.0175$), calculated by this formula, as a function of the resonance wavelength.

If σ is put equal to infinity in eqn. 23 the equation used by Hansen for the calculation of ω_0 is obtained. In this case, of course, the above formula gives $b = 0$. If, in that same formula, the factor of merit $Q = \omega/2b$ is introduced instead of b, then $Q = 1.10 \times 10^3\sqrt{\lambda/\rho}$. According to Hansen, $Q = 3.46 \times 10^5\sqrt{\lambda/\rho}$.

This discrepancy is presumably due to a difference in the values used for ρ. "If in Hansen's formula $\rho = c^2/\sigma$, then ρ must be 10^5 times greater in that formula than in the writer's. By dividing by $\sqrt{10^5}$ Hansen's formula is converted exactly into the writer's formula."

1844. SINUSOIDAL VARIATION OF A PARAMETER IN A SIMPLE SERIES CIRCUIT.—Maginniss. (*See* 1866.)

1845. ELECTROMAGNETIC WAVES IN TRANSFORMER COILS TREATED BY MAXWELL'S EQUATIONS.—Rüdenberg. (*See* 1837.)

1846. A COAXIAL FILTER FOR VESTIGIAL-SIDEBAND TRANSMISSION IN TELEVISION [with Cut-Off Sharpness of 32 db per 1% Frequency Change: Very Compact Structure].—H. Salinger. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 533: summary only.)

1847. RADIO-FREQUENCY MATCHING SECTIONS [Charts for Computation of L-Type Sections for Matching (*e.g.*) an Aerial to Its Feeder].—A. C. Omberg. (*Electronics*, Jan. 1941, Vol. 14, No. 1, p. 43.)

1848. AN ANALYSIS OF THE FUNDAMENTAL PROPERTIES OF BRIDGE FILTERS.—V. N. Listov. (*Automatics & Telemechanics* [in Russian], No. 2, 1940, pp. 19–38.)

The bridge filter in its simplest form consists of four impedances connected in a Wheatstone bridge circuit, the impedances of the opposite legs of the bridge being equal (Fig. 1). The frequency band to be filtered is applied to one of the diagonals of the bridge and the output is taken from the other diagonal. An extremely elaborate theory of this filter was evolved by Cauer, and many attempts have been made to simplify it sufficiently for ordinary design work. In the present paper a further simplification is attempted and numerous tables are given, including a classification table 10 of various types of filter, using a symbolical notation. In conclusion the consecutive stages of the design of a filter bridge are set out.

1849. ON ROCHELLE-SALT VIBRATORS FOR USE IN FILTERS [Experiments with A-Cut and B-Cut Rectangular Vibrators: Steepness of Resonance Curve about 1/10th of That of Quartz Crystal, and L is Small & C is Large: Many

Problems to be Solved: etc.].—Z. Kamayachi, T. Ishikawa, & E. Kamizeki. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, p. 195: summary only.)

1850. EXPERIMENTS ON THE ROCHELLE-SALT FILTER [for Carrier Frequencies below 50 kc/s, where Quartz is Inconvenient: Transmission Characteristics of Lattice-Type Rochelle-Salt Filter, and the Effects of Temperature, Moisture, & Impressed Voltage].—M. Monji & I. Kuwayama. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, p. 235.)

1851. A TRANSFORMATION EXTENDING THE USE OF HEAVISIDE'S OPERATIONAL CALCULUS [without Restriction on Initial Conditions].—P. L. Morton: Meyerhoff & Reed. (*Elec. Engineering*, Feb. 1941, Vol. 60, No. 2, p. 94.) "A more straightforward method" than that dealt with in 339 of February.

1852. D.C. CIRCUITS WITH NON-LINEAR IMPEDANCES.—V. E. Vartelski. (*Automatics & Telemechanics* [in Russian], No. 2, 1940, pp. 63–75.)

Circuits are often met with in practice containing elements having non-linear impedance, such as electron and ion tubes, copper-oxide rectifiers, transformers with saturated iron, etc. The design of such circuits by analytical methods presents great difficulties, especially in the case of elements with varying degree of non-linearity. Graphical methods are therefore proposed, and various types of circuits such as series and parallel circuits, mixed circuits, and circuits with several sources of current are considered. A particularly simple solution is obtained in the case of an unbalanced Wheatstone bridge, where for any number of non-linear impedances (of any type) a single diagram is derived giving voltage drops and currents in all components of the circuit.

1853. A CIRCLE DIAGRAM FOR THE CALCULATION OF THE PROCESSES ON LINES.—H. H. Meinke. (*Hochf:tech. u. Elek:akus.*, Jan. 1941, Vol. 57, No. 1, pp. 17–23.)

"With the recent application of very short waves the theory of the processes on lines becomes of fundamental importance. . . . The formulae for the input resistance of a damped line with arbitrary termination are almost always too lengthy for the applications. There is a general tendency, therefore, to simplify the work of calculation by the use of diagrams. That of O. Schmidt for the undamped line is well known [1933 Abstracts, p. 222]: the diagram is, unfortunately, infinitely extended, so that it can be drawn in parts only, and fails at large values of out-of-matching. This disadvantage is avoided by the diagram of P. Smith [1372 of 1939] which is derived from the other by a suitable co-ordinate-transformation and has a finite extension.

"The difficulties are much greater when it comes to a damped line. In the first part of the present work it is therefore shown what possibilities exist for a diagram of a damped line. In the second part the use of the diagram is extended to lines with certain definite discontinuities [Fig. 3: a series of lengths l_1, l_2 . . . l_n of homogeneous lines with discontinuous linkages $\ddot{u}_1$, $\ddot{u}_2$ . . . $\ddot{u}_n$ which may take the form of a change of characteristic impedance (Fig. 4, top), the insertion of a local, concentrated series reactance without change of characteristic impedance (Fig. 4, middle), the similar insertion of a parallel reactance (Fig. 4, bottom), or a combination of these three simple possibilities]. The third part gives a few applications."

1854. REMARKS ON MY PAPER "ELECTROMAGNETIC FORCE EFFECTS OF LARGE CURRENTS IN THE INTERIOR OF CONDUCTORS, AND THEIR CALCULATION."—P. Bachert. (*E.T.Z.*, 26th Dec. 1940, Vol. 61, No. 52, p. 1204.) *See* 1772 of 1940.

1855. ON THE DEGREE OF IMPROVEMENT OF THE DISTORTION FACTOR IN DUPLEX-FEEDBACK AMPLIFIERS [Comparison with Negative-Feedback Amplifiers: 10 db Superiority of Former over Latter Type].—Z. Oizumi & T. Hara. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 190–192.)

TRANSMISSION

1856. A RECENTLY DEVELOPED CIRCUIT FOR THE GENERATION OF POWER AT ULTRA-HIGH FREQUENCIES [by Valves of Conventional Design in High-Efficiency Frequency-Multiplying Circuits: depending on the Phase Characteristic of Associated Circuits].—A. L. Nelson. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 532: summary only.)

1857. DRIFT ANALYSIS OF THE CROSBY FREQUENCY-MODULATED TRANSMITTER CIRCUIT.—E. S. Winlund. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 534: summary only.)

1858. THE GENERATION OF OSCILLATIONS BY MULTI-STAGE LINEAR RESONANCE RETARDATION [in Devices analogous to the Linear Electron Accelerator].—H. E. Hollmann & A. Thoma. (*Hochf:tech. u. Elek:akus.*, Jan. 1941, Vol. 57, No. 1, pp. 10–14.)

Since the dynamic internal resistance of a resonance accelerator (Wideroë, 1929 Abstracts, p. 169, and Lawrence's cyclotron) is subject to an inversion law, it can be positive only for definite conditions of path time. The principle must therefore offer the possibility not only of resonance acceleration of the charged particles (with removal of energy from the h.f. voltage source and its conversion into kinetic energy) but also of resonance deceleration of the particles, in which case the direction of the energy exchange is reversed, the internal resistance becomes negative, and the ion or electron current returns a part of its kinetic energy to the modulating h.f. source in the form of h.f. energy. In suitable conditions this delivery of energy may be large enough to make an external modulating source unnecessary: the resonance-deceleration device becomes self-exciting and behaves as a generator (K. Fritz, Brit. Pat. 488 094).

Most dynamic oscillation generators (such as the retarding-field valve and the magnetron) have their mode of action fundamentally traceable to multiplicative resonance-deceleration: but the electron dynamics of such devices are extremely complicated. The one exception which lends itself to such a treatment is the Heil two-field chamber. The writers, therefore, take the circuit of the well-known multi-stage linear accelerator and examine the possibilities of converting it into a Heil generator with a performance improved because of the added stages. Fig 1a and b show two possible arrangements, the first having a series of "work cylinders" $z_1, z_2 \ldots z_n$ all connected in parallel but separated from each other by a series of intermediate cylinders $Z_1, Z_2 \ldots Z_{n-1}$ all at the anode potential, and the second having all "work cylinders" and no intermediate cylinders, the "work cylinders" being divided into two groups $z_1, z_3 \ldots$ and $z_2, z_4 \ldots$, and the two groups being worked in a push-pull connection. The highest possible modulation factor M_{max} is given by the requirement that the final velocity should not be imaginary (*cf.* 1640 of June) and for these optimum modulation factors the efficiencies of the Heil two-field chamber (broken line), the push-pull deceleration tube with 2 cylinders (full line) and with 3 and 4 cylinders (dotted lines) are calculated and shown in Fig. 2 as functions of the angular length of the "work cylinder." The efficiency of the 2-cylinder push-pull arrangement (35.5%) is seen to be more than twice as high as that of the simple Heil device. The 3-cylinder arrangement has about the same efficiency as the 2-cylinder but requires a fuller modulation (32.6% compared with 29%), the 4-cylinder arrangement is much worse because its path-time compression is out of phase. In practice, therefore, there is no advantage in exceeding two "work cylinders." The introduction of intermediate cylinders (at anode potential) of various angular lengths between a 2-cylinder push-pull arrangement also produces no improvement (Fig. 3) in efficiency.

The writers then consider a second factor affecting the merits of a generator, namely the internal resistance: for matching purposes at these extremely high frequencies it is important that this should not be too large. They suggest, therefore, that a quantity G should be defined, representing the "factor of oscillatory merit," and consisting of the ratio efficiency/internal-resistance: so that for the parallel-feed system $G = \eta/R_i = 2(\eta/M)^2 . I_o/U_a$ and for the push-pull system, because this requires twice the h.f. voltage, $= \frac{1}{2}(\eta/M)^2 . I_o/U_a$. For the Heil chamber the value reached is only 0.14 I_o/U_a, while the 2-cylinder push-pull arrangement at its best gives 0.72 I_o/U_a. A figure for the Klystron generator is given, at 0.67 I_o/U_a. Turning then to a consideration of the parallel system, with 2 "work" cylinders and 1 intermediate, the writers give the full-line curve of Fig. 4 for the efficiency at $M = 38\%$: this reaches the value of 45% (higher than that of the best push-pull arrangement) but what is more important, G comes out at 2.8 I_o/U_a. This is for an angular length of the intermediate cylinder equal to that of the two "work" cylinders: but if these angular lengths are adjusted to the optimum, practically the same high efficiency can be obtained with a G-value of as much as 3.6 I_o/U_a, five times as big as that of the push-pull arrangement and twenty-five times greater than that of the simple Heil chamber. With 3 "work" cylinders in parallel and 2 intermediate cylinders the dotted curves of Fig. 4 are calculated, showing again that as regards efficiency the 2 "work" cylinders cannot be improved on, but that the figure of merit for the 3-cylinder arrangement, at optimum $M = 15\%$, rises to nearly 7 I_o/U_a. In general, the figure of merit increases with an increasing number of cylinders, since the most favourable path-time compression is always to be reached as the h.f. voltages decrease: but the attainable energy transformation decreases at the same time because of the increasing number of "double layers" (*see* p. 11: the cylinders form a h.f. electron-lens system, and as an approximation each lens is treated as a homogeneous electrical double layer).

1859. TRANSVERSELY-CONTROLLED CATHODE-RAY TUBES WITH TRANSVERSE WORK FIELD [for Generation & Amplification of Ultra-Short Waves].—H. E. Hollmann. (*Hochf:tech. u. Elek:akus.*, Feb. 1941, Vol. 57, No. 2, pp. 33–40.)

"The writer and A. Thoma have shown for the first time in previous researches [3840 of 1938 and back references] that the energy conversion in the transverse vibration of an electron ray in an ultra-high-frequency field is subject to an inversion law; that is, the ray can not merely take up energy from the condenser field but can also give out energy to this field. Later, these inversions were demonstrated experimentally with the help of a ballistic transversely vibrating model [1376 of 1940]. Now, in the present paper, the problem will be developed further, in that the electron ray, before its entry into the plate condenser, is set into forced vibrations by an external ultra-high frequency control. The necessary arrangement, which was given some years ago by the writer as a means of generating and amplifying ultra-short waves (see for example Hollmann, French Pat. 818 706, priority 1936), is shown diagrammatically in Fig. 1.

"The new transverse-modulation tube contains, in addition to the usual electron gun K and a collector-anode A_2, an u.h.f. control field produced by the input potential $2u_o \sin \omega t$ between the two control plates P_1 and P_1', and a "work" field due to the potential $2U_o \sin \omega t$ induced in the load circuit S and acting between the two "work" plates P_2 and P_2'. From the steady-potential standpoint all the plates are at anode potential. The "formats" of the two transverse fields are defined by $F_1 = l_1/2a_1$ and $F_2 = l_2/2a_2$, where a_1 a_2 are the distances of the plates from the axis. The longitudinal space between the two plate systems is L, which is thus the "lever" length of the free beam. The times at which the electrons enter and leave the two fields are t_0, t_1, t_2, and t_3.

