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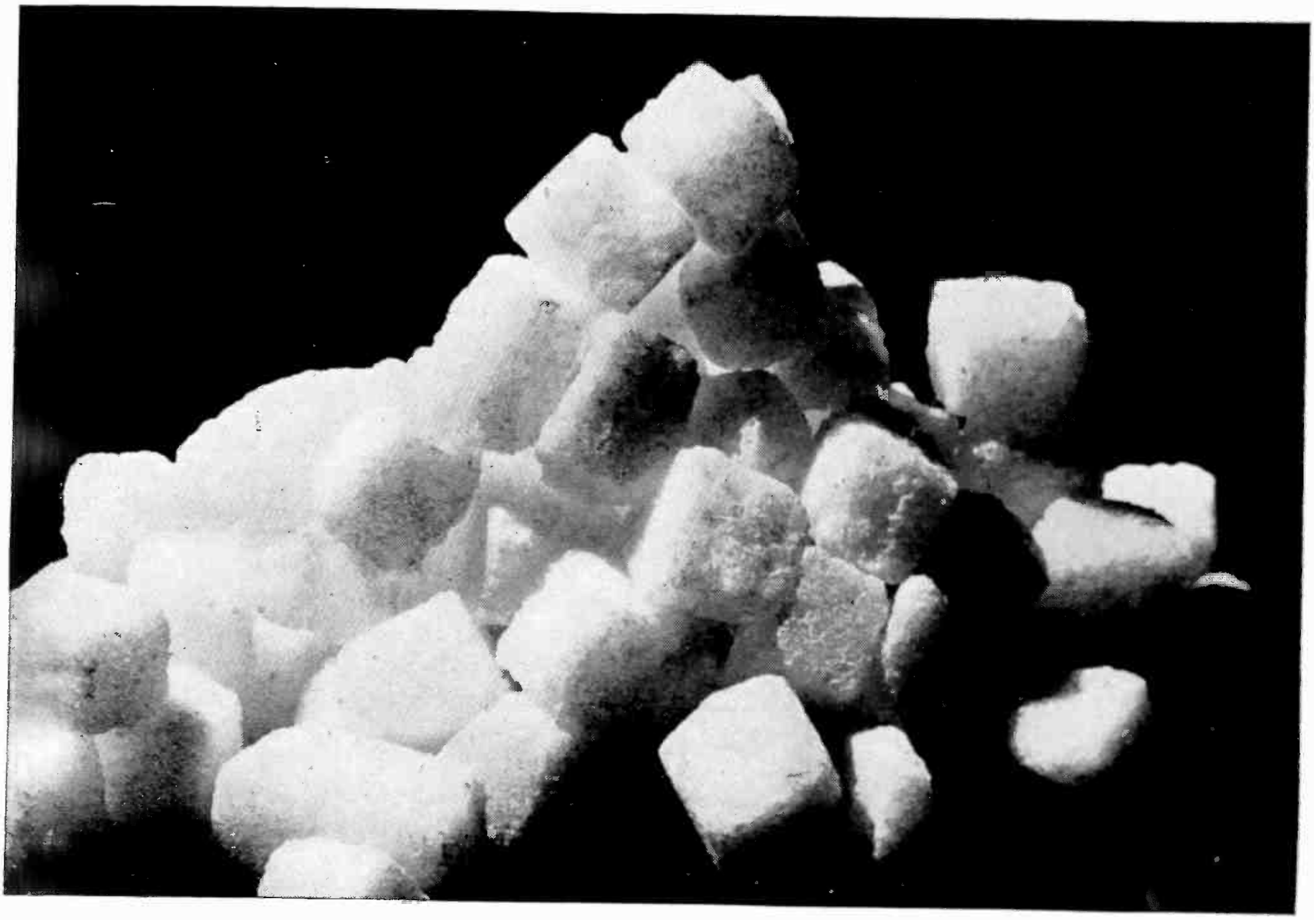

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WIRELESS ENGINEER

Editor HUGH S. POCOCK, M.I.E.E. Technical Editor Prof. G. W. O. HOWE, D.Sc., M.I.E.E.

VOL. XIX SEPTEMBER 1942 No. 228

Editorial

Research and Research Workers

THE demands of war bring forth many expressions of opinion concerning research work, and more particularly concerning the research workers—physicists, engineers, chemists and others. There are those who claim that our scientifically trained men are not being used by the Government; those who know that many thousands of them—well-known and eminent men, and men who would be eminent were their work not of necessity kept secret—are working, and working to their utmost limit, to complete research developments of vital import to the prosecution of the war effort; and there are even those who place the blame for the war entirely upon scientific developments and, therefore, wish to see all such work compulsorily stopped and to destroy the men and women who have collected and collated the knowledge that has made the developments possible.

The researches in question are being carried out in the academic surroundings of colleges and universities; in the various Government laboratories and those of research associations; and in the research and development laboratories of industrial manufacturing companies. The first-mentioned places were once always associated with the more fundamental researches into the laws of Nature, but to-day are frequently engaged upon much more practical and mundane matters concerned directly with the needs of the Defence Services. In this direction their work runs closely parallel and is frequently carried out in association with that of the various Government laboratories. The third-mentioned field deals mainly with the problems especially arising from the needs of production of the munitions of war, be it bomb-sight or radio set. Not the least among these problems is that of the numerous substitute materials which force of circumstances or the magnitude of the usage has compelled into employment, either to replace materials that are unobtainable or in short supply, or to reinforce existing ones to meet the larger needs.

Frequently, long and arduous research has to be undertaken before a substitute material can be approved for use in a complex manufacturing process which has been developed as a result of years of experiment and experience. This fact would seem in many instances to be quite beyond the knowledge of the various control or licensing authorities who apply a brake to the use of special materials. It follows, therefore, that when time is limited—as it almost invariably must be when a long-used material needs suddenly to be replaced by another—only those research workers thoroughly familiar not only with the scientific aspects of the problem but conversant also with the commercial processes associated therewith, can have any hope of solving it in a reasonably short space of time or in a manner which will enable them to "take a gamble" with a reasonable chance of success when time does not permit of the full investigation that ought to be made.

The status of the research worker in these various institutions and laboratories has often been the subject of controversy. The inadequacy of the supply of suitably trained workers[1] has given the less stable of them an exaggerated view of their indispensability; but the true scientist's love for his work rises above such difficulties. It must not be overlooked, however, that the ever more technical and specialised needs of the present-day wartime manufactures places the production managers more and more in the hands of the technical workers and dependent upon them.

Wartime Problems

Two notable reviews of the problems of wartime research have recently appeared, which deserve especial mention—one in the United States by L. A. Hawkins, of the General Electric Research Laboratories at Schenectady,[2] and the other by Sir Lawrence Bragg,[3] the well-known physicist of the Cavendish Laboratory.

One great difference between research work under normal peacetime conditions and those existing now is the much greater co-operation that is necessary between different workers or units. Wartime problems to-day are seldom such as can be tackled by one worker, or even by a team in one laboratory. They frequently require co-operation between different laboratories, either because these different laboratories have workers with different experience or equipment, or because the magnitude of the work is such that a larger number of researchers are needed adequately to deal with it.

To bring the germ of an idea into practical development so that it can be manufactured and put to use by the Services may, and frequently does, involve problems in many normally quite unrelated spheres of work. Radio equipment becomes tied up with gunnery, and electrical components with explosives. These very diverse fields must be brought together and co-ordinated by the technical staffs of a Government department or laboratory who are controlling the development as a whole. Only first-class technically trained men can do this work—which partakes more of the nature of application development than of true research work—usually a true research worker—such as a physicist—would not be so useful in this place as would be an engineer, whose training has been more on the lines of applying the results of scientific research to practical uses. Many of the sectional researches of these problems can be dealt with very successfully by the research laboratories of the larger engineering companies; but in general the main work of these laboratories lies in dealing with the more specific problems that arise when a device reaches the production stage. These problems are frequently numerous, since it often happens that the component parts that served well for the first experimental tests are either not so suited for mass production or cannot be prepared in sufficient quantities. The problem of substitutes then again crops up.

This type of work can be done more effectively by the researchers in the industrial laboratories, since it is a type of work which is similar to their normal occupations. Possession of the type of mind best adaptable to work of this character has, in fact, frequently been the basis for the selection of the staff of such laboratories. Not all physicists or engineers by any means can carry it out successfully.

Co-operative Research

Merely because an individual has been technically trained—for example, as a physicist, an engineer, or a chemist—does not fit him for all types of work in that sphere. This fact is often overlooked by those responsible for their employment.

This is sometimes a fault of research associations—particularly those with a wide range of activities—since their workers may have many and diverse aspects of a problem to deal with. It would often be better if technical staffs from industrial laboratories could go and work at times in the laboratories of the research associations or of a university, to co-operate with a given problem, rather than that the normal association staff should deal with it.

[1] *Journal I.E.E.*, Vol. 88, Part I, pp. 425–426 Dec. 1941.

[2] *Gen. Elec. Review*, Vol. 45, pp. 323–325, June 1942.

[3] *Nature*, Vol. 150, pp. 75–80, July 18th, 1942.

Some effort has already been made in this direction. Much more could usefully be done.

An expression of disappointment has not infrequently been made by industrialists regarding the results of research as affecting their particular line of business. As there is "no smoke without fire" it would be well if all who have the future welfare of the researcher at heart could bear this in mind and seek to eradicate the cause. Too often the fault—if there is one—lies in a lack of appreciation of the needs of the research worker. He cannot produce results to order. He must have free access to the work of others by actual discussion and by study; and, above all, he must be reasonably free from frequent distractions from his proper work.

Research and Production

Only too often is the so-called research or development laboratory of an industrial concern cluttered up with the worries of the production department. True, these worries must receive attention, but they should primarily get attention from an entirely different staff to those carrying out research or development work. There must be full co-operation between the two sections, so that at least all major matters come to the attention of the development staff, particularly when they concern the fundamentals of the manufacturing process.

It may be that in wartime the line of demarcation above indicated must be erased to a large extent; yet, on the other hand, the need for it must never be overlooked if really good and useful development work is to be produced—particularly when the present strife is over and thoughts can again be turned to making some practical and peaceful uses of the many developments that have been forced upon us by the war.

War tends to restrict fundamental researches, which frequently must, from their nature, extend over long periods. But it is the fundamental researches which in the long run yield the new developments in the commercial fields. The physical research of to-day becomes the engineering development of to-morrow. Applied research, under the rush of war needs, may yield greater potentialities for revolutionary developments afterwards than are often found in the applied research of peacetime. The much larger scale on which such researches are made may account for this.

The sacrifice that the scientist has to make in leaving the alluring search for truth for truth's sake, and turning to the developments of wartime devices, receives some special compensation in his knowledge that his war effort, beyond its primary and all-important purpose of contributing to victory over the enemy, will in all likelihood yield things of great value when peace returns.

The late E. H. Shaughnessy

WE record with regret the passing on July 29th of E. H. Shaughnessy, O.B.E., M.I.E.E., who, in his varying capacities in the Post Office engineering department, played a large part in the development of national and international wireless communications.

He was born in 1871 and entered the Post Office as a telegraphist at the age of 16. After obtaining a wide experience in most branches of telecommunications engineering he became head of the wireless section of the engineering department in 1913. He was appointed Assistant Engineer-in-Chief of the Post Office in 1925 and retired in 1931. His activities in the world of wireless were not confined to the Post Office. He was a member of the Radio Research Board and served on several committees of the British Standards Institution. He was a delegate to the Inter-Allied Technical Conference on Wireless Telegraphy in Paris in 1921 and to the International Radiotelegraphic Conference held at Washington in 1927. He was a member of the Council of the I.E.E. and a past-chairman of the Wireless Section.

Mr. Shaughnessy will perhaps be best remembered for his part in the construction of the Rugby wireless station. The design was entrusted to a technical commission of which the late Lord Milner was chairman and Dr. W. H. Eccles, Mr. Shaughnessy and Mr. L. B. Turner were members. The commission recommended a valve transmitter, although at that time no high-power station of this type was in existence, and Mr. Shaughnessy, as executive member, was responsible for the construction.

Harmonic Distortion in Audio-Frequency Transformers.—1*

By Norman Partridge, Ph.D., B.Sc.(Eng.), A.M.I.E.E.

(Abstracted from a thesis approved by the University of London for the award of the degree of Doctor of Philosophy) †

ONE of the primary requirements in an audio-frequency transformer is that it shall not distort. It is well known that the non-linearity of the magnetic properties of the core materials in common use gives rise to harmonic distortion. Yet, as far as the writer is aware, there exists no recognised procedure by means of which the magnitude of this distortion may be calculated. Neither has a "distortion coefficient" been associated with magnetic materials whereby their relative merits or demerits in this respect might be judged.

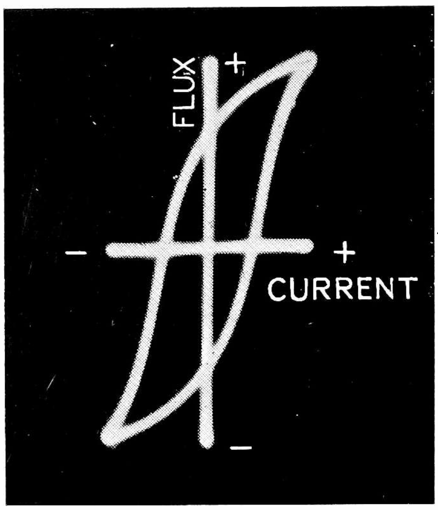


Fig. 1.—*Typical relationship between the instantaneous no-load current and flux density.*

The research about to be described was undertaken with a view to mitigating this technical deficiency. The outcome has been the discovery of many important facts concerning transformer distortion together with the introduction of an essentially practical method of treating relevant problems.

* MS. accepted by the Editor, May, 1942.

† Typescript copies of the original thesis are contained in the library of the University and in the library of the Institution of Electrical Engineers.

The relationship between the instantaneous values of the no-load current drawn by a transformer and the flux density within the core of the transformer can be represented graphically by a curve having the general form shown in Fig. 1. If the magnetic circuit be a closed one, this curve will approximate to the well-known hysteresis loop, but will depart from it to an extent dependent upon the current component associated with the eddy losses.

If an alternating voltage of sine waveform be applied to a winding having negligible resistance, the resultant flux will also have a sine wave-form. It follows from the relationship indicated by Fig. 1 that the no-load current will not be sinusoidal but will contain components at the harmonic frequencies. Conversely, if an alternating current of sine wave-form be caused to traverse the winding, it is evident that the wave-form of the flux will be something other than a simple sine curve. Since $v \propto dB/dt$, the harmonic content of the counter e.m.f. induced in the transformer winding will be greater than that of the flux within the core.

The former condition mentioned above is approached when the impedance in series with the sine wave source and the transformer is negligibly small. The latter condition will arise in the presence of a linear series impedance of infinite magnitude. Audio-frequency transformers normally function between these limits, the magnitude of the series impedance being comparable with the magnitude of the impedance of the transformer winding. Hence both the no-load current flowing through the winding and the voltage across its terminals will contain components at the harmonic frequencies of the source. Expressed in another way, the distorted no-load current will give rise to a distorted voltage drop across the series impedance which will be reflected in the voltage across the transformer. It is clear from this that the resistance of the transformer winding must be regarded as a part of the external series impedance.

Consider the general case of an unloaded transformer. Let Z_f (see Fig. 2) be the impedance (*not* reactance) of the transformer coil at the fundamental frequency, excluding the resistance of the winding. Also let

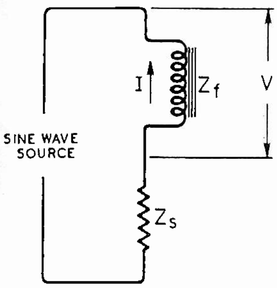


Fig. 2.—*Low-frequency circuit employing an unloaded transformer. Z_f is a non-linear impedance.*

I and V be the r.m.s. values of the current through the coil and the voltage across it respectively. These will be made up of fundamental components I_f and V_f, plus a series of harmonic components which can be represented by I_h and V_h for any one harmonic frequency. Since the total harmonic voltage in the source is zero, it follows that at any one harmonic frequency the voltage across the coil (V_h) must be equal and opposite to that across the series impedance, namely $-I_hZ_S$, where Z_S is the series impedance at the harmonic frequency under consideration and includes the resistance of the transformer winding. Therefore :—

$$V_h = -I_hZ_S$$

also $$V_f = I_fZ_f$$

hence $$\frac{V_h}{V_f} = -\frac{I_h}{I_f} \cdot \frac{Z_S}{Z_f} \qquad \ldots \quad \ldots \quad (1)$$

We thus have an expression for the fractional voltage distortion at any one harmonic frequency in terms of the fractional current distortion.