To obtain a preliminary, idealised dynamic theory for negligibly small "work" potentials, certain simplifying assumptions are made: thus the "lever" length L is taken to be so large that the beam movement in the "work" field may be considered as parallel to the axis, and format F_2 of the "work" field is taken to be so large that the condenser space can be considered as shut off from field-free outer space by two leakage fields of negligible thickness, such as might extend between two pairs of ideally transparent grids, one of each pair passing through the edges of the plates and the other at a short distance d from the first. Electron kinematic considerations then yield eqn. 2a for the velocity on entering the "work" field. This equation shows that the electrons suffer a two-fold modulation of their velocity, the first by the variation, in time, of the stray field at the entrance (amplitude or modulation depth M_2 given by U_o/U_a) and the second a modulation governed by the external control, having a geometrical depth N_2 given by y_{20}/a_2 (Fig. 3). Thus eqn. 2a can be re-written as eqn. 2b: $v_2 = v_o \ [1 + \frac{1}{2} M_2N_2 \{\cos(2\omega t_2 + \psi) + \cos \psi\}]^{\frac{1}{2}}$, where ψ (*see* eqns. 1a & b) represents the phase position of the useful potential with respect to the ray deflection at time t_2. With the further simplifying assumption that M_2 is small compared with unity, this equation yields an approximate equation for the velocity v_3 of emergence from the "work"-field system, and from this and other equations formula 4 is obtained for the efficiency: $\eta = -50MN[\cos(\phi_{20} + \psi) - \cos \psi]$, and η under the most favourable conditions cannot exceed 10%.

To get away from the limitation of M_2 to the small values such as 10% for which alone eqn. 4 is valid, the picture of what happens in the "work" field must be changed from Fig. 3 to Fig. 4, where the anode retroaction, hitherto neglected, is seen to produce an additional bending of the ray as it passes between the plates, and also to change the geometrical control in the stray field on the emerging side, previously taken as similar to that at the entrance. The full expression for the efficiency η now becomes that given in eqn. 7. Consideration of conflicting factors in the choice of a value for the format F_2 leads to a compromise at about unity (but *see* later). Under the best conditions (including the calculated optimum of 56% for M_2) the max. efficiency is calculated to be 43.5% (dotted curve in Fig. 5).

Section IV deals with the further modifications to the simplified theory which must be made to take into consideration the path-time compression (Hollmann, 2544 of 1940) both in the "lever" space (*i.e.* the space L between the two deflecting systems) and in the "work" field. In the "lever" space the modulation of the axial component of the ray velocity, which produces a density modulation of the electron flow, depends on the angle α at which the ray leaves the first condenser P_1, P_1'. If the deflection is quasi-static, that is if the path-angle ϕ_{10} between the plates is negligibly small, eqn. 9 is obtained, which shows that the axial velocity of the electrons in the lever space is modulated with twice the external control frequency. Fig. 6 shows an "instantaneous photograph" of a transversely modulated ray and the resulting path-time compression in the "lever" space. By the time the additional compression in the "work" field of the condenser P_2, P_2' has been taken into consideration (subsection $_2$), the original simple equation for the efficiency η given in eqn. 4, already elaborated into eqn. 7 to allow for anode retroaction, now takes the complicated form of eqn. 14. In order that the path-time compression, here allowed for, may improve the efficiency above that given by eqn. 7, the angular length Φ_o of the "lever" ray must be equal to $\pi/4 + n\pi$, where $n = 1, 2, 3, \ldots$ The Bessel function reaches its highest value when $Q^2 = P^2 + (p/2)^2 = 3.4$, where P is the compression factor for the "lever" space, p the additional factor for the "work" field, and Q the resultant over-all compression factor. This condition yields information as to the best working conditions, and when these are assumed the calculated efficiency, as seen in the full-line curve of Fig. 5, reaches a value of 68%.

Section V deals with the design-calculations of such a tube. Making N_2 as large as possible (*i.e.* as near unity as possible, so that the ray oscillates nearly the whole distance between the "work" field plates) it appears that the "lever" length L can only be one-fifth as long as the "work" plates if the conditions for the best utilisation of the path-time compression are to be fulfilled: but this would sacrifice the great advantage of the "lever" action. The best compromise seems to be to abandon the advantage of path-time compression in the "lever" space while maintaining that in the "work" field: the resulting calculated efficiency is seen in the intermediate, broken-line curve of Fig. 5, where it reaches 60% instead of the full 68%. With a ray velocity of 1000 volts and a current of 20 mA in the form of a flat beam, the calculated internal resistance of the "work" system comes out at 5.2×10^4 ohms. If, with accurate matching, etc., the optimum modulation depth $M_2 = 56\%$ (spoken of above) is obtained, the attainable voltage amplification should be 55 if a format $F_1 = 3$ is chosen. Without optimum conditions of matching it seems possible to obtain in practice a 10-fold voltage amplification on centimetric waves. Section VI describes electron-spectroscopic investigations with a filamentary ray in the gas-focused tube shown in Fig. 7: the modulating condenser is seen at K_1 and the "work" condenser (with $F_2 = 2$) at K_2. After passing through the anode stop A closing the "work" system, the ray enters an "electrostatic prism" P (consisting of two plates at different d.c. potentials) by which it is analysed so as to form on the fluorescent screen a "spectrogram" similar to a Lissajous' figure. The actual photographs shown in Figs. 10 a–c, taken with an anode voltage of 700 v and a wavelength of 148 cm, agree well with the calculated figures of Figs. 8 and 9; such records can be made to yield data from which the efficiency can be calculated. But such a "test" tube is very different from a practically useful tube with a flat ray of real energy: the development of such a tube must await a later opportunity for its reporting.

1860. ON THE BUILDING-UP PROCESS OF THE TRANSIT-TIME OSCILLATIONS OF THE MAGNETRON [of Particular Interest in connection with Pulse Transmissions].—H. J. Schmidt-mann. (*Hochf:tech. u. Elek:akus.*, Feb. 1941, Vol. 57, No. 2, pp. 40–47.)

Munich Dissertation, Oct. 1939, aided by a research grant from the D.V.L., Adlershof. Straightforward methods of investigation are first discussed. In these the voltage is alternately switched on and off the transmitter and the building-up and decay processes are recorded, either by a cathode-ray oscillograph or by dealing with the oscillations by a receiver with rectification, so that the received-current/switching-frequency characteristic gives a measure of the speed of rise and fall of the oscillations. Such methods, however, run into difficulties when tried at the ultra-high frequencies here considered, chiefly because at these frequencies it is almost impossible to make the switching-on and -off processes short compared with the period of oscillation. A third method is therefore proposed, which consists in modulating the oscillations (of frequency f) by a sinusoidal voltage of frequency f_M small compared with f. If the amplitude curve of the modulated oscillation is compared with the curve showing the temporal variation of the modulating voltage, the former curve will lag behind the latter more and more, the slower the rise and decay processes of the oscillations of the h.f. generator. The speed of building-up and decay thus expresses itself as a phase displacement between the two curves. For one and the same generator the displacement ϕ increases, the higher f_M is made and the greater its amplitude. If, therefore, with two different generators, or the same generator under two different types of working régime, one compares the curves which represent this phase displacement as a function of f_M or of the modulating amplitude, one can draw at least qualitative conclusions as to the ratio of the speeds of building-up and decay in the two cases and therefore as to comparative "reaction speeds" of the two generators or the two régimes.

The phase displacement ϕ is very simply obtained by making the modulating voltage U_M deflect the cathode-ray spot in a vertical direction while the modulated h.f. voltage deflects it in the horizontal direction. The type of figure obtained on the screen is seen in Fig. 9: it consists of two horizontal lines, the upper one somewhat shorter than the lower but situated symmetrically with respect to it: from the left-hand end of the upper line an ellipse slopes down to the left to join the left-hand end of the lower line, and a similar ellipse, sloping down to the right, joins the right-hand ends. From these ellipses ϕ is obtained by the formula $\sin \phi = a/x_0$ (Fig. 10). A single ellipse of the same form, but with its mid-point at the origin of the coordinates (Fig. 23) is obtained if the modulating voltage is applied, as before, to one pair of plates, while the other pair is supplied with the rectified oscillation ("amplitude curve") instead of with the modulated h.f. voltage. The oscillograms of Figs. 11–15 all concern a series of orienting tests on a long-wave back-coupled oscillator with modulating frequencies of 1, 5, and 8 kc/s. Then in section II the method is applied to a magnetron oscillator equipment working on a fixed wavelength of 1.86 m.

As finally selected, the equipment used a four-slit Telefunken LM29 with anode-voltage modulation. Part of the alternating voltage from the modulation generator was sent through a phase-adjuster (Fig. 22) to the horizontal-deflection plates (Fig. 16), while the other pair of plates received the voltage, rectified and amplified, from the ultra-short-wave receiver (Figs. 19–21) whose loop picked up the oscillations from the magnetron circuit. The insertion of the phase adjuster was necessary to compensate for the "basic phase displacement" due to the receiver amplifier. Ten series of measurements were made (*see* table on p. 45): the first three series were made to test the accuracy of the method, and Fig. 26 shows that the individual values of ϕ deviate from the mean curve only by $\pm 1.0°$: this is confirmed by the other series. In all these diagrams the angle denoted by ϕ is the gross angle made up of the basic phase displacement (*see* above) and the phase angle between the demodulated oscillation and the modulating voltage. Series 4 & 5 (Figs. 27 & 28) show that the amplitude of the modulating voltage, and the anode d.c. voltage, have only a slight effect on the phase displacement; which is, moreover, practically independent of the filament-heating voltage (series 8, Fig. 29). In the above series the modulating frequency was 115 kc/s, and the mean nett phase displacement was $8° \pm 1.0°$. Series 9 had $f_M = 230$ kc/s: again no change in ϕ for varying amplitude of modulating voltage could be found: the mean nett displacement was $16.0° \pm 1.5°$. In series 10, f_M was 460 kc/s, and here a change in ϕ appears: for modulating voltages below and up to 35 volts the nett ϕ was $19.0° \pm 2.0°$, for higher voltages it was $29.5° \pm 3.0°$ (Fig. 30). The two values apparently refer to two different oscillation régimes. The variation of the mean phase displacement with the various modulating frequencies 115, 230, and 460 kc/s is plotted in Fig. 31, where the isolated point right away from the line must be the lower, low-modulation reading of Fig. 30.

1861. THE SETTING UP OF RETARDING-FIELD OSCILLATIONS AT HIGH ALTERNATING VOLTAGES.—W. Kleinsteuber. (*Hochf:tech. u. Elek:akus.*, Jan. 1941, Vol. 57, No. 1, pp. 1–10.)

From the Julius Pintsch laboratories. As a general rule the behaviour of a h.f. generator is treated theoretically on the assumption of very small amplitudes. If larger amplitudes are to be considered—as is necessary when dealing with efficiencies or with modulation—the calculations must be extended. Such is the purpose of the present work, whose main result has already been employed in the writer's paper (with Allerding & Dällenbach, 2258 of 1938) on the Resotank microwave generator. In a later work the calculations will be extended to other transit-time oscillations, such as those given by the diode with positive anode (dealt with by Benham and others) and by velocity modulation.

The following assumptions are made:—the alternating voltage is between two neighbouring electrodes, *e.g.* between grid and anode as in Fig. 1: these electrodes are parallel planes, between which lie the h.f. field and the d.c. field (homogeneous field): the electrons move perpendicularly to these planes, and the electron motion is not influenced by electron space charge (*see* beginning of section II): the initial velocity of the electrons, at the cathode, is put at zero: and no "sorting-out" process at the electrodes is taken into account (*see* end of section IV on p. 7). Finally, the special assumption is made that there is no "electron swinging" round the grid: it is assumed that those electrons which pass through the grid plane a second time are caught by the grid and do not enter again into the h.f. space between grid and retarding electrode (*see* parts of section IV on pp. 5 and 6: it is concluded that this rejection of the "electron dance" is justified by the good agreement between the experimental and theoretical curves thus obtained, and also on other grounds): thus no "natural frequency" of their own is attributed to the electrons.

From the author's summary:—"Two methods are described, the first being the development of the 'generator current' into a power series in powers of the alternating-voltage amplitudes, and the second being an integral representation [graphical method] of the 'generator current' [in both cases, the "generator current" is as defined at the beginning of section II]. The results obtained are valid also when the overtaking of earlier-starting electrons by later-starting ones takes place. An equivalent circuit is obtained for the generator; its components R_{ge} and L_{ge} [*see* Fig. 5] are determined by the d.c. current $\bar{i}$, the electrode spacing d, the transit angle α [$= \omega\tau$ . . . eqn. 10, 1] and the alternating-voltage amplitude [K: *see* eqn. 10, 2]. It is found from this how sharply the negative initial conductance falls as the alternating voltages increase in amplitude, and it is seen that the point in the $\bar{\bar{U}}_1$, $\bar{\bar{U}}_2$ plane, for the best setting-up of oscillations, is also approximately the point for the best efficiency [the good agreement between the two methods of treatment is indicated by the two efficiency curves of Fig. 8]. It is also seen that the efficiencies for the higher oscillation zones, characterised by a greater transit time, are smaller, in contrast to their oscillation-tendency (initial conductivity) which is higher in the higher oscillation zones. The curves derived show the dependence of frequency on the transit angle α and on the alternating-voltage amplitude: this supplementary frequency dependence of an oscillatory circuit on the a.c. amplitude is, however, negligible for such values of α as give the best efficiencies."