The effect of a load upon the secondary of the transformer can readily be deduced. A modified circuit is shown in Fig. 3 where the load has been transferred to the primary in accordance with known and well established principles. Let the current flowing from the source and through Z_S be I'_f at the fundamental frequency and I'_h at any one harmonic frequency. If the corresponding currents through Z_f remain I_f and I_h as before, the currents through Z_L will be $I'_f - I_f$ and $I'_h - I_h$ at the fundamental and harmonic frequencies respectively. Let e be the r.m.s. voltage of the sine wave source. Then :—

$$e = (I'_f + I'_h)Z_S + V_f + V_h \qquad \text{(vector eqn.)}$$
$$= I'_f Z_S + V_f + I'_h Z_S + V_h$$

The value assigned to Z_S must be that appropriate to the frequency of the current (I'_f or I'_h) with which it is associated.

Since the total harmonic voltage present in the source is zero, it follows that :—

$$0 = I'_h Z_S + V_h$$

or $V_h = -I'_h Z_S$

Again :—

$$e = (I'_f + I'_h)Z_S + (I'_f - I_f + I'_h - I_h)Z_L$$
$$= I'_f(Z_S + Z_L) - I_fZ_L + I'_h(Z_S + Z_L) - I_hZ_L$$

therefore

$$0 = I'_h(Z_S + Z_L) - I_hZ_L$$

or

$$I'_h = I_h \cdot \frac{Z_L}{Z_S + Z_L}$$

hence

$$V_h = -I'_h Z_S = -I_h \cdot \frac{Z_SZ_L}{Z_S + Z_L}$$
$$= -I_hZ$$

where $$\frac{1}{Z} = \frac{1}{Z_S} + \frac{1}{Z_L} \qquad \text{(vector sum)}$$

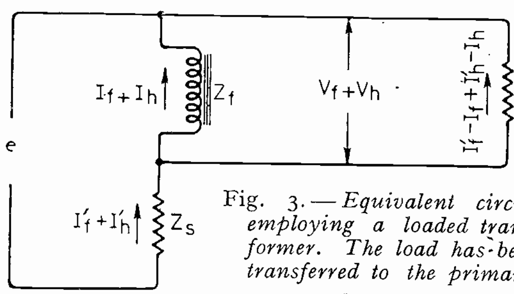


Fig. 3.—*Equivalent circuit employing a loaded transformer. The load has been transferred to the primary.*

Remembering that $V_f = I_fZ_f$, the fractional voltage distortion at any one harmonic frequency is seen to be :—

$$\frac{V_h}{V_f} = -\frac{I_h}{I_f} \cdot \frac{Z}{Z_f} \qquad \ldots \quad \ldots \quad \ldots \quad (2)$$

Equation (2) is of fundamental importance. Comparing equations (1) and (2) it is evident that the case of a loaded transformer can be reduced to the simpler case of an unloaded transformer by substituting an equivalent series impedance equal to that of the actual series and shunt impedances taken in parallel.

It may be noted in passing that :—(a) The value to be assigned to Z in equation (2) must be determined vectorially. (b) When the load and/or series impedance is non-resistive, Z is variable with frequency and the value allotted to it in equation (2) must be that corresponding to the particular harmonic frequency being considered. (c) When it is required to express only the relative magnitude of the harmonic voltage, either fractionally or as a percentage, the minus sign in equation (2) will have no significance and only the magnitudes of the various vector quantities involved need be taken into account.

It is known that the distortion of the no-load current (I_h/I_f when $Z = 0$) drawn by a transformer is a function of the peak flux density (B_m) within the core material. We have seen that I_h/I_f is also a function of Z, becoming zero at any value of B_m when Z is infinite. This dependence of I_h/I_f upon two independent variables renders equation (2) unsuitable in its present form for general application to practical problems. But it can be applied to a certain limited group of problems including all those cases where Z is very small by comparison with Z_f. The fractional distortion of the no-load current when $Z = 0$, which is easily measured and plotted as a function of B_m, can be accepted as remaining substantially unaltered when Z is finite but very small. Therefore we may write :—

$$\frac{V_h}{V_f} = -\frac{I_h}{I_f}\cdot\frac{Z}{Z_f} \approx -\frac{I_H}{I_f}\cdot\frac{Z}{Z_f} \quad \ldots \quad (3)$$

The symbol I_H has been used to denote the particular value of I_h when $Z = 0$. The difference between the true current distortion (I_h/I_f) when Z is finite and the known current distortion (I_H/I_f) when $Z = 0$ will determine the degree of approximation involved.

The validity of equation (3) cannot be doubted so long as the ratio Z/Z_f remains extremely small. But there appears to be no way of deducing the limiting value of this ratio above which the equation will cease to be of practical use. The writer therefore approached the problem experimentally by studying the behaviour of the equivalent circuit shown in Fig. 2 with a view to discovering the extent of the dependence of equation (3) upon the value of Z/Z_f.

The possible scope of such an enquiry extends almost indefinitely. In order to simplify the work and to ensure that the results should be of the greatest practical value, limitations were imposed in accordance with the following six considerations :

(1) *Core Material.*—The most urgent need for information concerning transformer distortion appears to be in connection with large output transformers where the tendency is towards the employment of high flux densities at the lowest considered frequency. Therefore silicon steels were selected for examination and Table I lists the particular grades studied.

TABLE I

SILICON STEELS* EMPLOYED FOR THE TESTS

Trade Name	Silicon Content† (Per cent.)	Sheet Thickness (in.)	Max. Loss in watts/kilo. $f = 50$, $B_m = 10\,000$	Spec. Resist.	Spec. Gravity	Equivalent Material by Sankey	Equivalent Material by Armco
Vicor	3½	0.020	1.26	56	7.5	—	—
Silcor 1	4	0.014	1.30	56	7.5	Super Stalloy	Tran-Cor II.
Silcor 2	3½	0.014	1.40	56	7.5	Stalloy	Tran-Cor I.
Silcor 3	2¾	0.018	2.14	41	7.5	42 Quality	Special Elec.
Silcor 4	1	0.018	3.17	18	7.5	Lohys	Armature.

NOTE.—Vicor is subjected to special rolling and annealing processes, and was obtainable only in one thickness 0.020 in. This material is unobtainable at the present time.

* Manufactured by Magnetic and Electrical Alloys, Ltd., of Wembley.

† The figures quoted for the silicon content were supplied by Magnetic and Electrical Alloys.

(2) *Form of the Test Specimen.* The investigation relates primarily to transformer technique rather than to the properties of magnetic materials as such. Hence a typical transformer stamping (M. & E.A., No. 4) was used in place of the usual ring sample.

(3) *Range of B_m.*—The behaviour of iron at low flux densities has been studied elsewhere (see E. Peterson, *Bell System Technical Journal*, Vol. 7, pp. 762–796, October 1928, and J. W. L. Kohler, *Philips Technical Review*, pp. 193–200, July 1937). The present experiments were therefore designed to extend the upward limit to peak flux densities of say 10,000 lines per sq. cm.

(4) *Nature of Z.* It is usual to specify the performance of transformers (and of A.F. amplifiers, etc.) with reference to a resistive load. Also Z is in practice very often substantially resistive. Hence Z was tentatively represented by a pure resistance (R).

(5) *Range of R/Z_f.* The bass attenuation of a transformer is determined by the factor R/Z_f. It is not of immediate interest to study the harmonic distortion produced by transformers whose bass attenuation is beyond practical acceptance. If 3 db be taken as the limit of attenuation, the maximum value of R/Z_f is restricted to unity.

considerably less than 5 per cent. Hence in all practical cases the peak flux density within the core can be estimated from a knowledge of the r.m.s. value of the fundamental voltage across the transformer coil.

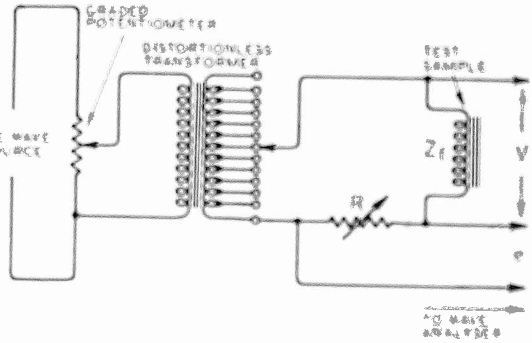


Fig. 4. *The circuit used to study the effect of a series resistance upon the harmonic currents at constant peak flux density.*

The circuit devised for the investigation is shown in Fig. 4. A low impedance source of sinusoidal voltage is applied to the circuit by means of a tapped transformer. The graded potentiometer is for the purpose of demagnetising the sample and to enable the test voltage to be applied gradually thus ensuring a normal cyclic condition within the sample. The supply transformer, which must itself be distortionless and have negligible resistance and leakage reactance, provides the required degree of voltage control. R is a decade resistance box of suitable current carrying capacity and low reactance. The sample (Z_f) consisted of

TABLE II

TEST ON SILICON 2 AT 1400 LINES PER SQ. CM. PEAK

R Ohms	V_f Volts	Voltage Analysis mV e_1	e_2	e_3	e_4	e_5	Deduced Currents (e/R) µA I_1	I_2	I_3	I_4	I_5	R/Z_f
0	10.0							[illegible]	984	72.3	35.3	0
122	10.0	1120	118	22	8.8	4.2	[illegible]	[illegible]	180	72	34.5	0.112
244	10.0	2250	235	43	17.0	8.4	[illegible]	[illegible]	176	70	34.5	0.224
366	10.0	3400	340	65	25	12.3	[illegible]	[illegible]	177	68	33.5	0.335
488	10.0	4500	435	83	34	16.0	[illegible]	[illegible]	[illegible]	70	33	0.45
610	10.0	5600	530	100	41	19.5	[illegible]	[illegible]	164	67	32	0.56
732	10.0	6800	620	117	48	22.5	[illegible]	[illegible]	160	66	31	0.67
854	10.0	7800	700	135	55	26	[illegible]	[illegible]	158	64	30.4	0.78
976	10.0	9000	780	150	63	30.5	[illegible]	[illegible]	154	65	31	0.89
1098	10.0	10100	850	165	69	35	[illegible]	[illegible]	150	63	30	1.01

Z_f = [illegible] = [illegible] ohms

(6) *Maximum Voltage Distortion.* The transformer distortion normally permitted in practice is certainly less than 5 per cent. Since $e \propto dB/dt$, the corresponding distortion of the flux wave-form must be

a 1in. stack of No. 4 (M. & E.A.) stampings wound with the required turns of enamelled copper wire. An electrical wave analyser (Marconi-Ekco Instruments, Type TF455) was employed to measure the voltages appearing across R at the fundamental and harmonic frequencies from which the corresponding currents are deduced. The wave analyser was also used to measure the fundamental voltage (V_f) across the test sample from which the peak flux density is computed.

Measurements were recorded at nine different values of R/Z_f between 0 and 1 at each of a number of selected peak flux densities. The procedure consisted of setting R to the desired value, adjusting the voltage of the source until the peak flux density within the sample attained the required value and then observing the magnitudes of the voltages appearing across R at the fundamental and harmonic frequencies.

The results of one series of tests upon a sample of Silcor 2 at a constant peak flux density of 1,400 lines per sq. cm. are set out in Table II. These results are presented in a different form in Fig. 5 (b). Here the harmonic currents when R is finite have been expressed as a percentage of their values when $R = 0$ and plotted against R/Z_f. The curves thus focus upon a common origin and the result of the test can be viewed as a whole. Further tests upon Silcor 2 at constant peak flux densities of 430, 3,500, 4,300 and 8,500 lines per sq. cm. are also shown graphically in Fig. 5, while tests upon Vicor and Silcor 4 at constant peak flux densities of 430, 3,500 and 8,500 lines per sq. cm. are shown in Figs. 6 and 7 respectively. An analysis of the various

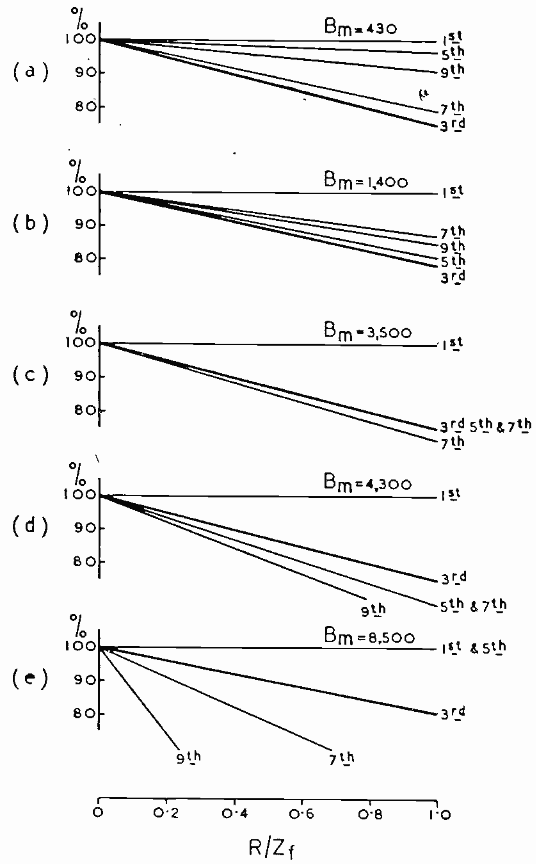


Fig. 5.—*Showing the relationship between the magnitudes of the harmonic currents and R/Z_f at constant peak flux density. Curves derived from Table II. (Silcor 2).*

TABLE III

CURRENT ANALYSES WHEN $R/Z_f = 0$.

Material	Peak Flux Density Lines per sq. cm.	Harmonic Current Per Cent.*				Reference
		3rd	5th	7th	9th	
Silcor 2	430	6.3	1.5	0.5	0.2	Fig. 5a
,,	1400	11	2.0	0.8	0.4	Fig. 5b
,,	3500	17	2.6	1.1	0.5	Fig. 5c
,,	4300	19	3.0	1.2	0.6	Fig. 5d
,,	8500	30	5.0	1.6	0.8	Fig. 5e
Vicor	430	4	1.6	0.6	0.15	Fig. 6a
,,	3500	13	1.7	0.5	0.2	Fig. 6b
,,	8500	26	4.5	1.2	0.4	Fig. 6c
Silcor 4	430	7	2.0	0.6	0.3	Fig. 7a
,,	3500	14	3.0	1.0	0.5	Fig. 7b
,,	8500	23	5.5	1.6	0.9	Fig. 7c

* The harmonic currents are expressed as percentages of the fundamental and *not* of the total (r.m.s.) current. Thus the fundamental is always 100 per cent.

no-load currents when $R/Z_f = 0$ will be found in Table III.

The investigation achieves the result expected from it and equation (3) is thereby rendered capable of practical application. For example, at a peak flux density of 4,300 lines per sq. cm. the values of I_H/I_f applicable to Silcor 2 at the 3rd, 5th, 7th and 9th harmonic frequencies are (from Table III) 0.19, 0.03, 0.012 and 0.006 respectively. Turning to Fig. 5 it can be seen that these values remain accurate within 5 per cent. for all values of R/Z_f between 0 and 0.2, 0.15, 0.15 and 0.12 respectively. If an accuracy of something other than 5 per cent. is desired, then a new set of limits to the maximum values of R/Z_f can be taken from the appropriate diagram.

But a careful study of the information disclosed by Table III and Figs. 5, 6 and 7 will reveal that the experiments have opened up considerable possibilities not at all anticipated at the outset. Consider the following facts :—

(a) The current at the 3rd harmonic frequency is in all instances so much greater

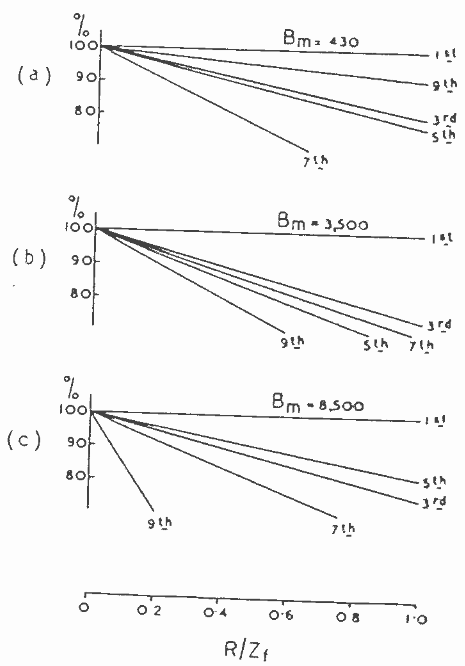


Fig. 6.—*As Fig. 5 but relating to Vicor.*

than those at the higher harmonic frequencies that the r.m.s. value of the total harmonic current approximates to that at the 3rd harmonic frequency taken alone. Expressed symbolically :—

$$I_3 \approx \sqrt{I_3^2 + I_5^2 + I_7^2 + \ldots + I_h^2}$$

It may be noted that if the 5th harmonic current is as much as 30 per cent. of the 3rd harmonic current the error occasioned by ignoring it is only $4\frac{1}{2}$ per cent.

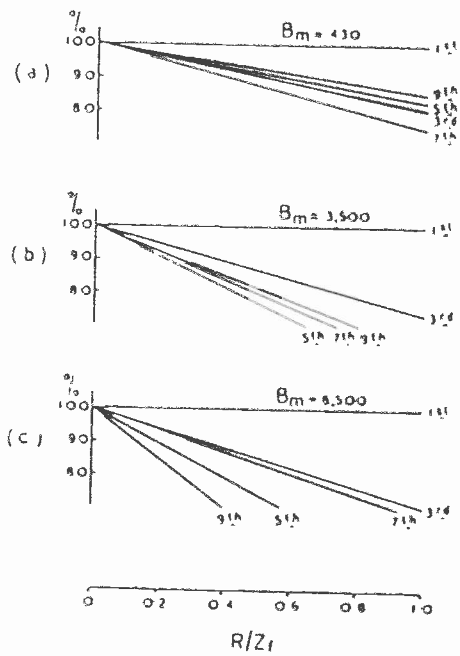


Fig. 7.—*As Fig 5 but relating to Silcor 4.*

Hence when considering the total harmonic distortion (r.m.s. summation) of the current it is necessary only to observe the distortion at the 3rd harmonic frequency providing an accuracy of 5 per cent. is acceptable.

(b) The true harmonic current (I_h) at the 3rd harmonic frequency at any value of R/Z_f between 0 and 1 can be estimated from a knowledge of the said current when $R/Z_f = 0$, i.e. I_H, by means of the following empirical relationship :—

$$I_h = I_H\left(1 - \frac{R}{4Z_f}\right) \quad \ldots \quad \ldots \quad (4)$$

This relationship appears to hold true, with a maximum error of the order of 5 per cent., for all the silicon steels in common use at all flux densities employed in practice.*

* Preliminary experiments conducted by G. A. V. Sowter, B.Sc., M.I.E.E., authority on nickel irons and their applications, suggest that the same relationship is displayed by the nickel alloys also.

This discovery is an important one. The approximation contained in equation (3) can now be avoided by substituting in equation (2) the value of I_h given by equation (4). The new equation becomes :—

$$\frac{V_h}{V_f} = \frac{I_H}{I_f} \cdot \frac{R}{Z_f}\left(1 - \frac{R}{4Z_f}\right) \quad .. \quad .. \quad (5)$$

Z, appearing in equation (2), has been replaced by R and also the minus sign has been omitted for reasons already discussed. The new equation is, of course, subject to the same limitations as equation (4). It may be employed with certainty only for the silicon steels operating below a peak flux density of, say, 10 000 lines per sq. cm. The maximum error, which occurs when $R/Z_f = 1$ will be of the order of 5 per cent. And the equation is applicable only to the 3rd harmonic frequency which, as has been shown, approximates to the total (r.m.s.) distortion.

Given a transformer of known design operating under stated conditions, the appropriate values can readily be assigned to the various factors appearing to the right of equation (5). R can be calculated without difficulty. Z_f is a function of B_m and can be measured at a number of values of B_m and recorded in the form of a curve. The value appropriate to any particular load upon the transformer can then be taken from the curve at will. Similarly, I_H/I_f, which is also a function of B_m, can be measured either at the 3rd harmonic frequency or as the r.m.s. sum of the distortion at all harmonic frequencies, and treated graphically.

Nevertheless, equation (5) does not offer so complete a solution to problems relating to transformer distortion as one would wish. The curves of I_H/I_f and Z_f obtained as just described will be applicable only to the one transformer and, furthermore, only at the one fundamental frequency at which the measurements were made. Both I_H/I_f and Z_f are dependent upon eddy losses. Any change, such as that of frequency or lamination thickness, which alters the relative eddy loss may at the same time invalidate the original test figures.

The employment of data having such limited application is clearly undesirable. The need is for a method of working from data appertaining to the core material and completely independent of the design of the particular transformer being examined. It is towards this end that attention will next be directed.

(To be continued)

High-Frequency Apparatus

Relaxation of Control Order

THE Government Control of High-Frequency Apparatus Order made in 1940, which prohibited the possession or use by any person in the United Kingdom of high-frequency apparatus having an H.F. output of over 10 watts except under permit from the Postmaster General, has been relaxed by the Home Office. Under the Order it was not possible for permits to be issued except to hospitals, clinics, or other authorised institutions; to manufacturers who require to use H.F. apparatus; to makers and dealers in high-frequency apparatus; and to research laboratories.

This restriction has now been removed and any person may apply for a permit, which, however, will not be issued until the necessary screen and mains filter has been installed in accordance with Post Office specifications. Applications for permits or for particulars of screening should be addressed to the Engineer-in-Chief, Radio Branch (W.2/8), General Post Office, Harrogate, Yorkshire.

The Secretary of State has also revoked the Aliens (High-Frequency Apparatus Restriction) Order, 1940, which prohibited enemy aliens from having high-frequency apparatus without Home Office permission. It will, of course, be necessary for enemy aliens who wish to use or possess such apparatus to apply to the General Post Office for a permit.

"Bell System Technical Journal"

DUE to U.S. Government restrictions on the export of technical periodicals the dispatch abroad of the *Bell System Technical Journal* is being discontinued for the duration of the war. Where subscribers so wish it the publishers will hold copies for dispatch after the cessation of hostilities.

Dr. C. C. Paterson

DR. C. C. PATERSON, who has been Director of the Research Laboratories of the General Electric Company of England since their inception in 1919, has been appointed to the Board of the Company.

Class C Telegraphy*

The Graphical Determination of Optimum Operating Conditions for Transmitting Valves

By D. G. Prinz, Ph.D. and R. G. Mitchell, B.Sc.

(Communication from the Research Staff of the M.O. Valve Co. Ltd., at the G.E.C. Research Laboratories, England)

SUMMARY.—The derivation is given of sets of curves which enable the optimum operating conditions for transmitting valves to be determined for Class C telegraphy operation, and the use of these curves explained.

Introduction

THIS article deals with the assessment from the static data of the dynamic performance of transmitting valves for Class C Telegraphy operation. Given the anode D.C. voltage E_a, the maximum anode dissipation D_{max}, the maximum D.C. anode current $I_{a\,max}$, the maximum peak space current, and a family of anode voltage—anode current characteristics for the valve in question, we wish to determine the maximum possible output compatible with these limitations and the various associated circuit constants required in order to obtain that output.

Part I gives a set of rules and graphs which enable the various factors to be determined in a simple and direct way, while Part II deals with the theoretical derivation of these formulae and curves.

List of Symbols Employed

E_a = Mean D.C. anode voltage.
$\hat{e}_a$ = Peak H.F. anode voltage.
e_a = Instantaneous anode voltage.
I_a = Mean D.C. anode current.
$\hat{i}_a$ = Peak anode current.
i_a = Instantaneous anode current.
E_g = D.C. grid bias voltage.
$\hat{e}_g$ = Peak H.F. grid voltage.
e_g = Instantaneous grid voltage.
D = Anode dissipation.
θ = Half angle of anode current flow per cycle.
θ/π = Fraction of H.F. cycle during which anode current flows.
Z_o = Anode load impedance.
h = $\hat{e}_a/E_a$.
b = $1 - h$.
F_{wi} = Input factor $= \dfrac{\sin\theta - \theta\cos\theta}{\pi(1-\cos\theta)}$.
F_{wu} = Output factor $= \dfrac{\theta - \sin\theta\cos\theta}{2\pi(1-\cos\theta)}$.
F_η = Efficiency factor $= \dfrac{\theta - \sin\theta\cos\theta}{2(\sin\theta - \theta\cos\theta)}$.
η = Efficiency $= h \,.\, F_\eta$.
W_i = Input $= E_a \,.\, \hat{i}_a \,.\, F_{wi}$.
W_u = Output $= \hat{e}_a \,.\, \hat{i}_a \,.\, F_{wu}$.
α = $1/F_{wi}$.

N.B.—F_{wi}, F_{wu} and F_η are functions solely of θ, and are plotted against θ/π, along with $\cos\theta$ in Fig. 7.

The following relationships should be noted :—

$$\hat{i}_a/I_a = 1/F_{wi} = \alpha \qquad D = E_a \,.\, \hat{i}_a \,.\, (F_{wi} - h \,.\, F_{wu})$$

$$F_\eta = \frac{F_{wu}}{F_{wi}} \qquad Z_o = \frac{\hat{e}_a^2}{2W_u}$$

Minimum anode voltage $e_{a\,min} = (1 - h)E_a$
i.e. $= b \,.\, E_a$

PART I

In every high-frequency cycle the valve passes through a state characterised by the grid voltage e_g and the anode current i_a having their maximum values while the anode voltage e_a is a minimum. This state corresponds to a definite point in the $e_a - i_a$ diagram, which is called the Peak Working Point, abbreviated P.W.P. (see Fig. 1). For optimum output, this point should lie close to the left-hand boundary of the field of characteristics. If then we draw on the $i_a - e_a$ characteristics a straight line through the origin just a little to the right of the boundary line, we should expect the P.W.P. to lie somewhere on that line (Fig. 1). The

* MS. accepted by the Editor, June 1942.

exact position of this line is not critical but it may require alteration should resulting values of grid current or, in the case of pentodes, screen current, be excessive. We call this line the Limiting Resistance Line, abbreviated L.R.L.

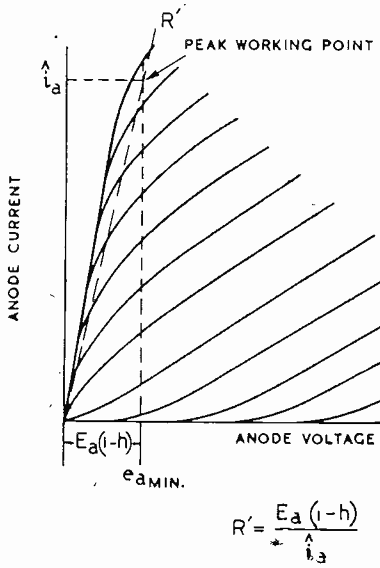


Fig. 1.

Fig. 2 (*right*).

At any point on this line, the ratio of e_a to i_a has the same value which we call the Limiting Resistance and denote by R', and which is a characteristic quantity of the valve in question.

By means of E_a, D_{max} and the Limiting Resistance R' defined above we form the auxiliary quantity $\beta = \frac{E_a^2}{R' \cdot D_{max}}$. Fig. 2 shows several factors plotted against β which serve to determine the data in the following way.

The input is $W_i = (\xi + 1) D_{max}$. The anode D.C. current $I_a = \frac{W_i}{E_a}$. If this turns out to be larger than is permissible, Fig. 3 must be used as will be explained later. Otherwise the remaining data are obtained as follows :—

Output $W_u = \xi \, . \, D_{max}$.

Anode swing $\hat{e}_a = h \, . \, E_a = (1 - b)E_a$.

Minimum anode voltage

$$e_{a\,min} = (1 - h)E_a = bE_a.$$

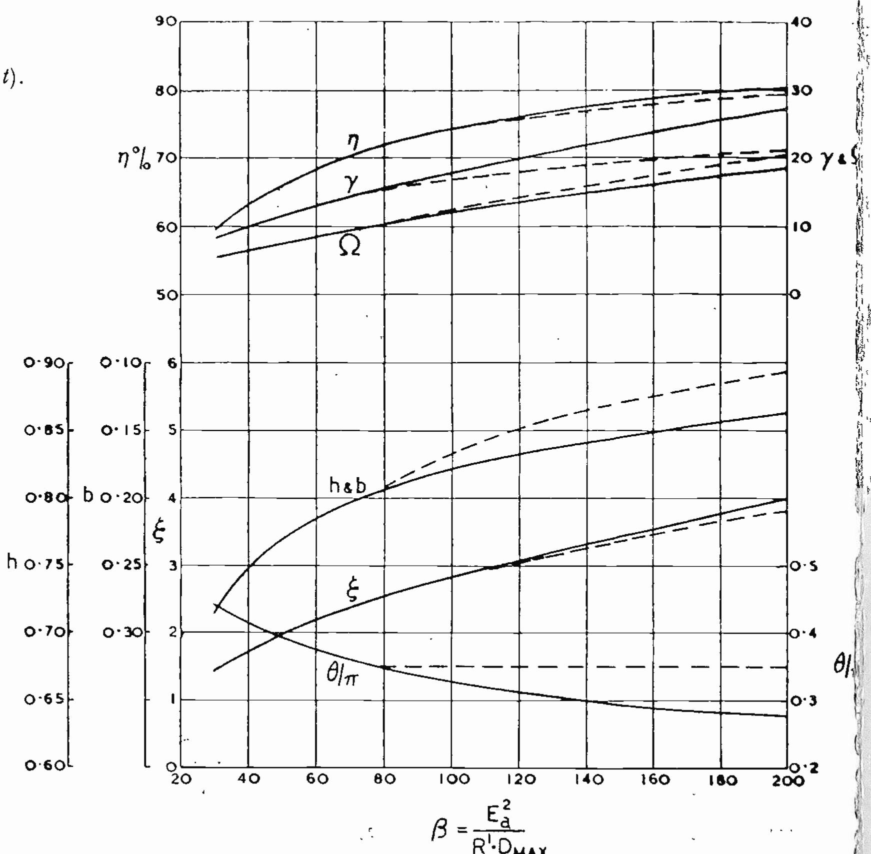
Peak anode current $\hat{i}_a = \frac{e_{a\,min}}{R'} = \frac{b \, . \, E_a}{R'}$

Anode Load impedance $Z_o = \Omega \, . \, R'$

Should $\hat{i}_a$ be excessive, reduce to the permissible value. Then as R' is fixed we can calculate $b = R' \, \frac{\hat{i}_a}{E_a}$.

Hence h and γ, which is equal to $\hat{i}_a \, . \, \frac{E_a}{D_{max}}$. The factors are thus obtainable from Fig. 5 by interpolation.

The grid voltages can be determined by



means of cos θ, i.e. the cosine of the " cut-off " angle, in the following manner :—

Determine the D.C. anode voltage at the point of commencement of anode current flow. This is equal to $E_a(1 - h \cos \theta)$. Then from the characteristics assess the grid voltage E_{gc} which would be required for anode current cut-off at this anode voltage, assuming linear characteristics, i.e. neglecting the " tail " of the characteristics.

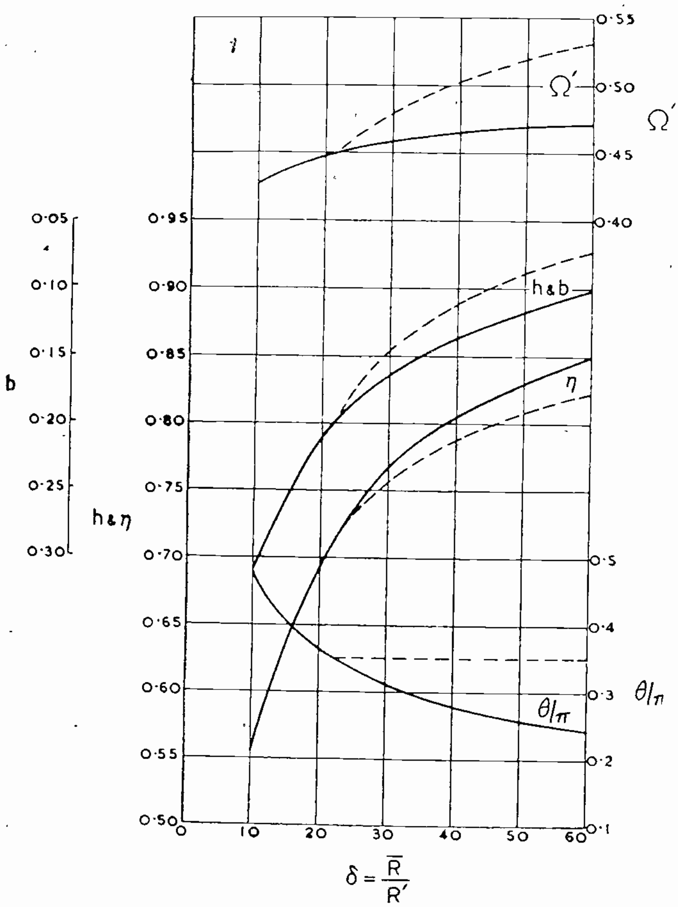


Fig. 3.