1862. THEORY OF FREQUENCY STABILISER FOR DECIMETRIC WAVE USING METALLIC ELLIPSOID.—K. Morita. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, pp. 229–230.)

"It has already been published some time ago [*see*, for example, 3168 of 1938] that a frequency stabiliser can be made of a metallic ellipsoid with antenna arranged along its focal axis and each dimension selected to suit the particular wavelength for which it is designed. This paper, however, deals with its theoretical discussion, pointing out that the frequency stability depends upon series resonance due to the capacitive reactance of the antenna and the inductive reactance of the metallic ellipsoid. Moreover, if this theory is further extended, it is possible to foresee many interesting applications of ellipsoid."

1863. ON THE FREQUENCY VARIATION OF VACUUM-TUBE OSCILLATOR BY THE DYNAMIC INTERNAL CAPACITY OF VACUUM TUBE [at Short & Ultra-Short Wavelengths: Measurements & Conclusions].—S. Uemura. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 151–154.)

"As shown in the above, the dynamic internal capacity is determined by the working condition of the vacuum tube. Therefore a change in the frequency becomes noticeable as the capacity of the tuning circuit becomes smaller. At a frequency less than 1000 kc/s C is fairly large and therefore the influence of C_d [the dynamic internal capacity due to moving charges and stationary space charge] is comparatively small, but at a frequency greater than 1000 kc/s the influence of C_d increases, varying directly with the frequency: it is very large at ultra-short waves and becomes one of the causes of the frequency variation. For the stabilisation of the oscillation of the ultra-short waves, various types of high-Q circuit are constructed, but from the standpoint of making the influence of C_d smaller it is rather important to make C larger instead of making Q larger, and in order to make C larger it is required to make Q larger." For complementary work on the influence of non-linear characteristics on the frequency, *see* 1864, below.

1864. ON THE INFLUENCE OF HARMONIC VOLTAGE [resulting from Non-Linearity of Valve Characteristic] UPON THE FREQUENCY OF VACUUM-TUBE OSCILLATOR [leading to Stabilisation Method based on Introduction of Harmonic Voltage at Suitable Phase Angle].—S. Uemura. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, p. 193: summary only.)

1865. A LOW-POWER TRANSMITTER FOR DEMONSTRATING FREQUENCY-MODULATION RECEIVERS.—M. Hobbs. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 20–23 and 86.)

1866. SINUSOIDAL VARIATION OF A PARAMETER IN A SIMPLE SERIES CIRCUIT [in connection (*e.g.*) with Amplitude & Frequency Modulation: Comparison of Case (already studied) when L or C varies as $1/(1 + k\cos\omega_s t)$ with That when it varies as $(1 + k\cos\omega_s t)$].—F. J. Maginniss. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, pp. 25–28.) *See*, for example, 2959 of 1940 (Brainerd) for the case already studied.

1867. LINEAR PLATE MODULATION OF TRIODE RADIO-FREQUENCY AMPLIFIERS [Analysis & Experimental Confirmation: System in which Grid-Excitation Voltage & Bias Potential are modulated together with Plate-Supply Potential: Detrimental Effects of Secondary Emission, etc., avoided].—C. Y. Meng. (*Proc. I.R.E.*, Dec. 1940, Vol. 28, No. 12, pp. 563–569.)

1868. OPERATION OF THE CLASS C MODULATION SYSTEM [Graphical Treatment showing Low Distortion, & Good Plate Efficiency, when Ratio Load-Resistance/Internal-Resistance is about 10 (assuming Valve Characteristic to be approximately Linear): Measured Distortions 2.7% & 5.7% at 60% & 95% Modulations].—M. Matudaira & I. Oguma. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 171–175.)

1869. A PERCENTAGE MODULATION METER [of Economical Design, using Same Meter to read Carrier Current & Percentage of Modulation].—S. T. Carter. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 50..56.)

1870. Study of the Short-Wave High-Power Telephone Transmitter with Class B Plate Modulator, and Its Comparison with the Low-Power Modulation System.—I. Taki. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 142–150.)

1871. A Twin-Channel Single-Sideband Radio Transmitter [providing Two Channels with Voice Bands 2750 c/s Wide or a Single Channel for 100–6000 c/s (Single or Double Sideband)].—K. L. King. (*Bell Lab. Record*, March 1941, Vol. 19, No. 7, pp. 202–205.)

1872. Sine Waves in Resistance-Capacity Oscillators [Development of Fundamental Basis of Operation of Inductance-less Sine-Wave Generator: Expressions for Frequency & Conditions for Oscillation: Experimental Confirmation].—P. S. Delaup. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 34–36.)

RECEPTION

1873. New Ultra-Short-Wave Frequency Changer: Neutralising Space-Charge Coupling in a Parallel Push-Pull Circuit [using the 6K8G Triode-Hexode].—J. A. Sargrove. (*Wireless World*, May 1941, Vol. 47, No. 5, pp. 124–127.)

"The normal commercial 6K8G valve can [in this way] be used up to frequencies of the order of 100 Mc/s. At first sight this may seem a surprising result, as the valve in question has a normal bakelite base, and thus is subject to the usual leakage troubles. However, in the ordinary type of simple mixer circuits, leakage was usually blamed for much graver troubles which occurred in the long electrode leads between the valve proper and the valve pins. Owing to the automatic neutralisation described above many of these detrimental couplings are rendered innocuous . . ."

1874. The Magnetron as Receiver for Centimetric Waves [including the Use of Super-Regeneration].—H. Schmersow. (*Hochf: tech. u. Elek:akus.*, March 1941, Vol. 57, No. 3, pp. 65–74.)

In reception and propagation experiments on these wavelengths, such as those of Esau & Ahrens (4144 of 1938) the best results have been obtained with magnetron receivers. The present paper reports on systematic laboratory tests (made to imitate, as closely as possible, the conditions of actual service) on such receivers, using magnetrons of various different types. The difficulties of such tests are first described, such as those caused by the formation of standing waves by reflections from walls and from people. Another great source of trouble was the lack of reliable measuring instruments: thus results with a bolometer calibrated with d.c. were often falsified by resonance effects in the bolometer. Again, the production of a steady, reproducible amplitude modulation, free from frequency modulation and constant over a range of frequencies, was difficult to obtain: even a good method like the voltage-modulation of a glow-discharge tube, whose resistance variations affected the radiation from the aerial, was vitiated by a gradual change in the gas pressure through absorption in the electrodes. The method finally adopted was to modulate "mechanically" at a frequency of 500 c/s, by interrupting the steady radiation from the dipole aerial by a rotating aluminium disc, with segments cut from it, mounted a few millimetres in front of an aperture in the box screening the transmitter and dipole. The modulated beam could be progressively weakened, before reaching the receiving room, by adjusting the orientation of a parallel-copper-wire grid through which it had to pass. The distance between transmitter and receiver was only 5.50 m. As in the generation of centimetric waves, so also in their reception, the two-slit magnetron was better than the four-slit type because its dimensions could be made smaller: this design and the whole-anode type were therefore used exclusively, with various anode dimensions and with or without a short-circuiting bar to form an internal resonant circuit (Fig. 4b). The loose capacitive coupling to the Lecher system (Fig. 4c), successful as it had been found for transmission, was soon rejected for reception in favour of a galvanic coupling.

The full scope of the tests can be gathered from the discussion of the results, given in section v and partly outlined below. The functioning of a magnetron as a receiver differs from its functioning as a transmitter in that it involves rectification in addition to damping-reduction. The difference is made evident when the working point is considered: for this purpose, instead of the usual "magnetron" characteristic (anode-current/magnetic-field), the writer takes the anode-current/anode-voltage curve for a constant field (Fig. 22), and points out that whereas the generation of oscillations involves only the lower part of the curve (the optimum working point lying on the lower half of the rise), for reception the optimum working point is always to be found in the upper half of the rising portion, so that the working region includes the upper bend. This means that the peak point of the electron paths in the receiving valve is closer to the anode than in oscillation production. A picture of the mode of action of the rectifying and damping-reduction processes, on lines analogous to Hollmann's treatment of the retarding-field valve, is given in the r-h column of p. 73: it involves the formation of a virtual cathode and the relation between the carrier frequency and the electron rotation frequency.

In general, the working point which is optimum for rectification does not coincide with the optimum for regeneration, so that for reception with regeneration the working point arranged by adjusting the working conditions must represent a compromise. The adjustment is mainly accomplished by varying the magnetic field and the anode voltage: by the former, the correct rotation frequency is obtained—that is, the receiver is tuned to the signal wave: by the latter, not only is the electron acceleration arranged for but also the radius of curvature of the electron paths—that is, the distance of the virtual cathode from the anode, and hence the degree of regeneration—is adjusted. Other working conditions have minor effects only, influencing the space charge and the exact position of the working point: thus if the emission is increased while the field and anode-voltage remain constant, the space charge increases, the rotation frequency diminishes, and a detuning occurs (with respect to the signal frequency) which must be corrected by an increase of the anode-voltage.

Without the use of super-regeneration, the adjustment of the working conditions is critical: reception occurs only over a small range of anode voltage. If a super-regenerative voltage is superposed on the anode voltage, this range is widened. Best reception occurs when the d.c. anode voltage is so adjusted that the resultant voltage remains as long as possible in the optimum region; that is, when the peaks of the resultant voltage lie in this region. This condition can be fulfilled in two ways, by choosing the d.c. voltage so that it is either below or above the optimum value, by the amount of the super-regenerative-voltage peak value. This accounts for the appearance of two maxima spaced by twice the value of the super-regenerative voltage (Figs. 14 & 15 and adjacent text, where it is mentioned that this effect is not equally clearly marked with all types of valve). The super-regenerative frequency employed was that of a 41.7 m wave: tests with lower frequencies showed that its choice was not a critical matter. "In adjusting for reception, particularly for high values of emission, several zones of background noise make their appearance: these must be explained partly as super-regeneration noise but partly also as due to irregular oscillation-building régimes in the receiver" [p. 70]. The occurrence of actual oscillations in the receiver (and their appearance in the receiving dipole), when no super-regeneration is employed, is discussed on p. 71 (section IV 7): they may occur also for low super-regenerative voltages, but disappear as these voltages are increased.

The influence of the angle of inclination of the magnetic field, and the striking decrease, at small angles, of the anode voltage required for best reception, are explained by the fact that for a parallel field the electron paths lie in a plane, whereas an inclination of the field produces spiralling, with a consequent "loosening" of the space-charge cloud. This can be countered by an increased emission, and in practice a change of angle can be compensated for, with the anode voltage unaltered, by a change in emission. In spite of all these apparent complications (due fundamentally to the compromise between the best conditions for rectification and regeneration) the adjustment of the receiver is not difficult, and depends very little on the design of the valve employed. "Even valves with very unsymmetrical construction proved serviceable for reception." In the reception of a given wavelength the anode voltage depends on the radius of the anode: this, and other points such as the best length of the anode, are discussed in section IV 9. "The best results were obtained with valves with 0.5 mm anode radius and 2 mm anode length" [the diameter of all the glass containers was only 10 mm, allowing the tungsten filaments to have a length of 6 mm].

The question whether the sensitivity could be increased, or the adjustment made easier, by using two valves, looking after the rectification and the damping reduction respectively, "must be decided by experiment." Finally, "in using the magnetron receiver in actual practice it is advantageous to employ intermediate-frequency reception [as used by Esau & Ahrens, *loc. cit.*]. By means of this system of transmission it has recently been possible to obtain remarkably good telephonic communication over 15 km with a wavelength of 2.8 cm and reflectors of only 60 cm diameter, and over 60 km with a wavelength of 4.1 cm and 1 m-diameter reflectors."

1875. Study of Impulse-Wave Output of Band-Pass Receiver [Analysis: Effect of Width of Band (including Selective-Sideband Reception): etc.].—K. Miya. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, p. 198: short summary only.) "Finally, the experimental result of the impulse wave accomplished by Jansky is theoretically demonstrated." No reference is given to Jansky's work, but the paper dealt with in 1392 of 1940 is presumably the one in question.

1876. Two-Signal Cross Modulation in a Frequency-Modulation Receiver [only to Extent that Undesired Signal has Amplitude Modulation and Receiver has Incidental Sensitivity to This: Possibility of Kind of Beat-Note Interference if Signals are in Adjacent Channels: Possible Attenuation of Desired Signal if Undesired Signal overloads Receiver before being Filtered Out].—H. A. Wheeler. (*Proc. I.R.E.*, Dec. 1940, Vol. 28, No. 12, pp. 537–540.)

1877. Frequency-Modulation Conversion Attachment [for Any Broadcast Receiver fitted with Gramophone Jack: a Nine-Valve Adapter].—Stewart-Warner Corporation. (*Electronics*, Jan. 1941, Vol. 14, No. 1, p. 96: paragraph only.)

1878. Impulse Noise in Frequency-Modulation Reception [Investigation with Oscillograph: Relative Effects of Plate-Voltage & Grid-Bias Types of Limiter: Recommendations to ensure Maximum Noise Reduction].—V. D. Landon. (*Electronics*, Feb. 1941, Vol. 14, No. 2, pp. 26–30 and 73..76.)

1879. Receiver Interference Chart [based on Receiver with Standard I.F. of 455 kc/s: Chart showing Interfering Frequencies as Function of the Tuned Frequency].—J. J. Adams. (*Electronics*, Feb. 1941, Vol. 14, No. 2, p. 43.)

1880. Some Insulator Designs require Special Features to insure Radio Quietness.—C. J. Miller, Jr. (*Elec. Engineering*, Feb. 1941, Vol. 60, No. 2, pp. 62–66.) For previous work *see* 1835 of 1940. A summary was referred to in 369 of February.

1881. A New Approach to Radio-Interference Bonding and Shielding Requirements for All-Metal Aircraft.—F. Foulon. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, p. 38: summary only.) From the Douglas Aircraft Company.

1882. Rules for the High-Frequency Interference Suppression of Electrical Machines and Apparatus of Nominal Powers up to 500 Watts.—V.D.E. (*E.T.Z.*, 26th Dec. 1940, Vol. 61, No. 52, pp. 1201–1202.)

1883. Broadcast Receivers at the 1940 Vienna Autumn Fair.—(*E.T.Z.*, 19th Dec. 1940, Vol. 61, No. 51, pp. 1168–1169.)

1884. Makeshifts and Improvisations [Editorial on Maintenance of Broadcast Receivers during War], *and* Economy in Receiver Maintenance: Where the Service-Man Can Help.—(*Wireless World*, May 1941, Vol. 47, No. 5, p. 123: pp. 139–140.) *See* also pp. 144–145.

1885. Wide-Range Tuning Indicator: Improving the "Magic Eye" [Circuit Arrangement giving Same High Sensitivity for Average & Abnormal Signals].—R.C.A. Laboratories. (*Wireless World*, May 1941, Vol. 47, No. 5, p. 143.)

1886. Auxiliary D.C. Source and Some of Its Applications [for Experiments with Receivers: Modification of Ordinary Rectifier Unit to provide This].—(*Wireless World*, May 1941, Vol. 47, No. 5, pp. 128–129.)

1887. Morse Gramophone Records [prepared with Cooperation of R.A.F. Signallers].—Columbia Company. (*Wireless World*, May 1941, Vol. 47, No. 5, p. 135.)

AERIALS AND AERIAL SYSTEMS

1888. Steady-State Solutions of Electromagnetic Field Problems: I—Forced Oscillations of a Cylindrical Conductor: II—of a Conducting Sphere: III—of a Prolate Spheroid.—J. A. Stratton & L. J. Chu. (*Journ. Applied Phys.*, March 1941, Vol. 12, No. 3, pp. 230–235, 236–240, & 241–248.)

Parts I & II really lead up to Part III, a problem of greater mathematical complexity but having "a direct bearing on the operation of linear antennas since a prolate spheroid reduces to a line of finite length as the eccentricity approaches unity. Furthermore, since the case of the sphere is obtained by allowing the eccentricity to become zero, one may follow the transition from the linear to the spherical configuration, and the effect of increasing the central cross section on the radiation impedance."

1889. Corona on Aerial Wires at Frequencies up to 50 Mc/s.—Rohde & Wedemeyer. (In paper dealt with in 1951, below.)

1890. Radio-Frequency Matching Sections [Charts for Computation of L-Type Sections for Matching (*e.g.*) an Aerial to Its Feeder].—A. C. Omberg. (*Electronics*, Jan. 1941, Vol. 14, No. 1, p. 43.)

1891. Some Tests on a Single Common Feeder used for Three Different Signals.—Y. Kato & Y. Umehara. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 176–179.)

The use of a single feeder for two different signals (1877 of 1938) has now become common practice. The extension of the idea to three signals is by no means simple: a theoretical treatment was given by Kato (1019 of 1940) and the present paper describes some preliminary experimental results: the system has actually been adopted at the Fukuoka receiving station, for wavelengths of about 20, 30, & 45 metres.

1892. A Solenoid-Whip Aerial [for Medium Frequencies: Four-Fold Increase of Field Strength compared with Whip Aerial of Same Height: primarily for Police Systems].—W. R. Wilson. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 56..64.)

VALVES AND THERMIONICS

1893. Transversely-Controlled Cathode-Ray Tubes with Transverse Work Field [for Generation & Amplification of Ultra-Short Waves].—Hollmann. (*See* 1859.)

1894. Some Properties of Tantalum, and Its Applications to Ultra-Short-Wave Tube [Gas-Evolution & Gas-Absorption (Getter Action) Characteristics: Heat-Radiation Characteristic: Advantages for U.H.F. Valves (Higher Temperatures, with Precautions against Back-Heating: No Getter—reducing the Electrode Gap—required): the LD-83, for 50–100 cm: the TC-552-A, for 1–3 m: the LD-138-A, for 4–10 m (Two in Push-Pull give 1 kW at 4.8 m): Special Suitability for Magnetrons].—M. Kobayashi & O. Harashima. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, pp. 224–227.) The wavelengths of the two larger valves are given as 1–3 and 4–10 centimetres, but this is evidently a misprint for metres.

1895. Doorknobs [Photographs of the D-156548 (generating 5 Watts at 20 cm) used in Absolute Altimeter].—Western Electric. (*Electronics*, Jan. 1941, Vol. 14, No. 1, front cover.) For this altimeter *see* 1892 of 1940.

1896. The Beam Type Valve 6K8G and Its Use in a New Ultra-Short-Wave Frequency-Changer Circuit.—Sargrove. (*See* 1873.)

1897. A New Ultra-High-Frequency Tetrode [RCA-827R] and Its Use in a 1-Kilowatt Television Sound Transmitter.—A. K. Wing & J. E. Young. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, pp. 5–9.) A summary was dealt with in 3414 of 1940.

1898. The Orbital-Beam Secondary-Electron Multiplier for Ultra-High-Frequency Amplification.—Wagner & Ferris. (*See* 1945.)

1899. Analysis of Voltage-Controlled [as opposed to Light-Controlled] Electron Multipliers [Voltage Amplification attainable in Practical Device is limited by Ratio of Transconductance to Space Current, Not Directly by Factor of Electron Multiplication: Consequences].—B. J. Thompson. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 534: summary only.)

1900. BEHAVIOUR OF ELECTRON MULTIPLIERS AS A FUNCTION OF FREQUENCY [Experimental & Theoretical Examination of Source of Loss in Amplification with Increasing Frequency: Result of Transit-Time Spread: Its Causes: Comparison of Electrostatic & Magnetic Types].—L. Malter. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 532: summary only.)

An upper limit of 3×10^{-9} sec. was found for the time taken for the phenomenon of secondary emission to occur.

1901. ELECTRO-OPTICAL FIELD MAPPING [Study of Inhomogeneous Electric Fields by Optical Method].—Mueller. (*See* 1963.)

1902. SIGNAL-TO-NOISE RELATIONS IN HIGH-TRANSCONDUCTANCE TUBES [in Particular Connection with Reduction of Noise in Two-Gang Receivers without H.F. Stage before First Detector].—J. R. Nelson. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 532: summary only.)

1903. EFFECTS OF HIGH VOLTAGE [External H.T. Electric Field] ON THE CHARACTERISTICS OF THERMIONIC RECTIFIERS.—Miyazaki. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, pp. 234–235.) Continuation of the work dealt with in 3423 of 1940.

1904. EQUIVALENT ELECTROSTATIC CIRCUITS FOR VACUUM TUBES.—W. G. Dow. (*Proc. I.R.E.*, Dec. 1940, Vol. 28, No. 12, pp. 548–556.) A summary was dealt with in 3418 of 1940.

1905. A METHOD OF CONTROLLING LINEAR FLOW OF ELECTRONS.—S. Sano. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, p. 196: summary only.

"It is heard that in recent years many devices, such as electron-ray deviation method, etc., have been studied to do away with this non-linearity [due to space-charge-current control], but apparently without practical success, due probably to the complexity of structure. The method herewith brought forth has its main purpose in its simplicity . . . By utilising the region of saturated current, which has heretofore never been regarded as important, and by adding a slight modification to the present amplifier tube, a practical linear amplifier tube can be easily produced.

"The decided change in the structure . . . is that the electrodes are much longer. The principle is to give these electrodes good distribution of controlling electrode, which means good distribution of electron current, thereby producing variation in the saturated current part in proportion to the change in the control voltage."

1906. BELL-JAR EXHAUST—A NEW METAL-TUBE PRODUCTION TECHNIQUE [promising Considerable Reduction in Material & Production Costs: Radical Re-Design of Metal Valve, and Simpler & Faster Method of Exhausting & Sealing].—General Electric. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 24–25: photographs and captions.) *See* also 1081 of April.

1907. A.C. HEATED 120 KW VACUUM TUBE TW-558-A [as used at Formosa 100 kW Broadcasting Station: 3-Phase Heating, 16 kV Plate Voltage, Doherty Amplification System: Investigation of Noise due to A.C. Heating: etc.].—M. Kobayashi & H. Nishio. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, pp. 227–229.)

1908. VACUUM TUBE RECONDITIONING [Device for Degassing Transmitting Valves to give Many Additional Hours of Life].—C. W. Singer. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 84 and 85.)

1909. ELECTRON EMISSION OF METALS IN ELECTRIC FIELDS: I—EXPLANATION OF THE PERIODIC DEVIATIONS FROM THE SCHOTTKY LINE.—E. Guth & C. J. Mullin. (*Phys. Review*, 1st April 1941, Vol. 59, No. 7, pp. 575–584.) A summary was dealt with in 1382 of May.

1910. THE EMISSION OF SECONDARY ELECTRONS FROM NICKEL [with Primary Beam (100–4000 Volts) incident at 45°–50°].—R. M. Chaudhri & A. W. Khan. (*Phil. Mag.*, May 1941, Vol. 31, No. 208, pp. 382–393.)

For a well degassed surface the max. value of s.e. coefficient was 1.58, the corresponding primary electron energy being about 60 volts. The s.e. coefficient decreased exponentially as the energy of the primary electrons was increased beyond that value, for degassed as well as undegassed surfaces.

DIRECTIONAL WIRELESS

1911. MOUNTAIN EFFECTS AND THE USE OF RADIO COMPASSES AND RADIO BEACONS FOR PILOTING AIRCRAFT [Results noted in Flights over Rocky Mountains, & confirmed by Berne/Basle Flights and Ultra-Short-Wave Tests: Effects, on Radio Compass, of approaching a Transmitting Aerial or Loop: the "Cone of Silence" and the Detection of Flight over a Station: etc.].—H. Busignies. (*Elec. Communication*, No. 3, Vol. 19, 1941, pp. 44–70.)

1912. RECENT DEVELOPMENTS IN RADIO AIDS FOR INSTRUMENT FLYING ON CIVIL AIRWAYS.—E. A. Laporte. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, p. 39: summary only.)

1913. COMPARATIVE INVESTIGATION OF A TARGET-FLIGHT RECEIVER AND AN "ENERGY-COMPARISON" DIRECTION FINDER.—E. Rosenkranz. (*Hochf:tech. u. Elek:akus.*, Feb. 1941, Vol. 57, No. 2, pp. 47–54.)

The target-flight receiver C113 (ZE1) developed by the Gräfelfing Research Station (DVG) and Telefunken depends on a combination of a loop aerial and an auxiliary aerial, the signal voltage from the latter being reversed and modulated, at a 35 c/s frequency, by the two reversing-valves R_1 and R_2 of Fig. 1. If the auxiliary-aerial voltage is equal to the maximum loop voltage, the theoretical characteristic is made up of two cardioids (Fig. 2). To get direct target-flight indication, the auxiliary-aerial voltage U_h is taken, correct in phase, to an oscillatory circuit into which the loop voltage U_r

is also injected : the voltage mixture passes through h.f. stages to a back-coupled audion (leaky-grid) receiver with l.f. amplification. At the receiver output the l.f. is again smoothed and demodulated (U_0 in Fig. 3) and combined with two push-pull comparison voltages U_1 and U_2 of the same frequency. Rotation of the loop through the minimum position thus causes (Fig. 3) a phase jump of 180° in the fundamental wave of U_0, so that a phase-sensitive device (push-pull rectifier circuit) gives the right/left indication for the target flight.

As a further development of this target-flight receiver, F. Berndorfer devised a modification which, instead of working on the minimum, works at the energy-equality point of a crossed-loop system, where about two-thirds of the maximum loop energy is available. The theoretical characteristic of such a system is made up of two figure-of-eight curves at right angles to each other (Fig. 6) : there are four azimuths for which the energy in each loop is the same, but the introduction, in the correct phase and amplitude, of the voltage from a non-directional aerial reduces the diagram to two cardioids displaced by 90°. Here there are still two points of intersection with equal energies, but they produce opposite pointer deflections in the indicating instrument, so that the target-flight indication is unambiguous. This instrument is named the energy-comparison d.f. type C110 (ZE2).