Determine also from the characteristics the value of $e_{g\,\max}$, i.e. the grid voltage corresponding to $\hat{\imath}_a$ and $e_{a\,\min}$.

Then the amplitude of the H.F. grid voltage $\hat{e}_g = \dfrac{e_{g\,\max} - E_{gc}}{(1 - \cos \theta)}$, cos θ being obtained from Fig. 7.

N.B.—E_{gc} is a negative quantity and so will be added numerically to $e_{g\,\max}$.

Then $E_g = e_{g\,\max} - \hat{e}_g$.

We have assumed so far that the calculated D.C. anode current I_a is below the rated maximum. If this is not the case, we form another auxiliary variable

$$\delta = \frac{E_a}{R' \cdot I_{a\,\max}} = \bar{R}/R', \text{ where } \bar{R} = \frac{E_a}{I_{a\,\max}}$$

Fig. 3 shows the required factors plotted against δ. The input is then $W_i = E_a \cdot I_{a\,\max}$, the output $W_u = \eta \cdot W_i$, the anode dissipation $D = W_i - W_u$, the anode load impedance $Z_o = \Omega' \cdot \bar{R}$, and $\hat{\imath}_a = \dfrac{b \cdot E_a}{R'}$. All the other calculations are carried out as before.

It has been found that for large values of β and δ on account of the low value of θ/π the grid bias and grid swing corresponding to optimum conditions may become

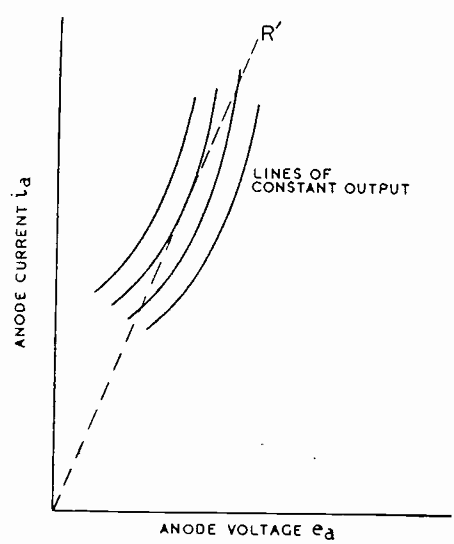


Fig. 4.

inconveniently high. It is then advisable to use the dotted curves shown in Figs. 2 and 3. These ensure a minimum value for θ/π of 0.35.

PART II

In this section the derivation of the curves in Figs. 2 and 3 is explained. The problem is how to find the *optimum* P.W.P., i.e. that set of values θ, h and $\hat{\imath}_a$ for which $D_{\max}$, I_a, or $\hat{\imath}_a$ (whichever condition is the criterion) is actually reached, and this in such a way that the output is larger than for any other possible combination of these values.

For a given valve, this point will have to lie near the left-hand boundary of the field of $e_a - i_a$ characteristics. Choosing it too far to the left results in an excessive maximum grid voltage relative to the minimum anode voltage with the result that a considerable part of the cathode current is diverted from the anode to the grid. Choosing it too far to the right means an unnecessarily high $e_{a\,\min}$ with resulting loss in efficiency. Fig. 1 gives an illustration of where to draw this line and experience makes this a simple process.

We wish to determine *where* on this line the optimum P.W.P. lies.

The difficulty of the problem is that the optimum conditions depend on two variables θ and h (or b). For any arbitrary point on the L.R.L. h is fixed and the required value of θ is that which gives $D = D_{\max}$ for that particular P.W.P. The value of resultant output will, however, vary with the position of the chosen point, the point which we wish to determine being that at which the output is a maximum.

Consider for a moment the $e_a - i_a$ plane without any reference to a particular valve, but suppose E_a and $D_{\max}$ known. Consider a point P_o with the co-ordinates e_{ao}, i_{ao} in this plane. It can be regarded as a potential P.W.P. with $e_{a\,\min} = e_{ao}$ and $\hat{\imath}_a = i_{ao}$. Then for any value of θ, the corresponding values of I_a, W_i, W_u, η, etc. can be calculated according to the rules given above. Now $D = W_i - W_u = E_a \,.\, \hat{\imath}_a \,.\, F_{wi} - \hat{e}_a \,.\, \hat{\imath}_a \,.\, F_{wu}$, so that $\hat{e}_a$ and $\hat{\imath}_a$ being fixed D will be a function of θ, at any chosen point P_o, and, at least in the relevant regions of the plane, D will reach the value $D_{\max}$ for a certain value of θ, say θ_o. Conversely, θ, together with the co-ordinates of P_o, defines a certain value of the output $W_{uo} = \hat{e}_{ao} \,.\, i_{ao} \,.\, F_{wu}(\theta_o)$ and every point of the $e_a - i_a$ plane can now be marked with a value of W_{uo}, corresponding to $D_{\max}$. Choosing a series of W_u values and connecting all points marked with the same W_u, we can thus plot a family of "curves of constant output," or more correctly, curves of possible P.W.P.s giving

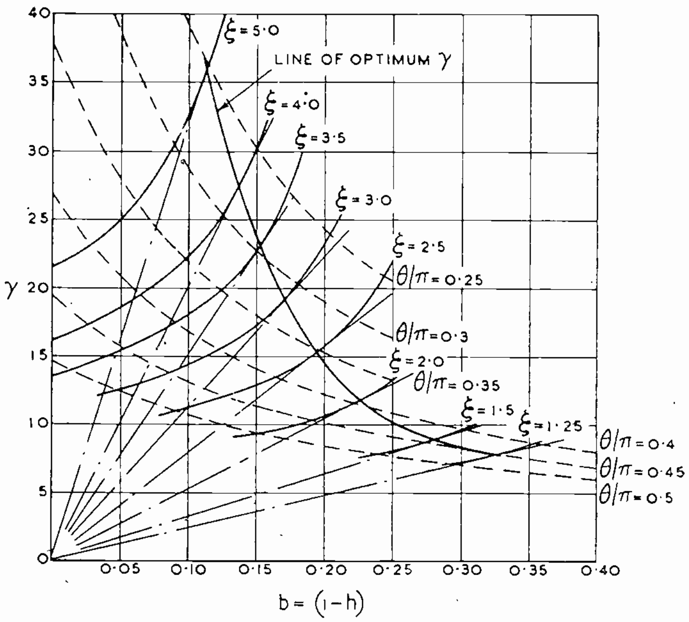


Fig. 5

constant output for a given anode dissipation $D_{\max}$. (Fig. 4).

Returning now to the case of a particular valve, the P.W.P. will have to lie on the L.R.L. This line, as shown in Fig. 4 intersects some of the W_u = const. curves in two points, some not at all, while to one of these curves it is tangential. This must be the curve of optimum output, as the curves to the right of it correspond to a smaller output, whilst the curves to the left of it do not yield any P.W.P. lying on the L.R.L. The point of contact is the optimum P.W.P. and the corresponding θ is the optimum.

We now draw lines through the origin tangential to all the W_u = const. curves. Then each of these lines can be regarded as the L.R.L. of a valve whose limiting resistance R' is given by the slope of the line, and all the points of contact obtained in this manner will be optimum P.W.P.s. Connecting all these points, we obtain a curve consisting entirely of optimum P.W.P.s, and once this curve is drawn in the $e_a - i_a$ plane, the optimum P.W.P. for any valve follows simply by drawing the Limiting Resistance

Line of this valve and marking its point of intersection with the above curve.

An analogous construction can be made for the case where the criterion is maximum D.C. anode current $I_{a\max}$, as will be shown later.

So far, the calculations have been based on the assumption of definite values for E_a, $D_{\max}$ and $I_{a\max}$. What we require, however, is a set of general relations from which, by a suitable combination with the given data, the unknown data can be derived. This is done first for the case $D = D_{\max}$ then for the case $I_a = I_{a\max}$.

We define a quantity γ by $\gamma = \frac{1}{F_{wi} - h \cdot F_{wu}}$ this being a function solely of θ/π and h. Thus γ can be plotted against b with θ/π as parameter, as shown by the dotted curves of Fig. 5.

We now put $$\frac{D_{\max}}{E_a} = i,$$

also $$\frac{D_{\max}}{E_a} = \hat{\imath}_a (F_{wi} - h \cdot F_{wu})$$

$$\therefore \hat{\imath}_a = i \cdot \gamma$$

Thus each pair of values $e_{a\min}$, $\hat{\imath}_a$ on any given output curve in Fig. 4 has a corresponding pair of values b, γ and vice-versa. These curves of constant output can therefore be represented by curves in a $b - \gamma$ diagram. These are obtained as follows:

Expressing W_u in terms of $D_{\max}$, i.e. $W_u = \xi \cdot D_{\max}$ we get a new quantity

$$\xi = \frac{W_u}{D_{\max}} = \frac{W_u}{W_i - W_u} = \frac{\eta}{1 - \eta}$$

which, as $\eta = h \cdot F_\eta$, is a function solely of θ and h, and so can be plotted in the $b - \gamma$ diagram.

The conditions $D = D_{\max}$, $W_u =$ const. are therefore equivalent to the condition $\xi =$ const., and so we construct the $\xi =$ const. curves in the $b - \gamma$ plane, as shown in Fig. 5.

Now in the $e_a - i_a$ plane we derived a curve consisting of optimum P.W.P.s by drawing tangents through the origin to all the $W_u =$ const. curves and connecting the points of contact. Similarly, we find the $b - \gamma$ points corresponding to optimum conditions by drawing tangents through the origin to all the $\xi =$ const. curves in the $b - \gamma$ diagram. Then connecting all these points we obtain a curve showing the optimum value of γ as a function of b ("γ_{opt} curve.")

Each of the tangents in the $e_{a\min} - \hat{\imath}_a$ plane was characterised by the Limiting Resistance $R' = \frac{e_{a\min}}{\hat{\imath}_a}$. The corresponding expression for the tangents in the $b - \gamma$ diagram is b/γ which is denoted by $1/\beta$. Then

$$R' = \frac{e_{a\min}}{\hat{\imath}_a} = \frac{b \cdot E_a}{\gamma \cdot i} = 1/\beta \cdot \frac{E_a}{i} = 1/\beta \cdot \frac{E_a^2}{D_{\max}}$$

hence $$\beta = \frac{E_a^2}{R' \cdot D_{\max}}$$

Thus for any particular case where E_a, $D_{\max}$, and R' are known, β can be calculated. Then the intersection of the line corresponding to β and the γ_{opt} curve determines a set of values of ξ, θ, b and γ, which facilitate the assessment of optimum conditions.

In order to save awkward interpolation however, the various factors are plotted as in Fig. 2, with β as abscissa. They give the final answer to our problem, for as β is known in any particular case, the corresponding factors give immediately the desired data as explained in Part I.

The anode load impedance Z_o is obtained as follows:—

$$Z_o = \frac{\hat{e}_a^2}{2W_u} = \frac{h^2 \cdot E_a^2}{2\xi \cdot D} = \frac{h^2 \cdot \beta}{2\xi} \cdot R' = \Omega \cdot R'$$

where $$\Omega = \frac{h^2 \cdot \beta}{2\xi}$$

and is fixed for any given value of β, as h and ξ are themselves fixed by β.

So far we have only considered the restriction imposed by the condition $D = D_{\max}$. Essentially the same procedure applies in the case $I_a = I_{a\max}$. Abbreviating $1/F_{wi}$ by α we have $\hat{\imath}_a = I_{a\max} \cdot \alpha$. and, as before, $e_{a\min} = E_a \cdot b$ so that in this case the $e_{a\min} - \hat{\imath}_a$ diagram is represented by the $b - \alpha$ diagram as shown in Fig. 6. The input $W_i = E_a \cdot I_{a\max}$ is in this case a known quantity, and, as $W_u = \eta \cdot W_i$, the curves of constant output in the $e_{a\min} - \hat{\imath}_a$ plane are represented by the $\eta =$ const. curves in the $b - \alpha$ diagram. Optimum output is thus represented by optimum efficiency. η being a function solely of θ/π and h, the lines of constant η may be constructed as shown in Fig. 6.

The points representing optimum conditions are thus found by drawing tangents to these curves through the origin; the curve connecting all points of contact is the α_{opt} curve. The ratio characterising the slope of the tangents is now b/α which we call $1/\delta$.

$$\text{As } R' = \frac{e_{a\,min}}{\hat{\imath}_a} = \frac{b \,.\, E_a}{\alpha \,.\, I_{a\,max}} = 1/\delta \,.\, \frac{E_a}{I_{a\,max}},$$

$$\text{then} \quad \delta = \frac{E_a}{R' . I_{a\,max}} = \bar{R}/R',$$

$$\text{where} \quad \bar{R} = \frac{E_a}{I_{a\,max}}$$

which can be calculated in any particular case.

Every point on the α_{opt} curve now defines a set of optimum conditions for different values of δ and it is possible to plot the various factors as functions of δ, as shown in Fig. 3. δ is calculated, the various factors read from this diagram, and hence the desired data can be assessed as described in Part I.

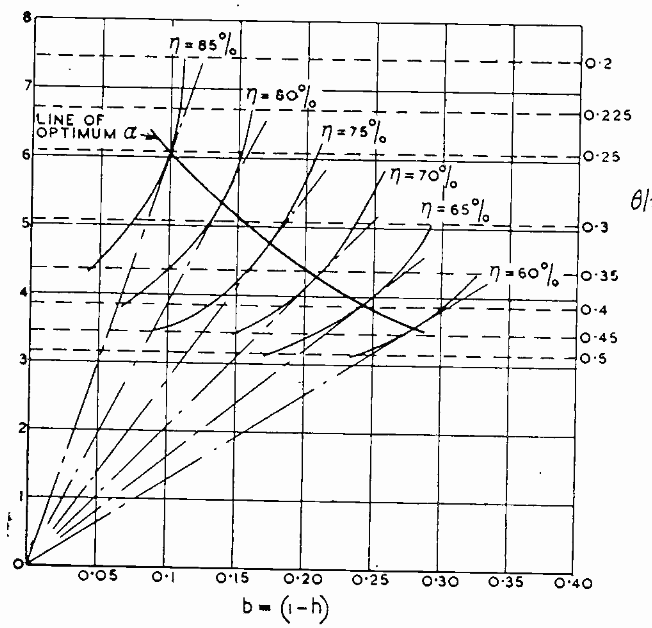


Fig. 6

The anode load impedance Z_o is obtained as follows:—

$$Z_o = \frac{\hat{e}_a^{\,2}}{2W_u} = \frac{\hat{e}_a^{\,2}}{2\hat{e}_a \,.\, \hat{\imath}_a \,.\, F_{wu}} = \frac{h \,.\, E_a}{2\hat{\imath}_a \,.\, F_{wu}}$$

$$= \frac{h \,.\, E_a}{2I_a \,.\, F_\eta} = \Omega' \frac{E_a}{I_a} = \Omega' \,.\, \bar{R}$$

where $\Omega' = \dfrac{h}{2F_\eta}$ which, being a function solely of h and θ/π, is fixed for a given ratio $\bar{R}/R'$.

When $\hat{\imath}_a$ turns out to be greater than desired the problem is simpler in that h is now fixed by $\hat{\imath}_a$, the only variable being θ, the value of which is chosen for maximum output compatible with the various limitations.

It was shown that $\gamma = \hat{\imath}_a \,.\, \dfrac{E_a}{D}$ and $b = 1 - h = \dfrac{R' . \hat{\imath}_a}{E_a}$ so that γ and h can be calculated. Thus the various factors can be obtained from Fig. 5 by interpolation, or alternatively θ/π assessed from Fig. 5 and the rest done by calculation using the values of F_{wi}, F_{wu}, etc. from Fig. 7.

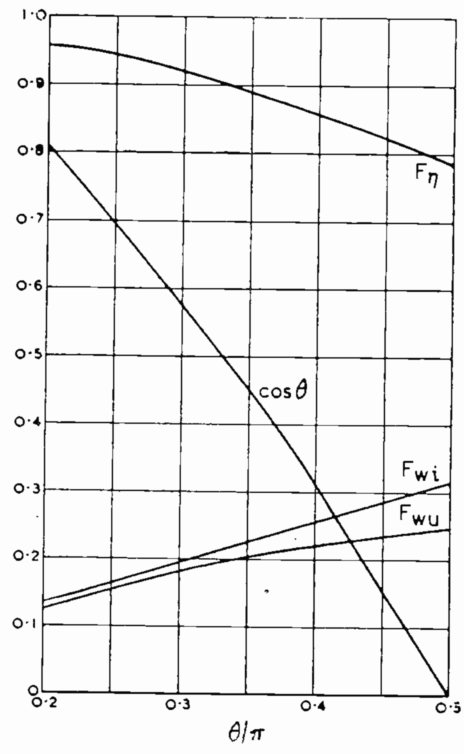


Fig. 7

One final word on the dotted branches of the curves in Figs. 2 and 3.