Systematic tests on the ground showed that the ideal characteristics given in Figs. 2 and 6 could actually be attained with good approximation. The results obtained on the test bench were confirmed by tests in the air, including a target-flight from Munich towards the Langenberg transmitter. Author's summary :—" The target-flight receiver is simpler in its construction and in its manipulation than the energy-comparison direction-finder. The injection of the auxiliary-aerial voltage, as regards phase and amplitude, is distinctly more critical in the latter instrument than in the former : this is of importance for the unambiguous determination of the transmitter direction. The energy-comparison d.f. works unambiguously only when the auxiliary-aerial voltage is equal to or greater than the maximum loop voltage ; in this condition, however, the indicating sensitivity in the actual target-flight direction is lower than that given by the target-flight receiver. On the other hand, the target-flight receiver, if no background noise is present, has its greatest sensitivity when the auxiliary-aerial voltage is less than the maximum loop voltage : in practice the former may be reduced to about half the latter. This sensitivity cannot be reached even theoretically by the energy-comparison d.f. The target-flight ranges of the two equipments are about equal." The crossed-loop aerial system of the energy - comparison d.f. is less favourable aerodynamically than the single loop of the other instrument.

1914. A Three-Mast Adcock Direction-Finder.—H. W. Breuninger. (*Hochf:tech. u. Elek:akus.*, Feb. 1941, Vol. 57, No. 2, pp. 54–56.)

Since direction-finding is a planar problem, and a plane is determined by three points, the direction of arrival of an electromagnetic wave must be determinable from the voltages produced by the wave in three aerials not standing along a straight line. On symmetrical grounds the three aerials may be taken as three vertical masts standing at the corners of an equilateral triangle, and the field coils may be in delta connection as in Fig. 1 (a star connection is also dealt with).

The goniometer search-coil voltage is then given by $G = P.\cos \omega t + T.\sin \omega t$, and if $\lambda \gg d$ (where d is the distance from each aerial to the centre of triangle) the quantity T becomes zero, the search-coil voltage becomes zero for $\phi = \psi$, direction-finding is satisfactory, and a mast is saved. If λ is not large compared with d, the search-coil voltage becomes zero for $\phi = \psi$ only when $\psi = 0°, 90°, 180°, 270°$, or an angle made from one of these by the addition of $\pm 120°$. For short waves, therefore, the three-mast Adcock system has a systematic error vanishing for twelve azimuths, compared with one vanishing for only eight azimuths in the ordinary four-mast Adcock. But with these short waves T is no longer zero, and the blurring of the minimum represented by the term $T.\sin \omega t$ makes the three-mast system definitely inferior to the four-mast for short waves. Attempts to compensate automatically for this blurring are hindered by its dependence on frequency, so that the coupling of the compensating voltage has to be altered in harmony with the receiver tuning.

1915. The Loaded Goniometer.—M. Päsler. (*Hochf:tech. u. Elek:akus.*, Jan. 1941, Vol. 57, No. 1, pp. 14–16.)

From the Telefunken laboratories. The accuracy of bearings taken by swinging the search coil on either side of a flat minimum, to find two points of equal signal strength, and to halve the reading between them, depends very much on the symmetry of the voltage/angle characteristic near the minimum. This fact raises the question whether a loading of the search coil (such as occurs always in practice, since the search coil is tuned with a condenser) does or does not disturb the symmetry of the voltage/angle curve given theoretically for the open-circuited search coil (Fig. 1).

Fig. 4 shows a circuit suitable for the experimental investigation of the problem, consisting of a signal generator exciting the search coil of a " testing " goniometer whose field coils are connected to those of a commercial " iron-type " goniometer. The search coil of the latter is loaded (in the diagram and in the analysis of the diagram) by a load inductance L_4 and resistance R_4 ; but in the actual use of the lay-out as a measuring circuit, by a tuning condenser. In these measurements the voltages appearing across this condenser are measured with a sensitive valve-voltmeter, and plotted in Fig. 5 as a function of the reading of the " iron-type " goniometer, for three different values of ϕ, the reading of the other (exciter) goniometer. These curves are all sine curves, within less than 1%. The theoretical analysis of the circuit leads to eqn. 17 for the voltage at the ends of the load coil : for a fixed frequency, the only factor which is not a constant is $\sin(\alpha - \phi)$, so that theory and measured results agree in stating that the voltage characteristic follows a sine law in the loaded condition as well as in the unloaded.

ACOUSTICS AND AUDIO-FREQUENCIES

1916. BINAURAL TRANSMISSION ON A SINGLE CHANNEL [by Simultaneous Use of Amplitude & Frequency Modulation].—Eastman & Woodward. (*See* 1984.)

1917. FANTASOUND [System used with Walt Disney's "Fantasia," giving a Third-Dimensional Effect by making Sound Source move with Action on Screen].—(*Communications*, Jan. 1941, Vol. 21, No. 1, p. 28.) *See* also 1100 of April.

1918. SOUND IN MOTION PICTURES [Progress in Methods & Equipment for Sound Recording].—N. Levinson. (*Electronics*, Jan. & Feb. 1941, Vol. 14, Nos. 1 & 2, pp. 17–19 and 73..76 & pp. 37–39 and 88.)

1919. HIGH- AND LOW-FREQUENCY LOUDSPEAKERS.—H. J. N. Riddle. (*Wireless World*, May 1941, Vol. 47, No. 5, p. 140.) Prompted by the article dealt with in 1685 of June.

1920. ACOUSTICAL DEVICE ["Tone Guard" Grooved-Wells Noise-Suppression Filter for Gramophone: applicable also to Doors & Windows].—H. F. Olson. (*Electronics*, Jan. 1941, Vol. 14, No. 1, p. 100: paragraph only.) *See* also 431 of February, and *Journ. Acous. Soc. Am.*, Jan. 1941, pp. 374–377.

1921. THE REDUCTION OF PICK-UP TRACKING ERROR.—G. E. Macdonald. (*Communications*, Jan. 1941, Vol. 21, No. 1, pp. 5–8 and 22..24.)

1922. VIBRATION MODES OF ROCHELLE-SALT PLATE WITH ANY ORIENTATION.—N. Takagi. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, pp. 232–233.) Further development of the work dealt with in 3521 of 1940.

1923. PAPERS ON ROCHELLE-SALT VIBRATORS FOR USE IN FILTERS.—Kamayachi & others: Monji & Kuwayama. (*See* 1849 & 1850.)

1924. NEW AEROPRESSURE MICROPHONE [with Directional Characteristics controlled by "Paracoustic" Reflector Baffle Attachment: Plastic Diaphragm: withstands Rough Usage & Bad Weather Conditions].—R.C.A. (*Journ. Applied Phys.*, April 1941, Vol. 12, No. 4, p. iv: paragraph only.)

1925. MEMBRANE/AIR-FILM SYSTEM [as Damping Device in an Electroacoustical Transformer: Derivation of Theoretical Foundations for Assumptions made in Crandall's 1918 Paper: Free Vibration: Forced Vibration: Representation of Air-Film Effect in the Equivalent Circuit].—T. Hayasaka. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 180–185.)

1926. THE REFLECTION OF SOUND PULSES BY CONVEX PARABOLIC REFLECTORS.—F. G. Friedlander. (*Proc. Cambridge Phil. Soc.*, April 1941, Vol. 37, Part 2, pp. 134–149.)

"An interesting feature of the solutions obtained is that when a suitable time scale is introduced (for a sharp-fronted pulse the time must be counted from the onset of the wave), the reflected wave experienced is the same at all points on any paraboloid (or parabolic cylinder) confocal with the reflector."

1927. PARLIAMENTARY SOUND SYSTEM IN THE ARGENTINE CHAMBER OF DEPUTIES.—Wilburn & Tenac. (*Elec. Communication*, No. 3, Vol. 19, 1941, pp. 37–43.)

1928. REMOTE CONTROL FOR REVERSIBLE PROGRAMME CIRCUITS.—A. E. Bachelet. (*Bell Lab. Record*, April 1941, Vol. 19, No. 8, pp. 234–240.)

1929. OPTICAL REFLECTION FACTORS OF ACOUSTICAL MATERIALS.—P. Moon. (*Journ. Opt. Soc. Am.*, April 1941, Vol. 31, No. 4, pp. 317–324.)

1930. REVERBERATION METER USING BRAUN TUBE [giving Direct Reading of Reverberation Time and Direct View of Decay Form].—K. Hoshi & S. Arai. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, p. 197: summary only.)

1931. GANGED IMPEDANCE BRIDGE FOR MEASURING THE CHARACTERISTIC IMPEDANCE OF LINES AT AUDIO-FREQUENCIES.—D. B. Green & P. K. Hudson. (*Communications*, Jan. 1941, Vol. 21, No. 1, p. 20.)

1932. PAPERS ON LONGITUDINAL WAVES IN CYLINDRICAL BARS.—Bancroft: Hayasaka. (*See* 1954.)

1933. EXPANSIONAL VIBRATION OF A FREE CIRCULAR RING [for Investigations on Magnetostriction Vibrators].—T. Hayasaka. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 186–189.)

1934. CHARACTERISTIC OF SENDUST CORE OF 30 KC/S HIGH-DENSITY FLUX [primarily for Ring Coil (replacing Larger Air-Core Coil) in Supersonic Transmitter: Unexpectedly Good Results].—Z. Saneyosi & S. Miura. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 197–198: summary only.)

PHOTOTELEGRAPHY AND TELEVISION

1935. NATIONAL TELEVISION SYSTEM COMMITTEE PROPOSES TELEVISION STANDARDS [Only Major Difference from R.M.A. Proposals is Use of Frequency Modulation for Sound Transmissions, Max. Deviation 75 kc/s: Account of Various Demonstrations to F.C.C.].—(*Electronics*, Feb. 1941, Vol. 14, No. 2, pp. 17–21 and 60..66.)

1936. SOME FACTORS AFFECTING TELEVISION TRANSMISSION [over Wire Lines: in relation to New-York/Philadelphia Coaxial Cable Results].—M. E. Strieby & C. L. Weis. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, pp. 533–534: summary only.) *See* also 1422 of May.

1937. A Phase-Curve Tracer for Television, *and* Special Oscilloscope Tests for Television Wave Forms.—B. D. Loughlin: A. V. Loughren & W. F. Bailey. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 532: p. 532: summaries only.)

1938. Versatile Multichannel Television Control Equipment, *and* New Designs of Television Control-Room Equipment.—Norgaard & Jones: Schantz & Ludwick. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 533: p. 533: summaries only.)

1939. Transient Response of Single-Sideband Systems [of Television], *and* A Mathematical Appendix to Transient Response of Single-Sideband Systems. — H. E. Kallmann & R. E. Spencer: C. P. Singer. (*Proc. I.R.E.*, Dec. 1940, Vol. 28, No. 12, pp. 557–561: pp. 561–563.)

"It is hoped that these curves may be helpful in a decision, just how much depth of modulation and steepness of single-sideband-filter cut-off can be permitted without causing intolerable overswing." For previous work *see* 227 of 1940 and 132 of January.

1940. A Coaxial Filter for Vestigial-Sideband Transmission in Television.—Salinger. (*See* 1846.)

1941. Radio-Frequency-Operated High-Voltage Supplies for Cathode-Ray Tubes [and Their Performance in Television Equipment].—O. H. Schade. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 533: summary only.) From 1 to 50 kv, power outputs ¼ to 50 w.

1942. Cathode-Ray Television Tube Lead Wire [Corona-Resistant Wire for H.T. Connections: protected by Special Rubber Compound, Pyro-Glaze Seal, & Fibre-Glass Braid].—Belden Company. (*Electronics*, Jan. 1941, Vol. 14, No. 1, p. 91: paragraph only.)

1943. The Geometry of Stereoscopic Projection.—J. T. Rule. (*Journ. Opt. Soc. Am.*, April 1941, Vol. 31, No. 4, pp. 325–334.)

1944. Electro-Optical Field Mapping [by Method using Colloidal Solutions of Bentonite with Large Kerr Constants].—Mueller. (*See* 1963.)

1945. The Orbital-Beam Secondary-Electron Multiplier for Ultra-High-Frequency Amplification [Multiplication applied to High-Transconductance Valve Structure to increase Transconductance without Increase in Inter-Electrode Capacitance & Input Conductance: primarily for Television Radio Relay Systems on 500 Mc/s].—H. W. Wagner & W. R. Ferris. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 534: summary only.)

1946. Behaviour of Electron Multipliers as a Function of Frequency.—Malter. (*See* 1900.)

1947. The Handling of Telegrams in Facsimile [Expedients to Accelerate the Whole Process, including the Reduction of Wasteful Scanning to a Minimum].—R. J. Wise & I. S. Coggeshall. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 535: summary only.)

1948. Transit-Time Phenomena in Photocells.—H. Geest. (*Hochf:tech. u. Elek:akus.*, March 1941, Vol. 57, No. 3, pp. 75–83.)

"Till now nothing has been reported concerning the effects of transit-time phenomena in high-vacuum photocells, although photocells have been proposed, for example, as rectifiers for h.f. currents [Behnken, in 1914] and recently as measuring rectifiers for h.f. voltages (valve voltmeters, phase measurements) [Schuhfried, 3121 of 1936: Hüttel, 4207 of 1940]. In all circuits in which an alternating voltage is used as the anode voltage for the photocell, as it is in the Karolus bridge circuit for carrier-injection [*see* Schröter's "Handbook of Facsimile and Television"], the range of application is limited at the high frequencies as soon as the electron transit time becomes of the same order of magnitude as the periodic time of the alternating voltage. The same thing applies to carrier injection in secondary-electron multipliers [Geest, 1503 of 1940]. In the course of these investigations, deviations from the behaviour at lower frequencies were found for the first time.

"Since the electrode spacing in photocells (and consequently the electron paths) amounts as a rule to a few centimetres—in large photocells, up to 15 cm—it is to be expected, from first principles, that from 1 Mc/s upwards the electron transit time at velocities of the order of 100 v would be comparable with the periodic time. It would at first sight be expected that under the influence of these transit times, for instance when using the photocell as rectifier, a decrease in the rectified current would appear. But as the following investigations will show, the phenomena found under these conditions are far more complicated than that. Instead of a steady decrease of current with increasing frequency, currents were observed which were larger by several orders of magnitude than the original photocurrent. Further, under certain conditions normal photocells in the unilluminated state were found to give currents of several milliamperes."

The following extracts are taken from the summary in section VI. "The rectifying action of a spherical photocell with an Ag-Cs cathode of 10 cm diameter was investigated for alternating voltages up to an r.m.s. value of 150 v and frequencies up to 20 Mc/s. For frequencies from 50 c/s to 1 Mc/s no change in the shape of the current/voltage characteristic could be detected. From 1 Mc/s upwards the photocurrent at first decreases under the influence of the electron transit time. After a minimum at 4 Mc/s an increase in the mean value of the current begins as the frequency is raised still higher. Above 11 Mc/s there appears, for a definite amplitude of alternating voltage, a resonance-like 'super-regenerative type' multiplication; the current may rise to several times its original value. At still higher frequencies the resonance point moves to higher alternating voltages, and the measured mean current value increases still further. At 12 Mc/s the maximum multiplication occurs at an r.m.s. value of 50 v, with a tolerance of a few volts. For a photocurrent of 3 μA the multiplied current reaches 24 μA at 12 Mc/s and 2000 μA at 20 Mc/s. When a steady voltage is superposed on the alternating voltage, the latter being kept constant, current maxima also appear for definite values of the steady voltage: they are only slightly higher than the mean values given by the pure alternating voltage.

"Above 12 Mc/s, in both cases (with and without d.c. voltage) the multiplying process can so build itself up that the limiting current becomes independent of the illumination. The dark current, present in every photocell from thermal emission, is enough to introduce the secondary-emission multiplication. The output currents may increase to some milliamperes, corresponding to an amplification of 10^7, since the unamplified dark current of the cell employed was of the order of 10^{-10} A".

The writer points out the similarity of this multiplying process to that occurring in the Farnsworth two-plate multiplier, in spite of the very different designs. Calculating the time over the 5 cm path in the photocell for 50 v, he arrives at 16 Mc/s for the frequency for maximum multiplication, when the path time should equal a half period of the alternating voltage: the measured resonance point was at 12 Mc/s. The action is in general different from that of the Orthuber-Steudel single-plate multiplier (2257 of 1940), which depends on the presence of a negative steady voltage in a definite proportion to the alternating voltage.

"In a definite region of alternating voltage the electron currents surprisingly reverse their direction. The currents in the direction from the anode to the cathode reach values similar to those in the opposite direction. For these currents the secondary emission at the anode must be greater than at the cathode". The writer concludes by pointing out that the multiplication processes here described are of technical use only if the thermal emission is prevented from building up similarly. This can be done by limiting the total multiplication to 10^3 or 10^4 by arranging that the action is broken off after a certain number of secondary-emission processes: "these interruptions could be attained by alteration of the alternating-voltage amplitude or by displacing the direct voltage". The multiplying processes may play an important part as a source of error in all measurements with photocells in which an alternating voltage of high frequency is used for voltage supply: "for example, in light-velocity measurements and in valve voltmeters". For such measurements cells should be used which have as small an anode/cathode spacing as possible, so that for a given voltage and frequency the path time may be smaller by an order of magnitude than the period of the alternating voltage.

The summary does not mention that in section IV the question of similar phenomena in caesium/antimony cells is discussed. These cells, with their extremely high internal resistance, have multiplying phenomena of their own special types, but their behaviour as regards the type now under consideration is greatly modified by the high resistance of the sensitive layer. Practically all such differences, however, are eliminated if the outside of the glass is coated with metal over the extent of the cathode, and this capacitive coupling to the cathode elements is connected to the cathode lead.

MEASUREMENTS AND STANDARDS

1949. A TEN-CENTIMETRE WAVEMETER [with 30 cm Oscillator yielding Third Harmonic (Wave-Guide Filter eliminating Fundamental), Tuned Pick-Up Probe, & Shielded Lecher-Wire Calibration System].—S. D. Lavoie. (*Communications*, Jan. 1941, Vol. 21, No. 1, pp. 9–10 and 24.)

1950. THE MEASUREMENT OF LOSSES AT HIGH VOLTAGES OF HIGH FREQUENCY [500 V–500 kV and 50 kc/s–50 Mc/s].—L. Rohde & G. Wedemeyer. (*E.T.Z.*, No. 26, Vol. 61, 1940, pp. 577–581: *Hochf:tech. u. Elek:akus.*, Dec. 1940, Vol. 56, No. 6, pp. 187–188—long summary.)

The paper referred to in 1455 of May. The apparatus described is based on the principle of conductance measurement by means of rectification, further developed for use at high voltages (Fig. 2 of the summary). The test voltage is taken from a constantly excited oscillating circuit and applied to the test sample and simultaneously to a diode circuit. The oscillating-circuit voltage is measured at resonance: the sample is removed and resonance restored by re-tuning, the necessary capacity change representing the reactive component of the required conductance, either capacitive or inductive. The resonance voltage now obtained is naturally higher than that when the loss-producing sample was present: this rise is then compensated by a corresponding damping of the test circuit with the help of the diode circuit, and the conductance can be deduced from the value of the loading resistance. The loading circuit (shown separately in Fig. 1) consists of the diode, through which the condenser C is charged to a voltage U, and a loading triode Tr, shunting the condenser, whose anode current is regulated by adjusting the grid bias. The circuit then acts (if C is large enough) as a linearly variable h.f. resistance R parallel to the oscillatory test circuit: the equation $R = U/i\sqrt{2}$ shows that the greater the voltage U, the larger R becomes, which means that the arrangement is particularly suitable for measuring small losses at high voltages. Steps are described for obtaining a sufficiently high voltage (high generator output, high-quality coil, large L/C ratio): the test circuit coil is on a Calit former: an amplifying valve is introduced between generator and test circuit, as shown in the complete circuit of Fig. 2. At the higher test voltages only a part of the oscillatory-circuit voltage is tapped off and rectified, so as to prevent the anode voltage on the loading triode from exceeding the safe value. An anode dissipation of 700 w is suitable for this valve, since higher losses have seldom to be measured. For extremely low losses a compensating circuit is provided for the valve voltmeter (included in Fig. 2): this increases the accuracy of the equipment so much that a loss angle of 10^{-5} to 10^{-6}

can be measured within $\pm 10\%$. The effect of mains fluctuations is eliminated by deriving the compensating current from a source which is also subject to these fluctuations, for instance from a rectifier directly connected to the generator. Some examples of work with the equipment are given in the present paper, but a later work (1951, below) is devoted to such results.

1951. Losses and Breakdown at High Voltages of High Frequency [up to 50 Mc/s: with Conclusions on New Design of Insulators].—L. Rohde & G. Wedemeyer. (*E.T.Z.*, 19th & 26th Dec. 1940, Vol. 61, Nos. 51 & 52, pp. 1161–1164 & 1188–1192.)

"With the help of the measuring technique described in an earlier paper [1950, above] the corona losses in air, the loss factors of various synthetic materials, and the loss angles of insulators were measured at high voltage of high frequency. The dependence of the losses on external influences, such as wearing-away, heating-up, exposure to weather, etc., was determined. The high voltages made possible by the equipment provided an opportunity to investigate the various forms of discharge occurring under h.f. high voltages and to throw light on their mechanism. The breakdown voltage of air, already known for low and medium frequencies, was also measured for high and ultra-high frequencies. Finally, the influence of the discharge forms characteristic of high frequencies on the electrical strength and design of h.f. insulators is discussed."

Fig. 2 shows a cylinder device for investigating the corona losses, at high frequencies, on short lengths of wire of various diameters. The losses were measured in turn as a function of frequency, voltage, cross-section, etc., and the results applied to the calculation of the behaviour of 1 m lengths of horizontal aerials at various heights above the ground (Figs. 3–7). The unexpectedly high values of loss made it clear that the aerial designer must arrange for the working voltage to be well under the initiating voltage, and that in his calculations he must make full allowance for weather effects. Thus by artificial icing of the inner conductor of the cylinder device the initiating voltage was found to fall by about 20% as a result of the point action of the ice crystals, rising gradually to the normal value as the ice thawed. Fig. 8 shows the dielectric strength of air for a sphere spark gap ($D = 10$ mm, $s/D = 0.2$) as a function of frequency: it is seen that the breakdown voltage (already known to keep constant up to about 20 kc/s) decreases, as the frequency rises further, below the value at 50 c/s: this decrease continues till the frequency reaches about 20 Mc/s (voltage only 80% of the 50 c/s value) and then changes to a much more rapid increase, until at 100 Mc/s the breakdown voltage is about 1.6 times that at 50 c/s. This behaviour is explained as follows:—below the critical frequency of 20 kc/s the half-wave period is so large that the ions formed during it have time to traverse the gap before the next half period begins, so that by then the striking space is deionised. At higher frequencies the ions left over from the previous half period begin to play a decisive rôle in the distribution of the space charge: as a result of the increase of space charge through these residual ions, the field strength in front of the cathode increases as the frequency rises, and the breakdown voltage therefore falls. But a limit is set to this space-charge increase, by the diffusion of the ions, and electrons begin to collect in the striking space and increasingly compensate for the ion charges: the breakdown is hindered and the breakdown voltage rises again.

Fig. 9 shows photographs of the very special types of discharge (in air at atmospheric pressure) at 50 Mc/s. Before the single-pole discharge of Fig. 9a began, the voltage between the two electrodes was nearly 10 kv: during the discharge it was only 3 kv, although the discharge seemed to take no account of the second electrode except for a slight inclination indicating an electrostatic attractive force. If the second electrode is made (by blowing) to "strike," there is no discharge between the two, but both discharges burn with halved energy and with apparently no current transport between them (Fig. 9b). Only when the volume of the two discharges is increased, by raising the energy supply, do the two discharges merge (Fig. 9c). This behaviour is discussed and explained with the help of equivalent circuits (Figs. 10–12): the explanation also makes clear the large amounts of power that may be represented by a single-pole u.h.f. discharge. Measurements of the current density at the emergence-point of the discharge gave the noteworthy result that for all single-pole h.f. discharges this current density remained constant at about 10 mA/mm², whatever the frequency. This result is discussed at the end of p. 1164.

The second instalment deals with solid dielectrics, beginning with results of measurements on Pertinax, Plexiglas, and Trolitul and continuing with a discussion of the several components of the losses at h.f. insulators and their relative importance at different voltages (Fig. 16, for a bracket insulator). The effects of moisture, surface cracks, soot, and varnish are examined, and also those of icing and hoar frost. As regards purely dielectric losses the writers' results confirm the belief that the loss factor of Calit decreases with increasing frequency (curve a of Fig. 19), but if brush discharges occur at surface cracks or at badly constructed insulator bodies the factor may increase with increasing frequency, as seen in curve b.

Finally, the special precautions that must be taken in designing h.t. insulators for very high frequencies are discussed with the help of discharge photographs and their equivalent circuits. The necessity for the attainment of the best possible potential distribution is stressed; this involves the avoidance of all sharp edges at points of high potential. An example of successful design is seen in Fig. 27b, where the insulator of height 5.8 cm has a spark-over voltage of 33 kv, while the type of Fig. 27a, 15 cm high, will stand only 15 kv. The former insulator, besides being of special shape, has "a metallic coating at its head to give the most uniform potential distribution possible."

1952. Transit-Time Phenomena in Photocells.—Geest. (*See* 1948.)

1953. On the Frequency Variation of Vacuum-Tube Oscillator by the Dynamic Internal Capacity of Vacuum Tube, *and* On the Influence of Harmonic Voltage upon the Frequency of Vacuum-Tube Oscillator.—Uemura. (*See* 1863 & 1864.)

1954. The Velocity of Longitudinal Waves in Cylindrical Bars, *and* Longitudinal Vibration of Bar [Theoretical Basis for Design of Constant-Frequency Oscillators, etc: Bars with Fixed Ends, Free Ends, & One Fixed, One Free].—D. Bancroft: T. Hayasaka. (*Phys. Review*, 1st April 1941, Vol. 59, No. 7, pp. 588–593: *Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 195–196: summary only.)

1955. Papers on the Rochelle-Salt Vibrations.—Kamayachi & others: Monji & Kuwayama: Takagi. (*See* 1849, 1850, & 1922.)

1956. Quartz Clock and Standard Frequency Generator [New, Greatly Simplified Design].—L. Rohde & R. Leonhardt. (*E.N.T.*, June 1940, Vol. 17, No. 6, pp. 117–124: *Bull. Assoc. suisse des Élec.*, 14th Feb. 1941, Vol. 32, No. 3, pp. 49–51—long German summary.)

The writers set themselves to transform the quartz clock from a highly complex laboratory apparatus abounding in frequency-reducing stages (each liable to introduce phase differences) into a practical instrument in which the frequency reduction is accomplished in a single stage. In their apparatus the 100 kc/s quartz-controlled frequency is reduced 100 times by a tuning-fork generator adjusted to a frequency of about 1 kc/s: by means of a distorting section and a filter-quartz (2360 of 1940) the hundredth harmonic of the fork frequency is extracted and after amplification is sent, together with the quartz frequency, through a rectifier to a correcting coil between the tines of the fork. "An increase in the d.c. through this coil decreases the fork frequency." If the latter does not agree exactly with the hundredth part of the quartz frequency, beats will occur, with corresponding varying phase displacements between the two currents passing through the rectifier, so that the correcting current will alter until the fork vibrates exactly at 1 kc/s (there is a misprint here in the summary).