For very small cut-off angles the necessary grid swing and grid bias may become inconveniently high and the adjustment rather critical. It is therefore advisable that θ/π should not be less than about 0.35, although this may mean an output slightly smaller than the theoretical optimum. The dotted parts of Figs. 2 and 3 are based on the assumption $\theta/\pi = 0.35$. The actual construction is as follows:—In Figs. 5 and 6, where the tangential points of contact give values of θ/π less than 0.35, the constants are taken from the intersection of the tangential lines with the curves representing $\theta/\pi = 0.35$.

A few examples are given below to illustrate the accuracy of the scheme.

(a) Valve Type P.T.5, in which the criterion is anode dissipation.

$$\left.\begin{array}{ll} E_a & = 1250 \text{ volts} \\ D_{max} & = 40 \text{ watts} \end{array}\right\} \text{(Maximum Ratings).}$$

$R' = 850$ ohms (from characteristics).

Then $\beta = 46$ which gives from Fig. 2,

$\xi = 1.9$, $h = 0.76$, $\theta/\pi = 0.4$, and $\Omega = 7.2$.

The data corresponding to this are given below with the experimental results:—

			Calculated	Experimental
E_a	=	volts	1250	1250
E_s	=	,,	300	300
I_a	=	mA	92	90
W_u	=	watts	76	74
η	=	%	65.5	66
D	=	watts	40	38.5
E_g	=	volts	− 64	− 65
$\hat{e}_g$	=	,,	109	110
I_g	=	mA	7.5	7.0
I_s	=	,,	28	30
Z_o	=	ohms	6100	6000

(b) Valve Type A.C.T.6, the criterion being I_a which is fixed at 140 mA. Two theoretical cases are given, one being for $\theta/\pi = 0.35$ and the other for optimum θ/π.

$E_a = 1500$ volts (Maximum Rating)

$I_a = 140$ mA

hence $\bar{R} = 10{,}700$ ohms

$R' = 330$ ohms, hence $\delta = 32.4$ which gives the following factors from Fig. 3:—

(1) $\theta/\pi = 0.3$, $\eta = 0.78$, $h = 0.845$, $\Omega' = 0.46$

(2) $\theta/\pi = 0.35$, $\eta = 0.765$, $h = 0.864$, $\Omega' = 0.486$.

The resultant data are given below with the experimental results:—

			Calculated	Calculated	Experimental
E_a	=	volts	1500	1500	1500
I_a	=	mA	140	140	140
W_u	=	watts	164	160	160
θ/π	=	—	0.3	0.35	0.345
η	=	%	78	76.5	76.5
D	=	watts	46	50	50
E_g	=	volts	− 195	− 125	− 135
$\hat{e}_g$	=	,,	280	210	220
I_g	=	mA	36	30	32
Z_o	=	ohms	4920	5200	5000

REFERENCES

H. Rothe: "Zur Theorie des Senderverstärkers." *Die Telefunken Röhre.* December 1938.

Everitt: "Optimum Operating Conditions for Class C Amplifiers." *Proc. Inst. Rad. Eng.*, Vol. 22 (1934).

Book Review

Short-Wave Wireless Communication

By A. E. Ladner, A.M.Inst.C.E., and C. R. Stoner, B.Sc., A.M.I.E.E., 4th Edition. Pp. 573+iv. Chapman & Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 35s.

Although the authors deal generally with the problems involved in short-wave wireless communication, they regard matters from a commercial aspect. This, of course, has little or no effect upon the theoretical parts of the book, except in their choice of illustrative examples, but in some cases it leads to omissions. This is particularly so in the aerial section. Large and complex arrays are discussed in considerable detail, but the reader will search in vain for any detailed account of the simple aerial systems, such as a dipole with reflector and/or director, which are so widely used non-commercially.

It should not be thought, however, that the book is of value only to those concerned with commercial wireless. This is very far from being the case, and there must be very few who cannot find in it much of interest and value. The treatment of modulation, with the aid of both vectors and waveform pictures, is particularly good and the chapter on feeders is excellent.

Quartz crystals are discussed in much more detail than is usual and the effect of the different "cuts" is well described. Power amplifiers and oscillators, including types of very high frequency stability, are well treated.

Many will quarrel with the authors over their use of the term "push-pull." They use it from a circuit point of view rather than a valve, and any stage in which the circuit is pushed and pulled alternatively by a valve or valves is called push-pull. A single-valve Class A amplifier is thus termed push-pull. The authors define their use of the term most carefully, but it seems a pity to use such a well-known term in such an unusual sense.

Originally push-pull was applied to a two-valve balanced Class A amplifier in which one valve " pushed " the circuit while the other valve " pulled " it. The latter development of a two-valve Class B amplifier in which the valves push and pull the circuit alternately was frequently known as push-push. This term is not now widely used and such an amplifier is usually called push-pull.

In common usage to-day, a push-pull amplifier is a balanced amplifier and nothing more. It is in essence two identical amplifiers fed with inputs of equal magnitude but opposite phase with respect to earth and delivering equal outputs again of opposite phase with respect to earth.

It is not submitted that the authors are wrong in their use of the word push-pull. They are probably more logical in their use of it than most people, but as the word has a commonly accepted meaning which is different from theirs, it seems a pity that they could not have found some alternative expression.

Each chapter in the book concludes with a bibliography, a by no means invaluable feature. Errors are very few and the book should prove exceedingly useful to all concerned with short waves. W.T.C.

The Industry

PRODUCTION problems arising from the use of the new lead-rich cored solders are dealt with in Reference Sheet 2 recently issued by Multicore Solders Ltd., Bush House, London, W.C.2, and available free of charge to firms engaged on Government contracts. It is pointed out that correct bit temperature is the secret of success and figures are given. Recommendations are also included for the best alloys and gauges for specific types of work.

"Introduction to Valves"

INSTEAD of the general practice adopted in text books of treating the valve as an auxiliary to the circuit in which it is employed, the author of " Introduction to Valves," F. E. Henderson, A.M.I.E.E., treats it as the central component.

Following an explanation of thermionic emission and the functions of the electrodes in a simple valve, the author deals with the practical applications of these principles to more complex types of valves and their uses and functions in typical circuits. Finally, cathode-ray tubes and stabilisers are dealt with. This manual, as its title implies, is intended for those who have not previously studied deeply the functions of the valve.

" Introduction to Valves," which contains 112 pages with many diagrams and illustrations, is published and distributed from the offices of *Wireless Engineer* and *Wireless World* on behalf of the General Electric Company of England and costs 4s. 6d., plus 3d. postage.

Institution of Electrical Engineers

AT the time of going to press, the programme of the meetings for the coming session of the Institution of Electrical Engineers had not been decided upon. It is, however, known that Professor Fortescue's presidential address will be given on October 1st.

Dr. R. L. Smith-Rose, D.Sc., Ph.D., M.I.E.E., D.I.C., A.R.C.S., who has been elected chairman of the Wireless Section for the ensuing year, joined the staff of the National Physical Laboratory as a member of the electricity department in 1919 and later formed the nucleus of the wireless division of that department, conducting investigations on thermionic valves, wireless reception and direction finding. His researches have also included the measurement of the electrical properties of the soil and sea water and their influence on the propagation of high and very-high frequencies. The results of these investigations have been described in numerous papers, some of which have appeared in the *Journal of the Institution of Electrical Engineers* and *Wireless Engineer*. He became principal scientific officer when the radio department of the N.P.L. was formed in 1933 and in 1939 he was appointed superintendent of the department and as such is responsible for the divisions at Slough and Teddington.

Paper Salvage

THE wireless industry is endeavouring to collect 5,000 tons of waste paper during a special campaign which has been organised by a committee representative of the Radio Manufacturers' Association, the Radio Wholesalers' Federation and the Radio and Television Retailers' Association. Manufacturers are asked to send a postcard to the Radio Industry Waste Paper Salvage Appeal, c/o R.M.A., 59, Russell Square, London, W.C.1, giving details of their collection.

Brit. I.R.E.

SIR LOUIS STERLING will deliver his inaugural address as president of the British Institution of Radio Engineers at the first meeting of the 1942-43 session which will be held at 21, Tothill Street, London, S.W.1, at 6 o'clock on September 25th. Dr. James Robinson, M.B.E., D.Sc., Ph.D., the new vice-president, will deliver a paper on " Modulation " at this meeting.

Radiation Energy and Earth Absorption for Dipole Antennae

By A. Sommerfeld and F. Renner

(Continued from page 359 of the August, 1942, issue)

5. The Earth Absorption for Dipole Antennas.

THE average of that part of the radiation which is emitted through the plane $z = h - \epsilon$ during a certain time and is absorbed by the earth is, as in the introduction, indicated by $S_{abs.} = -\underline{S}$ and is calculated for the *horizontal dipole* according to equation (24). The square brackets appearing in that equation contain the following expression :—

$$[\,] = J''(\lambda r)J''(lr)\lambda^2 l^2 f_1{}^*(\lambda)f_3(l)$$
$$+ \frac{1}{r^2} J'(\lambda r)J'(lr)\lambda l f_1{}^*(\lambda)f_3(l)$$
$$+ J(\lambda r)J(lr)[f_2{}^*(\lambda)f_3(l)l^2$$
$$- f_1{}^*(\lambda)f_4(l)\lambda^2 - 2f_2{}^*(\lambda)f_4(l)].$$

In writing this down we used in the last line the differential equation of the Bessel functions in order to simplify it. However, we can also give the first line the corresponding form, that is to say, we can reduce it to the product $J(\lambda r)J(lr)$ if we perform the integration with respect to r as provided for in (24). For this purpose, we now consider the integral $\int_0^\infty \chi r dr$, wherein

$$\chi = J''(\lambda r)J''(lr)\lambda l + \frac{1}{r^2} J'(\lambda r)J'(lr) \quad (38)$$

From the differential equation for $J(\lambda r)$ and $J(lr)$ it follows by suitable multiplication that :—

$$\int_0^\infty \chi r dr = \lambda l \int_0^\infty J(\lambda r)J(lr)r dr$$
$$- \int_0^\infty \frac{d}{dr}\{J'(\lambda r)J'(lr)\}dr \quad \ldots \quad (38a)$$

Since the second integral of the right hand side becomes zero, we obtain :—

$$\int_0^\infty \chi r dr = \lambda l \int_0^\infty J(\lambda r)J(lr)r dr.$$

After having done this it is possible to reduce the triple integral in equation (24) to a simple one[10] exactly as was done previously with respect to equation (20).

If again, for convenience, $+i$ is interchanged with $-i$ under the sign Re_1 one obtains :—

$$\frac{8\,S_{abs}}{ck_1 B^2} = \text{Re}\left\{ -i\int_0^\infty [(f_1\lambda^2 + f_2)f_3{}^* - (f_1 + \frac{2}{\lambda^2}f_2)f_4{}^*]\lambda^3 d\lambda \right\} \quad \ldots \quad (39)$$

If one introduces for $f_1 \ldots f_4$ the expression (16), (17), multiplies and takes into account that

$$\mu_1 = -\mu_1{}^*, \text{ for } \lambda < k_1, \text{ and}$$
$$\mu_1 = +\mu_1{}^*, \text{ for } \lambda > k_1,$$

one obtains without approximation the

[10] In the calculation of Mr. Niessen, which served the same purpose (*Ann. d. Phys.*, Vol. 32, see particularly pp. 452 and 453 thereof), a term is missing, which corresponds in his nomenclature to the expression $i_2\lambda l + i_3$, wherein

$$i_2 = \int_0^\infty J''(\lambda r)J''(lr)r dr,$$

$$i_3 = \int_0^\infty J'(\lambda r)J'(lr)\frac{dr}{r}.$$

(In these equations we have replaced his τ by our λ and his t by our l).

According to G. N. Watson, A treatise on the theory of Bessel functions, Cambridge 1922, equation 1, p. 405 :—

$$i_3 = \begin{cases} \frac{1}{2}\frac{\lambda}{l} \text{ for } \lambda < l, \\ \frac{1}{2}\frac{l}{\lambda} \text{ for } \lambda > l. \end{cases}$$

Now, Niessen proceeds in the following manner :—

$$i_2 = \frac{\partial^2}{\partial\lambda\partial l} i_3 = \begin{cases} -\frac{1}{2l^2} \text{ for } \lambda < l, \\ -\frac{1}{2\lambda^2} \text{ for } \lambda > l, \end{cases}$$

therefore $i_2\,\lambda l + i_3 = 0$ for $\lambda < l$ as well as $\lambda > l$. Obviously, this deduction is not correct when $\lambda = l$ since the function i_3 to be differentiated has a discontinuous tangent at this point.

following result :

$$\left.\begin{aligned}\frac{-2S_{abs}}{ck_1B^2} &= \mathrm{Re}\{i\int_{k_1}^{\infty} e^{-2h\mu_1}F(\lambda)\lambda d\lambda\} \\ &+\int_o^{k_1}\phi_1(\lambda)\lambda^3 d\lambda + \int_o^{k_1}\phi_2(\lambda)\lambda d\lambda\end{aligned}\right\} \quad (41)$$

$$\left.\begin{aligned}\phi_1(\lambda) &= \frac{\left|\frac{\mu_1-\mu_2}{N}\right|^2\left[\lambda^2 - \mathrm{Re}\frac{N}{\mu_1+\mu_2}\right]}{\sqrt{k_1^2-\lambda^2}} \\ \phi_2(\lambda) &= \tfrac{1}{4}\frac{2k_1^2-\lambda^2}{\sqrt{k_1^2-\lambda^2}}\left\{\left|\frac{\mu_1-\mu_2}{\mu_1+\mu_2}\right|^2 - 1\right\} \\ &\approx \frac{2k_1^2-\lambda^2}{|\mu_2|^2}\mathrm{Re}\{-i\mu_2\}\end{aligned}\right\} \quad (41a)$$

The detailed calculation is given in appendix 4.

We indicate the three parts with I, II, III respectively.

According to (30) and (32c) we obtain for I :—

$$\mathrm{I} = -\mathrm{Re}\{iL_{k_1}^{\infty}\} = \frac{2k_1^4}{\zeta^2}\mathrm{Re}\left\{\frac{i}{\sqrt{-k_2^2}}\right\}$$

$$= 2\frac{k_1}{|k_2|}\frac{k_1^3}{\zeta^2}\sin\delta \quad .. \quad .. \quad (41b)$$

wherein δ has the same meaning as in (34).

In computing II we make the approximations (31), (32) and $|\mu_1| \ll |\mu_2|$, and obtain :—

$$\left.\begin{aligned}\mathrm{Re}\frac{-N}{\mu_1+\mu_2} &= \sqrt{k_1^2-\lambda^2}\,|k_2|\sin\delta \\ \left|\frac{\mu_1-\mu^2}{N}\right|^2 &= \frac{1}{|k_2|^2(k_1^2-\lambda^2)}\end{aligned}\right\} \quad (41c)$$

Consequently, λ^2 has also to be cancelled in the square brackets of ϕ_1; thus we obtain :—

$$\mathrm{II} = \tfrac{1}{4}\frac{k_1}{|k_2|}k_1^3\sin\delta \quad .. \quad .. \quad (41d)$$

Finally we obtain directly according to (32) and (34) :

$$\mathrm{III} = \frac{\sin\delta}{|k_2|}\int_o^{k_1}(2k_1^2-\lambda^2)\lambda d\lambda = \tfrac{3}{4}\frac{k_1}{k_2}k_1^3\sin\delta \quad .. \quad .. \quad (41e)$$

Thus, the total absorption by the earth is :—

$$\frac{2S_{abs}}{ck_1^4B^2} = 2\frac{k_1}{|k^2|}\left(\frac{1}{\zeta^2}+\tfrac{1}{2}\right)|\sin\delta| \text{ [11]} \quad (42)$$

[11] sin δ is negative, see footnote 1 of page 355 of the August 1942 issue.

As we know, it becomes zero for $k_2 \to \infty$ (see the introduction), and it becomes infinite like ζ^{-2} if the antenna approaches the earth.

On the other hand, for the *vertical dipole* the absorption by the earth is given by (20). According to equations (3) and (3a), one can, in this case, obtain a simple integral. Taking into account (9a), one obtains :—

$$\frac{4S_{abs}}{ck_1A^2} = \mathrm{Re}\left\{-i\int_o^{\infty}\left(e^{-\epsilon\mu_1*} + e^{-2h\mu_1*}\frac{M^*}{N^*}\right)\right.$$

$$\left.\cdot\left(e^{-\epsilon\mu_1} - e^{-2h\mu_1}\frac{M}{N}\right)\frac{\lambda^3 d\lambda}{\mu_1}\right. \quad .. \quad (43)$$

This becomes, if one multiplies out and takes into account (40) :—

$$\left.\begin{aligned}&2\,\mathrm{Re}\left\{i\int_{k_1}^{\infty}e^{-2\mu_1 h}\frac{M}{N}\frac{\lambda^3 d\lambda}{\mu_1}\right\} \\ &-\int_o^{k_1}\left(\left|\frac{M}{N}\right|^2 - 1\right)\frac{\lambda^3 d\lambda}{\sqrt{k_1^2-\lambda^2}}\end{aligned}\right\} \quad (43a)$$

The first part which we will indicate by IV is connected with the integral K in equation (22c). If in this integral we replace the lower limit by k_1, which we will again indicate by writing $K_{k_1}^{\infty}$, we obtain :

$$\left.\begin{aligned}\mathrm{IV} &= 2\,\mathrm{Re}\,\{iK_{k_1}^{\infty}\} \\ &- 2\,\mathrm{Re}\left\{i\int_{k_1}^{\infty}e^{-2h\mu_1}\frac{\lambda^3 d\lambda}{\mu_1}\right\}\end{aligned}\right\} \quad (44)$$

wherein the second term of the right-hand side is caused by the fact that K is defined as comprising the factor $\frac{M}{N}+1$, while IV comprises the factor $\frac{M}{N}$. However, this second term becomes zero since the integral behind Re{i is real. In the first term, we can make use of the transformation of K given in equation (35). On the right-hand side, we replace L by $L_{k_1}^{\infty}$, (equation (32c)). In G we interchange the lower limit $-i$ with o (equation (34a)), and consequently substitute G_o^{∞} for G. Thus we obtain :—

$$\mathrm{IV} = -4k_1^3\frac{k_1}{|k_2|}\left(\frac{\sin\delta}{\zeta^2} + \mathrm{Re}\{ie^{-i\delta}G_o^{\infty}\}\right) \quad .. \quad .. \quad (44a)$$

According to the procedure of page 25 the integral G_o^{∞} can be given the form (36) if one replaces therein the lower limit $-i\zeta$ by $-\zeta u_o$ and correspondingly in (36a) substitutes $-i\zeta u_o$ for ζ. For sufficiently small ζu_o according to (36b) :—

$$Si(-i\zeta u_o) = 0$$

$$Ci(-i\zeta u_o) = C - \frac{i\pi}{2} + \log\zeta + \log u_o$$

$$= C - \frac{i\pi}{2} + \log\left\{\frac{k_1}{|k_2|}\zeta\right\} - i\delta,$$

(see also (34b)). From (36a) it now follows that:

$$G_o^\infty = -C - \log\left\{\frac{k_1}{|k_2|}\zeta\right\} + i(\pi + \delta) \quad \ldots \quad (44b)$$

By introducing this into (44a) we obtain :—

$$IV = -4k_1^3 \frac{k_1}{|k_2|}\left(\sin\delta\left[\frac{1}{\zeta^2} - C - \log\left\{\frac{k_1}{k_2}\zeta\right\}\right] - \cos\delta(\pi + \delta)\right) \quad \ldots \quad (44c)$$

We now revert to (43a). We will indicate the second part of this expression by V and compute it as follows :—According to the definitions (8a) and with the approximation (32) we can write :—

$$\frac{M}{N} = -1 + \frac{2k_1^2}{k_1^2 + i|k_2|e^{i\delta}\sqrt{k_1^2 - \lambda_2}}$$

With the substitution (22d) we can write without any further approximation :—

$$\left.\begin{aligned} \left|\frac{M}{N}\right|^2 - 1 &= 4\frac{k_1}{|k_2|}\frac{u\sin\delta}{(u-a)^2 + b^2} \\ \ldots &\left\{\begin{aligned} a &= \frac{k_1}{|k_2|}\sin\delta \\ b &= \frac{k_1}{|k_2|}\cos\delta \end{aligned}\right. \end{aligned}\right\} \quad (45a)$$

Thus we obtain :—

$$V = -4k_1^3\frac{k_1}{|k_2|}\sin\delta\int_0^1\frac{(1-u^2)udu}{(u-a)^2 + b^2} \quad \ldots \quad (45b)$$

If one performs the division and neglects terms with $\left(\frac{k_1}{|k_2|}\right)^2$ in the numerator the intergrand is :—

$$-u - 2a + \frac{u}{(u-a)^2 + b^2}$$

From this it follows by integrating from 0 to 1 :—

$$\left.\begin{aligned} &-\tfrac{1}{2} - 2a + \tfrac{1}{2}\log[(1-a)^2 + b^2] \\ &\quad - \tfrac{1}{2}\log[a^2 + b^2] \\ &\quad + \frac{a}{b}\left[\tan^{-1}\frac{1-a}{b} + \tan^{-1}\left(\frac{a}{b}\right)\right] \end{aligned}\right\} (45c)$$

If one introduces in this expression the meaning of a and b from (45a) and considers that in (45b) the factor $\frac{k_1}{|k_2|}$ appears in front of the integral, then one can cancel the second and third terms in (45c). The fourth term gives $-\log\frac{k_1}{|k_2|}$, the last term gives $\tan\delta\left(\frac{\pi}{2} + \delta\right)$.

Thus, one obtains finally :—

$$\left.\begin{aligned} V = 4k_1^3\frac{k_1}{|k_2|}\sin\delta\{&\tfrac{1}{2} + \log\frac{k_1}{|k_2|} \\ &-\left(\frac{\pi}{2} + \delta\right)\tan\delta\} \end{aligned}\right\} (45d)$$

As a whole, we obtain for the vertical transmitter, according to (43), (44c) and (45d)

$$\frac{2\,S_{abs}}{ck_1^4A^2} = 2\frac{k_1}{|k_2|}\left(\frac{1}{\zeta^2} - \log\zeta + \Delta\right)|\sin\delta| \quad \ldots \quad (46)$$

wherein

$$\left.\begin{aligned} \Delta = &-C - \tfrac{1}{2} - 2\log\frac{k_1}{|k_2|} \\ &+(\pi + \delta)|\cot\delta| - \left(\frac{\pi}{2} + \delta\right)|\tan\delta| \end{aligned}\right\} (46a)$$

As with the horizontal transmitter (equation (42)), the absorption by the earth becomes infinite as ζ^{-2} for $\zeta \to 0$. For $k_2 \to \infty$ it becomes, of course, zero again in this case.

We should like to mention that for $\zeta \to \infty$ equation (46) indicates that the absorption by the earth becomes logarithmically infinite, which of course cannot be real. In appendix 2, we shall clarify this point.

6. Discussion and Graphical Illustration of the Results.

We shall deal first with the limiting case of the earth as a perfect conductor. Using the dimensionless variables :—

$$\zeta = 2hk_1 = 4\pi\frac{h}{\lambda},\ s = \left\{\begin{aligned} \frac{2S}{ck_1^4A^2} &= s_V \\ \frac{2S}{ck_1^4B^2} &= s_H \end{aligned}\right. \quad \ldots \quad (47)$$

C

we obtain from (23) and (29) for $k_2 \rightarrow \infty$:—

$$\left.\begin{aligned} s_V &= \frac{2}{3} + \frac{2}{\zeta^2}\left(\frac{\sin\zeta}{\zeta} - \cos\zeta\right) \\ s_H &= \frac{2}{3} - \frac{1}{\zeta^2}\left(\frac{\sin\zeta}{\zeta}(\zeta^2 - 1) + \cos\zeta\right) \end{aligned}\right\} \quad (48)$$

For $\zeta \rightarrow \infty$ this results in :—

$$s_V = s_H = \frac{2}{3} \quad \ldots \quad \ldots \quad \ldots \quad (48a)$$

This corresponds to the radiation of a Hertzian dipole into unlimited space, which

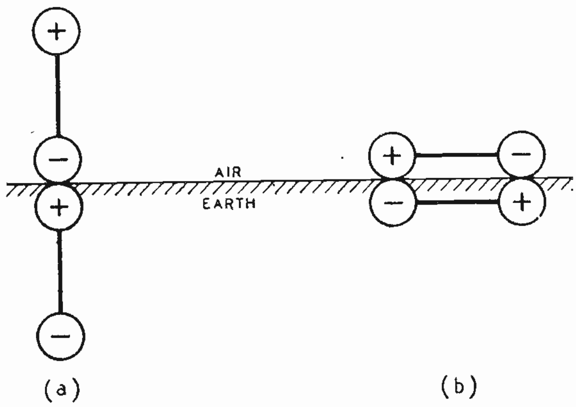


Fig. 2.—*Diagram explaining the reflection method when the dipole approaches the perfectly conducting earth : (a) case of the vertical dipole, in which the moment is doubled ; (b) case of the horizontal dipole, in which the moment vanishes.*

radiation is of course independent of the axial direction of the dipole, that is to say it is the same for s_V and s_H. It should be noted that the factor k_1^4 in the denominator of equation (47) corresponds to the Rayleigh λ^4 law.

In the case of $\zeta \rightarrow \sigma$ we obtain :—

$$\begin{aligned} s_V &= \frac{2}{3} + 2\left(\frac{2}{3\,!} - \frac{4}{5\,!}\zeta^2 + \frac{6}{7\,!}\zeta^4 + \ldots\right) \\ &= \frac{4}{3}\left(1 - \frac{1}{20}\zeta^2 + \ldots\right) \\ s_H &= \frac{2}{3} - \left(\frac{4}{3\,!} - \frac{16}{5\,!}\zeta^2 + \frac{36}{7\,!}\zeta^4 + \ldots\right) \\ &= \frac{2}{15}\zeta^2\left(1 - \frac{3}{56}\zeta^2 + \ldots\right) \end{aligned} \quad \ldots \quad \ldots \quad (48b)$$

If the dipole approaches the surface of the earth the radiation of the vertical dipole is doubled compared with the value $\frac{2}{3}$ when the dipole was remote from the earth, but the radiation of the horizontal dipole becomes zero. This can be explained diagrammatically by considering the images taken with opposite sign of the individual poles. In Fig. 2a the inner poles cancel each other and a dipole remains having double the moment. In Fig. 2b the two pairs of poles cancel each other.

In Fig. 3 the results of equation (48) are plotted. $\zeta = \pi$ corresponds, according to equation (47), to the distance $h = \frac{\lambda}{4}$; $\zeta = 2\pi$ corresponds to the distance $h = \frac{\lambda}{2}$, and so on. The waves appearing in both curves indicate that the radiation of the antenna and its reflected image interfere with each other. They decrease with increasing ζ, both curves approaching the straight line $s = \frac{2}{3}$, equation (48a). The distance between two consecutive maxima or minima is approximately 2π in the scale of ζ, that is to say $\frac{\lambda}{2}$ measured in the scale h, as it ought to be according to the reflector conception.

We now proceed to the *correcting term of the first order* for the *vertical dipole*. According to (23), (37) and (33), we obtain :—

$$\Delta s_V = 2\frac{k_1}{|k_2|}\left[\frac{1}{\zeta^2}\left(\sin(\zeta - \delta) - \zeta\cos(\zeta - \delta)\right) + \sin\delta\, Ci(\zeta) - \cos\delta\left(Si(\zeta) - \frac{\pi}{2}\right)\right] \quad \ldots \quad \ldots \quad (49)$$

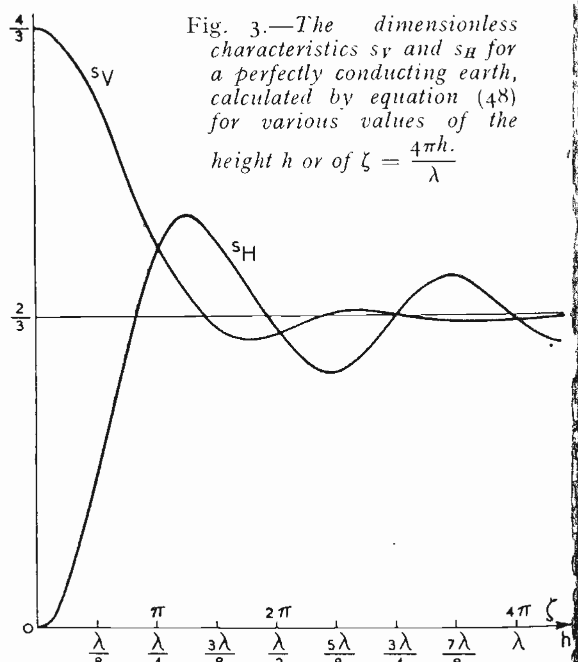


Fig. 3.—*The dimensionless characteristics s_V and s_H for a perfectly conducting earth, calculated by equation (48) for various values of the height h or of $\zeta = \frac{4\pi h}{\lambda}$.*

For $\zeta \to \infty$:—

$$\Delta s_V = 0 \quad \ldots \quad (49a)$$

since $Ci\ (\infty) = 0$, and $Si\ (\infty) = \frac{\pi}{2}$.

Thus, the earth, assumed to be at an infinite distance, does not influence the radiation, whatever its conductivity.

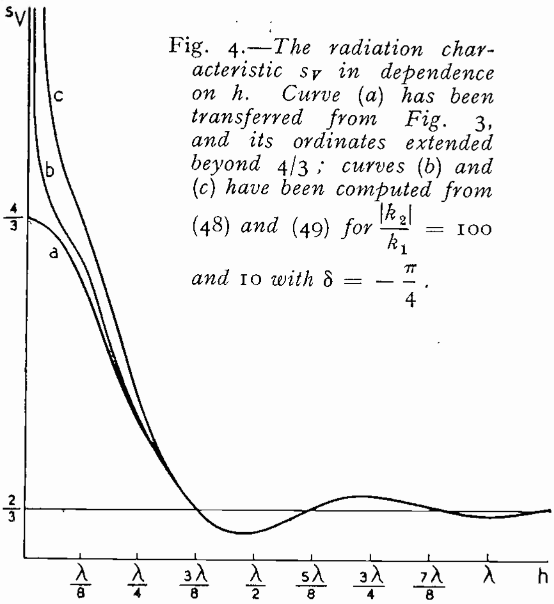


Fig. 4.—*The radiation characteristic s_V in dependence on h. Curve (a) has been transferred from Fig. 3, and its ordinates extended beyond 4/3; curves (b) and (c) have been computed from (48) and (49) for* $\frac{|k_2|}{k_1} = 100$ *and 10 with* $\delta = -\frac{\pi}{4}$.

For $\zeta = 0$ according to (36b) $Si(0) = 0$ and $Ci(0) = C + \log \zeta$, and thus according to (49), with consequential approximation, we obtain :—

$$\Delta s_V = 2\frac{k_1}{|k_2|}\left[\left(\frac{1}{\zeta^2} + \frac{1}{2} - C - \log \zeta\right)|\sin \delta| + \frac{\pi}{2}\cos \delta\right] \quad \ldots \quad (49b)$$

The final value

$$s_V = \frac{4}{3},$$

which in (48b) *we have computed for* $\zeta = 0$ *and* $k_2 \to \infty$ *and illustrated in Fig.* 3, *is thus misleading.* If one takes into account the finite conductivity, a *correction increasing to infinity* with decreasing ζ has to be added.

In Fig 4, we show once more the curve s_V of Fig. 3, but supplement it by the positive ordinate axis following the value 4/3, which indicates the limit of the correcting term for $\zeta \to 0$. We compute this correcting term, for example, for sea water. In this case, in equation (1) the σ-member is very great for k_2^2, if ω is not too great. Therefore, k_2^2 can be considered as purely imaginary. Thus, in equation (34)

$$\delta = -\frac{\pi}{4},\ \cos \delta = -\sin \delta = \frac{1}{\sqrt{2}} \quad (50)$$

For $\lambda = 40$ m (see the beginning of section 4),

$$\frac{k_1}{|k_2|} = \frac{1}{100}.$$

Thus, we obtain, according to (49b) :—

$$\Delta s_V = \frac{\sqrt{2}}{100}\frac{1}{\zeta^2} + \ldots$$

Accordingly, the curve ending in Fig. 3 at 4/3, must have a very steeply increasing branch superimposed upon it, which branch approaches closely to the ordinate axis with decreasing ζ. For greater ζ, for example $\zeta = \pi$, the correction is negligible. Details can be read off from Fig. 4.