The correction range is arranged for a max. deviation of 2×10^{-4}, which is quite wide enough since a good fork is found to vary only by 10^{-5}. The synchronous clock is driven by the 1 kc/s current. Apart from the thermostat valves for the quartz oscillator (the filter-quartz is in the same thermostat) only five valves are employed. Since the quartz frequency depends slightly on the grid capacity parallel to the quartz, the clock can be given a final automatic regulation against slow changes by making the 24-hour pointer connect correcting capacities. The necessary careful selection of the quartz is discussed: it is so cut that the reversal point of the temperature-coefficient comes at the working temperature. The weight of the apparatus with its stand is only 46 kg: the time-keeping is accurate to 0.002 sec. per day, and the standard frequencies obtainable (50 c/s, obtained from a small armature on the shaft of the synchronous motor, 1 kc/s, and 100 kc/s) are constant within less than 10^{-7}. For another long summary, with a fuller circuit diagram, see *Hochf:tech. u. Elek:akus.*, March 1941, pp. 90–93.

1957. Midget Signal Generator [Multivibrator-Type, for A.F., I.F., Medium & Short-Wave Frequencies: Scarcely Larger than Fountain Pen: the "Pen-Oscil-Lite"].—(*Electronics*, Jan. 1941, Vol. 14, No. 1, p. 98: para. only.)

1958. Ganged Impedance Bridge for measuring the Characteristic Impedance of Lines at Audio-Frequencies.—D. B. Green & P. K. Hudson. (*Communications*, Jan. 1941, Vol. 21, No. 1, p. 20.)

1959. A Percentage Modulation Meter [of Economical Design, using Same Meter to read Carrier Current & Percentage of Modulation].—S. T. Carter. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 50..56.)

1960. The Shielding of Radio-Frequency Ammeters [to eliminate the Additional Source of Error introduced when operating at a Point at High R.F. Potential with respect to Ground or Near-By Low-Potential Objects: Disadvantage of External Thermocouples: etc.].—J. D. Wallace. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, pp. 1–5.)

1961. Climatic Factors in Tropical Regions and their Reproduction in Testing Technique.—W. M. H. Schulze. (*E.T.Z.*, 26th Dec. 1940, Vol. 61, No. 52, pp. 1194–1200.)
A climatological introduction to the report VDE 0475 on the reproduction of tropical conditions in the test room.

SUBSIDIARY APPARATUS AND MATERIALS

1962. Papers on Losses and Breakdown at High Voltages of High Frequency [up to 50 Mc/s: including the Design of Insulators].—Rohde & Wedemeyer. (*See* 1950 & 1951.)

1963. Electro-Optical Field Mapping [Study & Measurement of Inhomogeneous Electric Fields by Optical Method (analogous to Photoelasticity Method) using Colloidal Solutions of Bentonite with Large Kerr Constants].—Mueller. (*Journ. Opt. Soc. Am.*, April 1941, Vol. 31, No. 4, pp. 286–291.)

1964. A Method of Controlling Linear Flow of Electrons.—Sano. (*See* 1905.)

1965. After-Acceleration and Deflection.—Pierce. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, pp. 28–31.)

"In the case of magnetic deflection, after-acceleration can result in no gain in deflection sensibility [as distinct from deflection sensitivity: it is defined as the reciprocal of the deflecting voltage or current required to move the spot *one spot diameter* on the screen] . . . In the case of electrostatic deflection, the improvement in deflection sensibility achieved through aberrationless after-acceleration is dependent only on the lowering of the potential in the region of deflection, so that all aberrationless systems of after-acceleration are equally good."

1966. Radio-Frequency-Operated High-Voltage Supplies for Cathode-Ray Tubes.—Schade. (*See* 1941.)

1967. Cathode-Ray Television Tube Lead Wire [Corona-Resistant].—Belden Company. (*See* 1942.)

1968. On the Aberration of Electron Microscope.—Kato & Inoue. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, pp. 219–222.)

"Following the method of Punke eikonal, the calculations will be performed for the third and fifth aberrations for the cases in which the object and the image are lying respectively within and outside of the electron lens—such as in a case of the electron microscope." For previous work *see* 4650 of 1939.

1969. Physical Interpretations of Resolving Power, *and* The Photon Theory of Optical Resolving Power.—Ramsay & others. (*Journ. Opt. Soc. Am.*, March 1941, Vol. 31, No. 3, pp. 202–208: April 1941, No. 4, pp. 296–300.) Further development of the work referred to in 1478 of May.

1970. On the Minimum of Aperture Error for Thin [Optical] Lenses.—Staeble. (*Zeitschr. f. Instrum:kunde*, Feb. 1941, Vol. 61, No. 2, pp. 55–58.)

1971. On Current Distribution by an Electron Commutator.—Zernov. (*Automatics & Telemechanics* [in Russian], No. 2, 1940, pp. 113–124.)

It may seem that electron commutators are free from inertia, but an analysis here given of the transference of a charge to the commutator lamellae shows that this process possesses considerable inertia which limits the speed of commutation. Two types of electron commutator are considered, one in which the electron beam is deflected to the required lamella and the circuit connected to it is thereby switched on, the other in which all lamellae are continuously scanned but the electron beam is not triggered until a signal arrives and the beam is found on a predetermined lamella. Formulae are derived for determining the voltages on the lamellae and the currents in the external circuits, both for transient and stabilised conditions. The time necessary for achieving stabilisation (which is a measure of inertia) depends on the lamella capacity and the capacity elements in the external circuit. From numerical examples given it is shown that it may be as high as 150 μsec.

1972. A Combined Amplifier for the Detection of the Smallest Ion Amounts, particularly Individual Beta Particles [Greinacher Amplifier, modified by Introduction of Special Pentodes & an Electron-Multiplier Stage, driving Cathode-Ray Oscillograph with Time Base synchronised with Camera Shutter: 39 Records in 2 Minutes].—Masing. (*Ann. der Physik*, Vol. 37, 1940, pp. 557–582: *E.T.Z.*, 19th Dec. 1940, Vol. 61, No. 51, p. 1169—summary only.)

1973. Errata: Mechanism of Electrical Discharges in Gases of Low Pressure.—Druyvesteyn & Penning. (*Reviews of Mod. Phys.*, Jan. 1941, Vol. 13, No. 1, pp. 72–73.) *See* 4030 of 1940.

1974. Effects of High Voltage on the Characteristics of Thermionic Rectifiers.—Miyazaki. (*See* 1903.)

1975. Cathode-Spot Initiation on a Mercury Pool by means of an External Grid [Experiments with Mercury-Pool Stroboscope Tube with External Starting Band: Phenomenon of Unidirectional Current flowing in Anode Circuit when there is No E.M.F. Source therein: Correlation between This Current & the Starting of the Tube: etc.].—Townsend. (*Journ. Applied Phys.*, March 1941, Vol. 12, No. 3, pp. 209–215.)

1976. Push-Pull Vibrators [primarily for Car-Radio Supply: Ten Advantages claimed for Use of Equal Amounts of Magnetic Power for Pushing & Pulling the Reed].—Turner Company. (*Communications*, Jan. 1941, Vol. 21, No. 1, p. 32: paragraph only.)

1977. A Unique Selective-Calling System [using 1000 c/s Pulses from Synchronous-Motor Commutator: Synchronising Pulses precede Code Pulses, to put Receiving Decoding Commutator in Step].—Colwell: R.C.A. (*Proc. I.R.E.*, Dec. 1940, Vol. 28, No. 12, p. 577: summary only.)

1978. Applying Magnetic Relays for Sensitive Control [Uses of the Western "Sensitrol" Relay with Magnetic Reinforcement of Contact Pressure: Methods of Re-Setting: etc.].—Lamb. (*Electronics*, Feb. 1941, Vol. 14, No. 2, pp. 31–33 and 89.) For a previous paper *see* 1257 of April.

1979. The Carborundum Spark Quencher.—Korostelev. (*Elektrosvyaz* [in Russian], No. 10, 1940, pp. 31–38.)

Exhaustive tests were carried out with samples of ceramic carborundum to determine the effect of the applied voltage, temperature, and contact pressure on its resistance. The variation of the specific resistance of carborundum with applied voltage was also observed. Numerous experimental curves and tables are given, and it is shown that the resistance of carborundum decreases with the increase of the applied voltage and obeys the law $Ri^{\alpha} = C$, where α and C are constants depending on the type of carborundum and on the shape of the sample, respectively. Thus it appears that carborundum possesses the self-regulation which is required from spark quenchers connected across the windings of electromagnetic relays in telephone circuits. A subsequent experimental investigation has proved this view. A brief reference is made to tests with other materials such as thyrite, galena, elastic carborundum, etc., "which have shown their inferiority in this respect to ceramic carborundum."

1980. CHARACTERISTIC OF SENDUST CORE OF 30 KC/S HIGH-DENSITY FLUX.—Saneyosi & Miura. (*See* 1934.)

1981. THE NEW DRY CELL WITH ATMOSPHERIC-OXYGEN ELEMENT AT THE VIENNA AUTUMN FAIR [using Active Carbon charged with Atmospheric Oxygen, in place of Manganese Dioxide].—(*E.T.Z.*, 19th Dec. 1940, Vol. 61, No. 51, p. 1168.) "The centre point of expert interest": paragraph only.

STATIONS, DESIGN AND OPERATION

1982. TRANSIENT RESPONSE OF SINGLE-SIDEBAND SYSTEMS [of Television], *and* A MATHEMATICAL APPENDIX TO TRANSIENT RESPONSE OF SINGLE-SIDEBAND SYSTEMS.—Kallmann & Spencer: Singer. (*See* 1939.)

1983. COMMERCIAL 50-KILOWATT FREQUENCY-MODULATED-WAVE BROADCAST TRANSMITTING STATION [in Helderberg Mountains].—H. P. Thomas & R. H. Williamson. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, p. 534: summary only.)

1984. BINAURAL TRANSMISSION ON A SINGLE CHANNEL [Stereophonic Broadcasting given by Simultaneous Use of Amplitude & Frequency Modulation: Promising Preliminary Tests, supported by Demonstration of Reception of Two Separate Programmes].—Eastman & Woodward. (*Electronics*, Feb. 1941, Vol. 14, No. 2, pp. 34–36.) *Cf.* Gee, 910 of March. For an abbreviated version of the present paper see *Wireless World*, May 1941, pp. 130–131.

1985. WIRED RADIO BROADCASTING: EXPERIMENTS AND BASIS OF NETWORK DESIGN [History of Japanese Developments and Recommendations for Future: Design of Apparatus for Telephone-Line System].—Shinohara & Hirano. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 155–170.)

1986. BROADCASTING IN INDIA: A SURVEY OF ITS DEVELOPMENT.—(*Wireless World*, May 1941, Vol. 47, No. 5, pp. 132–134.)

1987. BROADCASTING "ON LOCATION" [WFBL Mobile Stations in Tractor (for Golf Courses), Trailer, Motor-Boat, etc.].—Langham. (*Electronics*, Feb. 1941, Vol. 14, No. 2, pp. 40–42 and 98, 99.)

MISCELLANEOUS

1988. A TRANSFORMATION EXTENDING THE USE OF HEAVISIDE'S OPERATIONAL CALCULUS.—Morton: Meyerhoff & Reed. (*See* 1851.)

1989. HYPERBOLIC FUNCTIONS OF COMPLEX VARIABLES [in Transmission-Line Theory: a Helpful Interpretation].—Lutz. (*Elec. Engineering*, Feb. 1941, Vol. 60, No. 2, pp. 95–96.)

1990. CALCULATION OF GEAR WHEELS TO OBTAIN THE BEST APPROXIMATION TO A GIVEN RATIO.—Clay. (*Journ. of Scient. Instr.*, April 1941, Vol. 18, No. 4, p. 66.)

1991. SIXTEENTH ANNUAL CONVENTION OF THE INSTITUTE OF RADIO ENGINEERS, NEW YORK, JAN. 1941 [Summaries].—(*Electronics*, Feb. 1941, Vol. 14, No. 2, pp. 22–25 and 84..87.) *See* also 1536 of May.

1992. "MITTEILUNGEN AUS DER FORSCHUNGSANSTALT DER DEUTSCHEN REICHSPOST" [German P.O. Research Department (July 1939 / June 1940): Book Review].—(*Hochf:tech. u. Elek:akus.*, Dec. 1940, Vol. 56, No. 6, p. 192.) For the preceding volume *see* 2494 of 1940. Most of the papers have already appeared in journals.

1993. LOOKING AT 1940/41 TRENDS [in Broadcasting, Television, Frequency Modulation, Receivers, Valves, etc.].—(*Communications*, Jan. 1941, Vol. 21, No. 1, pp. 11–13 and 28.)

1994. CLIMATIC FACTORS IN TROPICAL REGIONS AND THEIR REPRODUCTION IN TESTING TECHNIQUE.—Schulze. (*See* 1961.)

1995. FIRE PROTECTION IN BROADCASTING [Use of Carbon Dioxide, including Automatic Systems].—Grant. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 38–39.)