Moreover, in this figure a curve is inserted for

$$\delta = -\frac{\pi}{4},\ \frac{k_1}{|k_2|} = \frac{1}{10}.$$

As is obvious, this curve approaches less closely the ordinate for $\zeta \to 0$, and for greater ζ it departs still more from the limiting case of the perfect conductor.

It would not be difficult to furnish curves for other earth conditions, for example for fresh water, in which case, in view of the very small value of σ the ϵ term in equation (1) would not have to be neglected at the same wavelengths. However, we do not want to lengthen our article with such further details.

For the *horizontal dipole* the *correcting member of the first order* Δs_H is, according to (29) and (33), given by :—

$$\Delta s_H = 2\frac{k_1}{|k_2|}\frac{1}{\zeta^2}[\sin(\zeta - \delta) - \zeta\cos(\zeta - \delta)] \quad \ldots \quad (51)$$

Thus, as before, we obtain for $\zeta \to \infty$:—

$$\Delta s_H = 0 \quad \ldots \quad (51a)$$

and for $\zeta \to 0$:—

$$\Delta s_H = 2\frac{k_1}{|k_2|}\left(\frac{1}{\zeta^2} + \tfrac{1}{2}\right)|\sin \delta| \quad \ldots \quad (51b)$$

Thus, also in this case the correcting member becomes *infinite* ; the finite value previously obtained for the perfect conductor, namely

$s_H = 0$ is incorrect. In Fig. 5 the curve for s_H is reproduced from Fig. 3 and supplemented by curves b and c for $\delta = -\frac{\pi}{4}$ and $\frac{k_1}{|k_2|} = \frac{1}{100}$ and $\frac{1}{10}$.

It seems at first surprising that Δs becomes infinite for $\zeta \to 0$, but we shall now show that this is caused by that part of the total radiation which is radiated towards the earth and absorbed by the earth, that is to say is caused by the amount $S_{abs.}$ which was computed in the last paragraph. We define $s_{abs.}$ from $S_{abs.}$ in the same manner as we defined in (47) s from S and find that in the difference the members $\frac{1}{\zeta^2}$ and $\log \zeta$ disappear for $\zeta \to 0$ for the vertical as well as for the horizontal transmitter. This is so because,

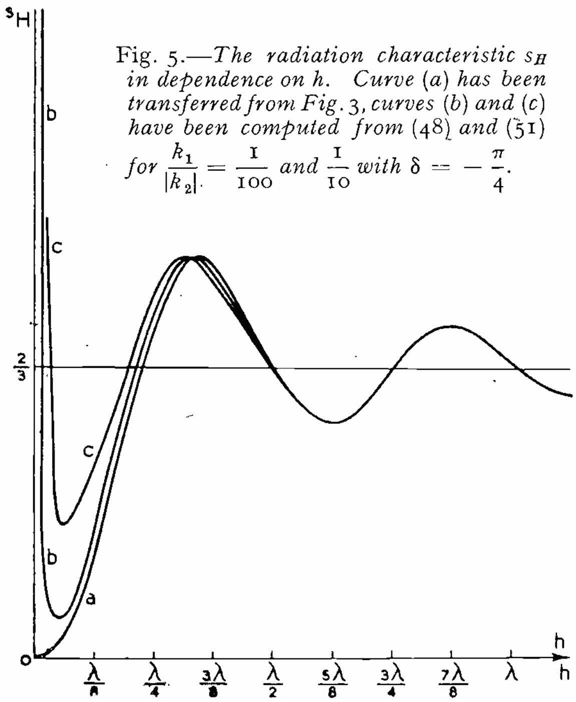


Fig. 5.—*The radiation characteristic s_H in dependence on h. Curve (a) has been transferred from Fig. 3, curves (b) and (c) have been computed from (48) and (51) for $\frac{k_1}{|k_2|} = \frac{1}{100}$ and $\frac{1}{10}$ with $\delta = -\frac{\pi}{4}$.*

according to (49b) and (46) or (51b) and (42) respectively, we have

$$(\Delta s - s_{abs.})_V = 2\frac{k_1}{|k_2|}\left[\left(\frac{1}{2} - C - A\right)|\sin \delta| + \frac{\pi}{2}\cos \delta\right],$$

$$(\Delta s - s_{abs.})_H = 0 \qquad \ldots \quad \ldots \quad (52)$$

In appendix 5 we shall show in a more fundamental manner that the energy (S_+ in our previous nomenclature) radiated into the upper hemisphere is in any case, and thus also for $\zeta \to 0$, finite, so that the difference between the total radiation S and the absorption $S_{abs.}$ by the earth remains with certainty finite, not only in the members of the first order which are proportional to $\frac{k_1}{|k_2|}$ but also in those of any order. We shall call this difference the "utilisable radiation."

For the energy to be fed to the antenna (see the following section), it is obviously not the utilisable radiation but the total radiation including the energy absorbed within the earth that is important, so that for the total energy our curves in Figs. 4 and 5 remain decisive.

It might appear that the absorption by the earth has to be computed by integration along the surface $z = 0$ of the earth instead of by integrating the radiation along the plane $z = h - \epsilon$. We remark, however, that both integrations must lead to exactly the same value. This can be recognised from the fact that between the planes $z = h - \epsilon$ and $z = 0$ no absorbing material is contained, and that the radiation through the infinitely distant cylinder surface of the height h becomes zero for all finite values of ζ, and therefore also if $\zeta \to \infty$. Mathematically, this can be proved in the following manner: if instead of introducing into (43) the values of f_1 and f_2 given in equation (9a) for $z = h - \epsilon$, one inserts the following expressions, which are valid for $z = 0$:—

$$f_1 = e^{h\mu_1} - e^{-h\mu_1}\frac{M}{N},$$

$$f_2 = -\frac{1}{\mu_1}\left(e^{h\mu_1} + e^{-h\mu_1}\frac{M}{N}\right),$$

one arrives at the sane expression as in (42a). This is true for the vertical dipole. One can proceed correspondingly with a horizontal dipole and ascertain that in this case the flow of energy through the plane $z = 0$ is the same as that through the plane $z = h - \epsilon$.

(*To be concluded*).

Wireless Patents

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

545 343.—Interstage coupling circuits for an amplifier designed to give a substantially uniform gain over a wide band of frequencies.

Standard Telephones and Cables (assignees of J. M. West). Convention date (U.S.A.) 26th April, 1940.

AERIALS AND AERIAL SYSTEMS

544 933.—Aerial coupling circuit for eliminating interference from a mains-operated wireless receiver.

F. E. Bole; C. M. Edwards; and J. B. MacLaughlin. Application date 30th October, 1940.

545 052.—Aerial array with adjustable phase-couplings for "steering" the directive response of the system.

Standard Telephones and Cables (assignees of A. Polkinghorn). Convention date (U.S.A.) 17th February, 1940.

545 501.—Coupling a dipole aerial through a quarter-wave short-circuited section which serves to adjust the aerial impedance to that of a standard type of concentric transmission line.

Marconi's W.T. Co. (assignees of G. H. Brown). Convention date (U.S.A.) 24th November, 1939.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

544 893.—Eliminating interference from a mains-operated receiver by means of one or more variable band filters which are connected across the supply lines.

F. E. Bole; C. M. Edwards; and J. B. MacLaughlin. Application date 30th October, 1940.

544 945.—Means for improving the signal-to-noise ratio in a receiver for phase- or frequency-modulated signals.

I. J. P. James and J. E. Best. Application date 31st October, 1940.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

545 078.—System of scanning, primarily for coloured television reception, and capable of being applied to high-grade and lower-grade receiving sets.

J. L. Baird. Application date 7th September, 1940.

545 266.—Television system of synchronisation which facilitates the separation of the picture signals and the application of automatic volume control at the receiver.

Hazeltine Corporation (assignees of J. C. Wilson). Convention date (U.S.A.) 5th October, 1938.

545 411.—Method of separating by amplitude discrimination the line and frame synchronising impulses from the signal frequencies in a television system.

Hazeltine Corporation (assignees of H. A. Wheeler). Convention date (U.S.A.) 7th June, 1939.

545 440.—Automatic amplification control in a television scanning system in which the line and frame frequencies are separated by amplitude discrimination.

Hazeltine Corporation (assignees of H. A. Wheeler). Convention date (U.S.A.) 7th June, 1939.

545 462.—Combination of Kerr cells and light-filters for producing and reproducing television pictures in colour.

J. L. Baird. Application date 23rd October, 1940.

545 491.—Producing colour effects in television by an arrangement in which Kerr cells at the receiver are connected by wires to photo-electric cells at the transmitter.

J. L. Baird. Application date 23rd October, 1940.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

544 075.—Combined transmitter and receiver for use with a pulsed system of signalling.

Standard Telephones and Cables and W. A. Beatty. Application date 5th November, 1940.

545 126.—Wireless telegraph system in which signals are radiated by the intermittent interruption of a radio-frequency wave modulated by a low-frequency tone.

Standard Telephone and Cables and C. W. Earp. Application date 28th September, 1940.

545 313.—Multiplex signalling over a number of coaxial conductors specially designed and arranged to prevent cross-talk.

Standard Telephones and Cables (assignees of R. P. Booth and T. M. Odarenko). Convention date (U.S.A.) 6th June, 1940.

545 402.—Method of coupling a high-frequency oscillator of the velocity-modulated electron-beam type to a working load.

Eletcrical Research Products Inc. Convention date (U.S.A.) 11th May, 1940.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

544 822.—Method of producing sleeves without interlocking ribs for indirectly-heated cathodes.
H. Kershaw. Application date, 28th October, 1940.

544 825.—Construction of valve bases with circularly-arranged pins which are directly connected to lead-in wires.
United-Carr Fastener Corporation (assignees of A. W. Kimbell). Convention date (U.S.A.) 15th December, 1939.

544 831.—Arrangement of an auxiliary anode for initiating the arc discharge in a cathode-controlled rectifier.
The British Thomson-Houston Co. and H. de B. Knight. Application date 4th February, 1941.

544 850.—Resonant electrode system for modulating the high-frequency oscillations generated by the passage of an electron stream. [Addition to 541 271).
The British Thomson-Houston Co. Convention date (U.S.A.) 27th September, 1939.

544 951.—Method of coating valve electrodes in order to improve emission and to maintain a high vacuum.
The Mullard Radio Valve Co. and A. J. van Hoorn. Application date 31st October, 1940.

545 123.—Means for limiting the standing or D.C. component of the space current in an electron multiplier.
F. J. Granden Bosch. Application date 7th August, 1940 and 7th February, 1941.

545 146.—Electrode arrangement, including reflecting means, for generating high-frequency oscillations by the passage of an electron stream through a resonating system.
The Board of Trustees of the Leland Stanford Junior University. Convention date (U.S.A.) 20th April, 1939.

545 213.—Means for fixing the potential at certain points of an electron stream as it passes through a cathode-ray tube.
The British Thomson-Houston Co. Convention date (U.S.A.) 27th April, 1940.

545 380.—Construction of a blocking-layer rectifying-cell with one or more grids embedded between the rectifying layers.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 14th October, 1941.

545 389.—Cooling device for safeguarding the seals of a high-powered electron-discharge tube of the mercury-vapour type.
The British Thomson-Houston Co.; H. K. Bourne; and E. J. G. Beeson. Application date 10th January, 1941.

545 414.—Magnetic yoke for the deflecting system of a cathode-ray tube.
Philco Radio and Television Corporation (assignees of L. J. Bobb). Convention date (U.S.A.) 21st October, 1939.

545 445.—Electrode arrangement for deflecting an electron team in a frequency-converting or similar tube.
Marconi's W.T. Co. (assignees of H. M. Wagner). Convention date (U.S.A.) 24th November, 1939.

SUBSIDIARY APPARATUS AND MATERIALS

544 834.—Method of cutting and mounting a piezo-electric crystal oscillator required to maintain a constant frequency over a wide variation in temperature.
Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 29th March, 1940.

545 129.—Construction of radio-frequency bridge for measuring impedances. The variable elements in the bridge are mounted axially in a rotatable drum.
Marconi's W.T. Co.; C. D. Colchester; P. E. Jellyman; and R. A. Nightingale. Application date 4th December, 1940.

545 140.—Photo-electric apparatus for measuring the position and width of a moving strip.
The British Thomson-Houston Co. Convention date (U.S.A.) 13th July, 1940.

545 321.—Compact arrangement of a hearing-aid microphone-amplifier unit designed to be worn on the body of the user.
Sonotone Corporation. Convention date (U.S.A.) 13th September, 1939.

545 357.—Coding system for automatically "scrambling" the elements of a signal in at least two definite stages with different time-sequences in order to ensure secrecy.
Akt Brown, Boverie et Cie. Convention date (Switzerland) 26th July, 1939.

545 401.—Range-control system including a variable-gain amplifier to compensate for selecting signal fading.
Standard Telephones and Cables (assignees of S. B. Wright). Convention date (U.S.A.) 2nd May 1940.

545 430.—Training apparatus for transmitting combination Morse signals of gradually-increasing difficulty.
Creed and Co.; A. E. Thompson; and R. D. Salmon. Application date, 22nd November, 1940.

545 535.—Method of compensating for frequency errors in the load circuit, e.g. a rectifier type of meter, of an amplifier with negative feed-back.
Standard Telephones and Cables and A. W. Ewen. Application date 29th November, 1940.

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

2599. THE DISPERSION OF ULTRA-SHORT WAVES IN POLAR LIQUIDS WITH MORE THAN ONE RELAXATION TIME [Debye Theory: Perrin's Theory assuming Ellipsoidal Molecules: Case of Molecule containing a Freely Rotatable Polar Group: Theory of Anomalous Dispersion for Two Relaxation Times: Measurements by Drude's Second Method, Wavelengths 8–150 cm (and the Failure of the Coolidge-Romanow Formulae below 30 cm, for Absolute Measurements): Discussion of Results].—G. Klages. (*Physik. Zeitschr.*, 20th May 1942, Vol. 43, No. 9/10, pp. 151–166.)

2600. CORRECTION TO "THE ASSIMILATION OF ELECTROMAGNETIC REFLECTION AND REFRACTION THEORY TO THE PHYSICAL PHENOMENA."—O. Schriever. (*Ann. der Physik*, 29th April 1942, Vol. 41, No. 4, p. 324.)

Sommerfeld, Ott, & Magnus have pointed out a flaw in the mathematics of the paper dealt with in 628 of March: this does not seriously invalidate the results, but causes certain difficulties which the writer has now solved in a way to be described in a coming paper.

2601. ASYMPTOTIC SOLUTIONS OF LINEAR DIFFERENTIAL EQUATIONS [reducible to the Form $d^2y/dx^2 = \chi(x)y = (h^2\chi_0 + h\chi_1 + \chi_2)y$: Treatment providing Direct Connection between Asymptotic Solutions and Airy Integral & Its Companion Function].—H. Jeffreys. (*Phil. Mag.*, June 1942, Vol. 33, No. 221, pp. 451–456.)

2602. IONOSPHERIC MEASUREMENTS DURING TOTAL SOLAR ECLIPSE [South Africa, 1st Oct. 1940: F_2 Effects: F_1 Region "showed Expected Results" on the whole, but is "More Complex than generally Supposed": Most of Radiation producing E Region comes from Regions near Clouds of Bright Hydrogen or Calcium].—A. J. Higgs. (*Nature*, 20th June 1942, Vol. 149, p. 701: summary only.) For the F_2 results *see* 685 of 1941 and back reference.

2603. PROBE MEASUREMENTS IN RAREFIED AIR IONISED BY A BEAM OF ELECTRONS.—Székely & Zauner. (*See* 2771.)

2604. "ERGEBNISSE UND PROBLEME DER SONNENFORSCHUNG" [Results & Problems of Solar Research: Book Review].—M. Waldmeier. (*Naturwiss.*, 5th June 1942, Vol. 30, No. 23/24, p. 376.) Vol. XXII of the "Problems of Cosmic Physics" series (edited by Jensen).

2605. MEASUREMENTS OF ULTRA-VIOLET SOLAR- AND SKY-RADIATION INTENSITIES IN HIGH LATITUDES [Louise A. Boyd Arctic Expedition: Wavelengths 3200 AU & Shorter: Results in Agreement with Existing Ideas on Variation of Ozone with Latitude & Season: etc.].—W. W. Coblentz, F. R. Gracely, & R. Stair. (*Journ. of Res. of Nat. Bur. of Stds.*, May 1942, Vol. 28, No. 5, pp. 581–591.)