1996. RADIO TRAFFIC CONTROL IN AMERICA [including Distinctive Tones corresponding to "Stop" & "Go" Lights].—(*Nature*, 12th April 1941, Vol. 147, p. 450.) For the George Washington Bridge induction-field system *see* 649 of February.

1997. ON CURRENT DISTRIBUTION BY AN ELECTRON COMMUTATOR [and the Inertia of Such Devices].—Zernov. (*See* 1971.)

1998. THE TRANSIENT ELECTROMAGNETIC PROCESSES OCCURRING AT THE RECEIVING POINT WHEN A CONSTANT ELECTROMOTIVE FORCE IS APPLIED TO A LINE [in Remote Control].—Kovalenkov. (*See* 1836.)

1999. APPLYING MAGNETIC RELAYS FOR SENSITIVE CONTROL [Uses of the Weston "Sensitrol" Relay].—Lamb. (*See* 1978.)

2000. CONTROL CIRCUITS FOR INDUSTRY [Applications of the Gas Tetrode Type 2050 or 2051 to Time Delay & Photocell Relay Circuits, in controlling Injection-Moulding Machinery, Printing Presses, Washing Machines, etc.].—Smiley. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 29–33.) For this valve *see* 4279 of 1940.

2001. THE DESIGN OF MULTI-CHANNEL REMOTE CONTROL SYSTEMS.—Gavrilov. (*Automatics & Telemechanics* [in Russian], No. 2, 1940, pp. 77–100.)

The operation is discussed of systems using (a) polarised signals, (b) amplitude signals, (c) amplitude and polarised signals with manual indication, and (d) amplitude and polarised signals with automatic indication. Formulae are derived for determining the resistances of, and currents in, the signal and control relays. Formulae necessary for design are shown in table 2 (facing p. 100).

2002. Systems with Flexible Back Coupling, developed by the All Union Thermo-technical Institute, and Their Use for Purposes of Regulation.—Dudnikov. (*Automatics & Telemechanics* [in Russian], No. 2, 1940, pp. 147–152.)

In the automatic regulation of certain technological processes it is essential to employ systems with some type of back coupling in which the deviation amplitude is gradually reduced during the regulation process. In systems with a "rigid" back coupling, however, a new zero position differing from the original position is attained at the end of the regulation process. It is obviously desirable to have the original conditions restored, and this is achieved in systems with a "flexible" back coupling. Two types of such a system using electrical balanced circuits are described, one (Fig. 6) for maintaining temperature, the other (Fig. 8) for maintaining pressure.

2003. Use of Johnsen-Rahbek Effect for Automatic Frequency Control.—Marconi Company. (*See* 1359 of May.)

2004. Special Issue devoted to Papers on Automatic Regulation.—(*Zeitschr. V.D.I.*, 25th Jan. 1941, Vol. 85, No. 4, pp. 81–104.)

The technical problem and its economic, social-political, and cultural implications: the automatic pilot for aircraft: the control of movement by the vestibular organ of the ear: the numerical solution of oscillation equations: the control of the circulation of the blood: the automatisation of mass-production processes.

2005. Device for Determining the Velocity and Direction of Wind.—Goncharski. (Russian Pat. No. 56 662, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 44.)

The rotor of a two-phase generator is mounted on the spindle of the anemometer, and the voltage generated is applied to the plates of a cathode-ray oscillograph. In addition, the wind vane closes a contact once every revolution of the spindle. The diameter of the circular trajectory on the oscillograph screen serves as a measure of the wind velocity, while the phase of the spot flash towards the trajectory indicates its direction.

2006. Electronic Instruments in Analysis, Testing, and Control.—Müller. (*ASTM Bulletin*, Jan. 1941, No. 108, pp. 24–25.)

2007. Theory and Practice of *pH* Determination and Control using the Glass Electrode [and the DuBridge & Brown Internally Compensated Amplifier Circuit].—Dole. (*ASTM Bulletin*, Jan. 1941, No. 108, pp. 26–28.)

2008. A Sensitive Contact Indicator [Use of "Magic Eye" (6E5) Tube for Precise Indication of Metallic Contacts].—Mills. (*Review Scient. Instr.*, Feb. 1941, Vol. 12, No. 2, p. 105.) Positions of first contact in successive tests agreed within four millionths of an inch.

2009. High-Precision Gauging [Survey of Various Methods].—(*Sci. Abstracts*, Sec. B, Feb. 1941, Vol. 44, No. 518, p. 27.)

2010. Tool Dynamometer for measuring Rapid Force Fluctuations [up to 1500 c/s: Short Survey of Mechanical, Electrical, & Hydraulic Devices: even Electrical Type limited to about 50 c/s: New Mechanical Design (using de Forest Scratch-Extensometer) for Chatter up to & over 5000 c/s].—Arnold. (*Engineering*, 21st March 1941, Vol. 151, pp. 221–222 and Plate.)

2011. The Electrical Design of Induction Meters for measuring Small Displacements.—Milstein. (*Automatics & Telemechanics* [in Russian], No. 2, 1940, pp. 125–145.)

For the remote measurement of small displacements, in structures and machines, caused by tension, torsion, vibration, etc., the induction type of device is the most commonly employed. This is based on the use either of an a.c. bridge (Figs. 1–5) or of a differential transformer (Fig. 6). The displacement under observation causes the inductance of one or more elements in the circuit to be changed and as a result of this a current flows through the current indicator. The design of these circuits is discussed from the point of view of obtaining the maximum sensitivity, and it is shown that the optimum parameters of the circuit have a definite relationship to the parameters of the pick-up. It appears that the various types of circuit under consideration (Figs. 1–6) can be reduced to a common equivalent circuit, and from an analysis of this the necessary relationships are established. Methods are also indicated for determining the optimum parameters of the pick-up for given dimensions of this and given maximum power dissipation in its windings.

2012. A Ballistic Meter for measuring Time and Speed [Reliable & Portable Thyratron Instrument primarily for Motor-Car Speed Measurements at Dangerous Points].—Reich & Toomim. (*Review Scient. Instr.*, Feb. 1941, Vol. 12, No. 2, pp. 96–98.)

2013. High Rotational Speeds in Vacuum [Speeds up to 3200 r.p.s. by use of Holmes' Magnetic Suspension (later with Photocell Stabilisation replaced by Capacity-Change Stabilisation) and Electrostatic or Rotating-Magnetic-Field Drive].—Smith. (*Review Scient. Instr.*, Jan. 1941, Vol. 12, No. 1, pp. 15–20.) *Cf.* Skarstrom & Beams, 1265 of April.

2014. An Interferometric-Dilatometer with Photographic Recording.—Nix & MacNair. (*See* 1768 of June.)

2015. "Fortschritte der Photographie: II" [Book Review].—Stenger & Staude. (*Naturwiss.*, 6th Dec. 1940, Vol. 28, No. 49, pp. 767–768.)

2016. Single-Flash Photography [using the "Strobotac" or "Strobolux"].—Clayton. (*Electronics*, Jan. 1914, Vol. 14, No. 1, p. 82: summary only.)

2017. THE PERFORMANCE LIMITS OF THERMAL RADIATION-MEASURING INSTRUMENTS [Bolometers, etc.].—Dahlke & Hettner. (*See* 1706 of June.)

2018. PROTECTION AGAINST RADIATION, AND MEASUREMENTS OF ITS EFFECTIVENESS [with Bibliography].—Jaeger & Zimmer. (*Physik. Zeitschr.*, 15th Feb. 1941, Vol. 42, No. 2/3, pp. 25–35.)

2019. X-RAY EQUIPMENT IN THE AVIATION INDUSTRY [including Rapid Selection of Working Conditions by Electronic Methods].—Triplett & Erdman. (*Proc. I.R.E.*, Jan. 1941, Vol. 29, No. 1, p. 38: summary only.)

2020. ANTI-REFLECTION FILMS ON GLASS SURFACES [Criticism of French's Statements].—Turner: French. (*Journ. Applied Phys.*, April 1941, Vol. 12, No. 4, pp. 351–352.) *See* 955 of March.

2021. A PHOTOTUBE ABSORPTION ANALYSER [for determining the Concentration of Solvent Vapours in Chemical Processing: Detection of a Fraction of One Part in a Million].—Hanson. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 40–41.) From the du Pont de Nemours Company.

2022. A SIMPLE [and Rugged] PHOTOELECTRIC TURBIDIMETER [suitable for White Blood or Bacterial Counts, etc.]—Silverman. (*Review Scient. Instr.*, Feb. 1941, Vol. 12, No. 2, pp. 77–78.)

2023. PHOTOELECTRIC TEMPERATURE CONTROL [Advantages of Thyratron more fully exploited by Use of Phase-Shift Method of Control, eliminating Make-&-Break Contact].—Compton. (*Science*, 28th Feb. 1941, Vol. 93, pp. 215–216.)

2024. AN INTEGRATING PHOTOELECTRIC METER [for Ultra-Violet Energy Measurements in the Field or Laboratory: using Specially Pure Titanium Cathode and a Cold-Cathode "Trigger" Tube].—Kuper & others. (*Review Scient. Instr.*, Feb. 1941, Vol. 12, No. 2, pp. 87–90.)

2025. PHOTOELECTRIC CONTROL OF BESSEMER STEELMAKING.—Work. (*Engineering*, 21st March 1941, Vol. 151, pp. 237–240.)

2026. SPECTROSCOPY IN THE VACUUM ULTRA-VIOLET [Survey].—Boyce. (*Reviews of Mod. Phys.*, Jan. 1941, Vol. 13, No. 1, pp. 1–57.)

2027. THE CENTRAL CONTROL OF A TOWN LIGHTING PLANT BY CLOCK AND PHOTOCELL [at Basle].—Troller. (*Bull. de l'Assoc. suisse des Élec.*, No. 25, Vol. 31, 1940, pp. 585–587: in German.)

2028. PHOTOCELL DROPS HEADLIGHT SCREENS [Anti-Glare, Polarising] WHEN MEETING ANOTHER CAR.—Pollack. (*Sci. News Letter*, 1st March 1941, Vol. 39, No. 9, p. 137: U.S. Patent.) Thus maintaining the efficiency of the headlights at other times.

2029. A PRECISION DIRECT-READING SPECTROPHOTOMETER [revealing Fine Structure (of Fluorescence & Other Spectra) Not Detectable by Usual Methods].—Narayan & Ananthasubrahmanyam. (*Indian Journ. of Phys.*, Oct. 1940, Vol. 14, Part 5, pp. 393–399.)

2030. A PHOTOMETRIC PROCEDURE USING BARRIER-LAYER PHOTOCELLS.—Barbrow. (*Journ. of Res. of Nat. Bur. of Stds.*, Dec. 1940, Vol. 25, No. 6, pp. 703–710.)

2031. FILTER AND BARRIER-LAYER PHOTOCELL AS AN OBJECTIVE PHOTOMETER.—Rieck. (*Zeitschr. f. tech. Phys.*, Vol. 21, 1940, pp. 184–187.)

2032. NOTE ON THE PHOTOELECTRIC MEASUREMENT OF THE AVERAGE INTENSITY OF FLUCTUATING LIGHT SOURCES [Use of a Smoothing Condenser].—Preston. (*Journ. of Scient. Instr.*, April 1941, Vol. 18, No. 4, pp. 57–59.)

2033. "DIE PHOTOELEMENTE UND IHRE ANWENDUNG" [Vol. I: New & Revised Edition: Book Review].—Lange. (*Physik. Zeitschr.*, 15th Feb. 1941, Vol. 42, No. 2/3, p. 59.)

2034. HINTS ON THE USE OF LENS SYSTEMS IN INDUSTRY [*e.g.* in Photocell Applications & Recording Oscillographs].—Wright. (*Journ. of Scient. Instr.*, April 1941, Vol. 18, No. 4, pp. 53–57.)

2035. CONCERNING RESISTIVITY IN ELECTRICAL PROSPECTING: A PRACTICE TO BE REJECTED.—Mercanton. (*See* 1720 of June.)

2036. THE APPLICATION OF TELLURIC CURRENTS TO SURFACE PROSPECTING. — Schlumberger. (*Bull. No.* 11, *Int. Union Geod. & Geophys.*, Washington Transactions 1939, pub. 1940, p. 467: summary only.)

2037. THE FUNCTIONING OF RADIO-GEOLOGICAL PROSPECTING [Survey].—Fritsch. (*Naturwiss.*, Nos. 26 & 27, Vol. 28, 1940.) For a protest by Burstyn against the omission of all reference to his 1906 paper and 1916 patent, see *ibid.*, 6th Dec. 1940, No. 49, Vol. 28, p. 768: Fritsch replies.

2038. "GRUNDZÜGE DER FUNKGEOLOGIE" [Geophysical Prospecting by Radio Methods: Book Review].—Fritsch. (*Funktech. Monatshefte*, Jan. 1941, No. 1, p. 16.)

2039. "GEOPHYSICAL PROSPECTING FOR OIL" [Book Review].—Nettleton. (*Journ. Applied Phys.*, April 1941, Vol. 12, No. 4, pp. 355–356.)

2040. THE BRUSH SURFACE ANALYSER [Piezo-electric Pick-up, Amplifier, & Direct-Inking Oscillograph].—(*Engineer*, 4th April 1941, Vol. 171, p. 231.)

2041. AN ELECTRICAL GOVERNOR [for Prime Movers, primarily Hydraulic Turbines].—Morgan. (*Elec. Engineering*, Feb. 1941, Vol. 60, No. 2, Transactions pp. 81–84.)