2606. SOLAR INFLUENCE ON COSMIC-RAY INTENSITY [Negative Sunspot Pulse associated with Cosmic-Ray Positive Primary Pulse, following 3–4 Days Later,] *and* A NEW COSMIC-RAY GEOMAGNETIC RELATION [Continuous Series of Spherical Shells of Current (Density proportional to Cosine of Latitude) concentric with Earth, augmenting Magnetic Field: etc.].—J. W. Broxon: Foster Evans. (*Phys. Review*, 1st/15th April 1942, Vol. 61, No. 7/8, p. 545: p. 545: summaries only.) *See* also 1888 of July.

2607. SOME MEASUREMENTS ON THE ELECTRONIC COMPONENT OF COSMIC RADIATION [at 2200 Metres above Sea Level: with Deductions as to Corrections necessary to Results of Counter-Telescope Observations].—G. Cocconi & V. Tongiorgi. (*La Ricerca Scient.*, Feb./March 1942, Vol. 13, No. 2/3, pp. 112–117.) For a previous paper, on the nature of the electronic component at 120 and 2200 metres, see *ibid.*, 1941, p. 144 onwards: and *see* also 645 of March. For further work *see* April/May issue, Vol. 13, No. 4/5, pp. 192–194.

2608. ON THE SPECTRUM OF THE COSMIC RADIATION AT 2200 METRES ABOVE SEA LEVEL [Measurements leading to Refutation of "Fine Structure" of Cosmic Rays and Presence of Bands in Primary Spectrum: etc.].—G. Cocconi & V. Tongiorgi. (*Naturwiss.*, 29th May 1942, Vol. 30, No. 22, pp. 328–329.) *See*, for example, 4206 of 1940 and 47 of 1941.

2609. A HYPOTHESIS AS TO THE ORIGIN OF COSMIC RAYS AND ITS EXPERIMENTAL TESTING IN INDIA AND ELSEWHERE [Five-Band, Four-Plateau Hypothesis].—R. A. Millikan & others. (*Phys. Review*, 1st/15th April 1942, Vol. 61, No. 7/8, pp. 397–407.) The full paper, summaries of which have been referred to in 2065 of 1941 and 644 of March.

2610. THE NATURE OF REACTIONS OCCURRING IN THE PRODUCTION OF THE AFTERGLOW OF ACTIVE NITROGEN, AND THE EFFECT OF TEMPERATURE ON THE PHENOMENA [Picture of Mechanism, in Agreement with Rayleigh's Results (4205 of 1940 [and 2289 of August]) and based on Freezing-Out of One Component of Active Nitrogen (J. J. Thomson)].—D. E. Debeau. (*Phys. Review*, 1st/15th May 1942, Vol. 61, No. 9/10, pp. 668–669.)

2611. CONTINUOUS EMISSION SPECTRA OF THE RARE GASES [and Their Intensity Distribution, Variation with Current Strength & with Pressure, etc.].—B. Vogel. (*Ann. der Physik*, 9th April 1942, Vol. 41, No. 3, pp. 196–210.)

2612. BAND SPECTRUM AND STRUCTURE OF THE CH^+ MOLECULE: IDENTIFICATION OF THREE [Hitherto Unexplained] INTERSTELLAR LINES.—A. E. Douglas & G. Herzberg. (*Canadian Journ. of Res.*, June 1942, Vol. 20, No. 6, Sec. A, pp. 71–82.)

2613. RESEARCHES ON THE STRUCTURE AND ON THE PREDICTION OF BAROGRAMS: PRELIMINARY NOTE [on Scheme taking Advantage of Recent Progress in Periodic Analysis & of Modern Mechanical Analysers].—F. Vercelli. (*La Ricerca Scient.*, Feb./March 1942, Vol. 13, No. 2/3, pp. 99–105.)

2614. DISTORTION OF SURGES BY SERIES INDUCTANCES AND PARALLEL CAPACITANCES: I—THEORY: II—MEASUREMENTS.—H. Lau. (*Arch. f. Elektrot.*, 18th Oct. & 17th Nov. 1941, Vol. 35, Nos. 9 & 10, pp. 507–532 & 609–615.)

2615. TRANSIENTS IN NON-UNIFORM LINES [Fundamental Theory of Reflection & Refraction of Impulses of Infinitesimal Length: Theory of Reflection in Its Heuristic Aspect: Exponential Line in the Transient Régime (with Application to Acoustics—Exponential Horn): etc.].—G. Zin. (*Alta Frequenza*, Dec. 1941, Vol. 10, No. 12, pp. 707–750.) An English summary is given at the end of the journal.

2616. GRAPHS FOR TRANSMISSION LINES [Parallel-Wire or Coaxial-Cylinder].—B. Salzberg. (*Electronics*, Jan. 1942, Vol. 15, No. 1, pp. 47–48.)

2617. IMPEDANCE DETERMINATIONS OF ECCENTRIC LINES, *and* GRAPH OF IMPEDANCE OF ECCENTRIC-CONDUCTOR CABLE.—G. H. Brown: W. J. Barclay & K. Spangenberg. (*Electronics*, Feb. 1942, Vol. 15, No. 2, p. 49: p. 50.) Primarily in connection with the deliberate variation of characteristic impedance for matching purposes.

2618. ON THE THEORY OF PHASE COMPENSATION [in Pupinised Lines].—Wald. (*See* 2728.)

2619. SKIN-EFFECT FORMULAS [and Curves: including Coated Conductors, of Special Interest for Ultra-High Frequencies].—J. R. Whinnery. (*Electronics*, Feb. 1942, Vol. 15, No. 2, pp. 44–48.)

2620. SKIN EFFECT IN CYLINDRICAL CONDUCTORS WITH ELLIPTIC CROSS-SECTION AT HIGH [and Medium] FREQUENCIES.—F. Lettowsky. (*Arch. f. Elektrot.*, 15th Dec. 1941, Vol. 35, No. 11, pp. 643–662.) Extension of 4073 of 1935, which dealt with low frequencies.

2621. DATA SHEETS XXVI AND XXVII: SKIN EFFECT.—(*Electronic Eng:g*, April 1942, Vol. 14, No. 170, pp. 715–717.)

PROPERTIES OF CIRCUITS

2622. THE ELECTRICAL OSCILLATIONS OF A PERFECTLY CONDUCTING PROLATE SPHEROID.—Ryder. (*See* 2662.)

2623. SKIN-EFFECT FORMULAS, *and* SKIN EFFECT IN CYLINDRICAL CONDUCTORS WITH ELLIPTIC CROSS-SECTION AT HIGH FREQUENCIES.—Whinnery: Lettowsky. (*See* 2619 & 2620.)

2624. DATA SHEET XVIII: THE SELF-CAPACITY OF COILS, ITS EFFECT AND CALCULATION.—(*Electronic Eng:g*, Jan. 1942, Vol. 14, No. 167, pp. 589 and 590.)

2625. RECENT QUESTIONS ON THE OPERATIONAL CALCULUS [Comparison & Correlation of Methods of Heaviside, Giorgi, Carson, & Doetsch for Treatment of Transient States in Linear Systems: Need for Unification in Teaching Methods].—A. M. Angelini. (*Alta Frequenza*, Jan. 1942, Vol. 11, No. 1, pp. 42–53.)

2626. Calculation and Construction of a Quartz Bridge Filter, *and* Various Circuits for Quartz Bridge Filters.—E. Hudec. (*E.N.T.*, Dec. 1941, Vol. 18, No. 12, pp. 265–276: Jan./Feb. 1942, Vol. 19, No. 1/2, pp. 16–25.)

(i) After a short discussion of the quartz plate as a circuit element, and of its advantages over corresponding coil/condenser combinations ($R/\omega L$ from 10^{-4}–10^{-5} compared with 10^{-2}, only rarely improved on: Kiessling's work is here referred to, 2726 & 3771 of 1938), the writer outlines the principle of the bridge filter and goes on to analyse a particular type, in which each branch is composed of a quartz plate with a parallel condenser and an inductance with a parallel condenser (Fig. 4). The treatment is confined to the practically important case where the pass-band is comparatively narrow (*e.g.* ±1.5 kc/s about a middle frequency of 100 kc/s). This type of filter has the advantage over the well-known Mason bridge types (Stanesby & Broad, 1390 of 1939) that the necessary terminating resistance can, for a given pass-band width and middle frequency, be varied within wide limits. The actual filter built to confirm the theoretical conclusions (circuit of Fig. 17) used h.f.-iron pot-cored coils with adjustable core, and fixed condensers each with a trimmer of Tempa S.

(ii) The filter dealt with above has all four branches of the quartz-type specified. The present paper describes a simplified circuit in which only two branches are of the quartz-type, the other two being composed of the two halves of the input resistance $\mathfrak{R}_a$, which is connected through a transformer (with a wide pass-band) to the anode circuit of a screen-grid valve. The circuit is analysed, and the terminating resistance for obtaining the best possible attenuation characteristic is calculated, with particular attention to the case where two filters in series are employed. Results were confirmed by the building of four filters, two for a middle frequency of 500 kc/s and a calculated pass-band width of ± 1.5 kc/s and two for a middle frequency of 1.5 Mc/s and a calculated pass-band width of ±4.5 kc/s: the pass-band widths mentioned are those given by the formula $p_4 = (1 + \Delta f/f_0)^2$, the actual widths being smaller: for the 1.5 Mc/s filter the width was about 3.3 kc/s, the cut-off attenuation was about 6 nepers, and the average flank steepness about 2.5 nepers/kc. Table 1, giving the data for the two duplicate filters to each specification, provides information as to the accuracy with which the individual values must be worked out in order to obtain filter-branch constants with an accuracy within about 1 per thousand. Fig. 15 shows the attenuation curves of the 500 kc/s "simplified" filters and Fig. 16 the curves for two of these in series.

2627. Contribution to the Complete Solution of the Differential Equation of Free Coupled Oscillations for Arbitrary Damping and Any Type and Value of the Coupling.—P. Schneider. (*Ann. der Physik*, 9th April 1942, Vol. 41, No. 3, pp. 211–224.)

Kiebitz (in 1913: ref. "1") gave a solution for inductive coupling which was applicable to a numerically specified case. More recently Wagner (1935 Abstracts, p. 613, and 3152 of 1938) has examined the general relations between the damping and frequency, of two circuits linked by a generalised coupling, and the constants of the uncoupled circuits, and has given a series of rules on the displacement of the natural frequencies and damping, produced by the coupling, for the case of not too high damping and moderate coupling. "The present investigations are concerned with the general case of arbitrary damping and any type and value of coupling. As was to be expected on grounds already given by Wagner, no simple expressions or rules are obtained. But by the determination of a parametric function y, whose values (so far as they are involved in the required solution) lie within two easily ascertained limits, the coupling values of damping and frequency are represented as functions of a damping expression r_0 [quotient of resistance and limiting resistance] applying to the uncoupled circuits: the behaviour of this quantity can be followed fairly easily even at large values of detuning. The present developments, in whose representation we have employed the terminology and symbols used by Wagner, have been carried out for electrical oscillatory circuits only, since the results can be converted directly to mechanical systems."

2628. The Input Impedance of a Coupled-Circuit System [Graphical Method giving Value and facilitating Survey of General Effect of Change in One or More Circuit Constant].—T. F. Wall. (*Electronic Eng:g*, April 1942, Vol. 14, No. 170, pp. 704–707.)

2629. A Coupling-Free Bus-Bar Circuit for Alternating-Current Sources in Communication Technique.—U. John. (*E.N.T.*, Dec. 1941, Vol. 18, No. 12, pp. 276–283.)

From the Kiel Electroacoustic Laboratory. It is frequently necessary that several a.c. sources with equal internal impedances but arbitrary no-load voltages should work in a combined circuit on a common load. The difficulty is that this common load provides a coupling which links the different sources and makes them react on each other. Such a coupling is generally undesirable, but steps taken to reduce or even eliminate it are opposed by the necessity for a correct matching of the load with the system formed by the various sources, in order to obtain the maximum transference of power. Bus-bar circuits hitherto known give either a correct matching *or* a decoupling, the latter only to a limited extent and under seriously restricting conditions as to open-load voltages.

The writer therefore makes a thorough analysis of the simple series connection and of the simple parallel connection, and of the "extended" versions of these obtained by adding an extra terminal resistance to each source, in parallel in the first case and in series in the second, this resistance $\mathfrak{Z}_z$ being about equal to the internal resistance of the source "or else strictly equal to the characteristic impedance (corresponding in order of magnitude with the internal resistance) of the correctly terminating quadripole, if such a quadripole is present." The equations show that even these "extended" circuits, though they do reduce the coupling to a certain extent, have the limitations mentioned above, and that a complete decoupling, free from restrictions on the open-circuit voltages and from deterioration of the matching conditions, "can only be obtained satisfactorily by the writer's method of simultaneous series and parallel connection."

It is true that in the comparatively unimportant case of only two sources the well-known "fork" circuit can be used instead, while for more than two sources a cascade fork connection will also give complete decoupling. The latter circuit, however, is less simple than that proposed by the writer, and is also inferior in the matter of power loss, particularly when the number of sources is large: the simultaneous series-parallel connection is as simple and efficient for many sources as it is for two. It is shown in Fig. 5. The device which makes it possible is that each source is converted, by a suitable bridge connection of simulating impedances, into two mutually independent virtual sources, and the load itself into two virtual loads. Two independent duplicate systems are thus obtained, one of which can be connected in series with the help of transformers of a certain transformation ratio, and the other in parallel with the help of transformers of another ratio. The whole circuit is somewhat complicated, but a greatly simplified form of it is shown in Fig. 6, and another in Fig. 7. These simplifications are based on the fact that eqns. 39, 42, and 48 show that certain of the simulating impedances $\mathfrak{Z}_i$ forming the bridge circuits for the generators, and of those ($\mathfrak{Z}_a$) for the load, carry no current or voltage and can therefore be short-circuited or omitted; a further simplification (already applied in the previously known circuits) is the use of a common transformer with several primary windings, instead of a separate transformer for each source. In the new circuit there would be, of course, two such transformers, one for the series and one for the parallel connection, except in the special case where $\mathfrak{Z}_a = n\mathfrak{Z}_i$, when the series transformer would have a ratio of unity and could be omitted, unless required as an isolating transformer. Finally, if the currents to be transmitted do not form a frequency band but are of one frequency only, all the simulating impedances can be replaced by ohmic resistances, provided that any reactive component which may be present in $\mathfrak{Z}_i$ is compensated by a corresponding reactance. It is claimed that the simplified circuit of Fig. 6 or 7 (the former is the one selected for experimental confirmation of the theory) provides an arrangement of almost unlimited application.

2630. Data Sheet XIX: Circuit Noise due to Thermal Agitation.—(*Electronic Eng:g*, Jan. 1942, Vol. 14, No. 167, pp. 591 and 592.)

2631. The Shunt-Loaded Tuned-Anode Circuit [in Wide-Band Amplifiers], *and* Data Sheets XXIII, XXIV, and XXV: Performance of the Shunt-Loaded Tuned-Anode Circuit.—C. E. Lockhart. (*Electronic Eng:g*, March 1942, Vol. 14, No. 169, pp. 673–676: pp. 677–680.) For XXVIII, supplementing these, *see* April issue, pp. 715–718.

2632. Stable Admittance Neutralisation [in Resistance-Coupled Amplifiers, by Auxiliary Valve giving Negative Mutual Conductance, with Instability removed by Suitable Negative Feedback].—E. W. Herold. (*Electronic Eng:g*, Jan. 1942, Vol. 14, No. 167, p. 594.)

2633. A New Principle for Stable Direct-Current Amplification [for Process Control, etc.]: Part II—Practical Forms of Negative-Feedback Direct-Current Amplifiers.—Eberhardt, Nüsslein, & Rupp. (*Arch. f. Elektrot.*, 18th Oct. 1941, Vol. 35, No. 9, pp. 533–549.)

See 3588 of 1941 and 1633 of June. Of the various ways of converting the d.c. voltages into a.c. voltages, modulation methods (with dry-plate rectifiers or valves) have the fundamental defect that to obtain proportionality between input and output they must use symmetrical arrangements (push-pull, ring, or star), which however get out of balance owing to changes in the non-linear elements: the result is that the modulator delivers an a.c. voltage even when there is no d.c. input, and the amplifier no longer has a steady zero. For input voltages of less than 1 volt, modulators are dismissed as unsuitable for the present purpose. On the other hand, vibrating-contact choppers are also rejected because of contact difficulties, and the remaining solution—a rotating variable condenser or variometer—is discussed (Fig. 13): in practice it is impossible to make a variable inductance as free from loss as a variable capacitance, and it is presumably the latter device that is employed in the complete amplifiers seen in Figs. 27 and 28.

The next point to be discussed is the phase-sensitive rectifier forming part of the general scheme (*see* previous abstracts). Unlike the case of the d.c./a.c. conversion at the input, the constancy of symmetry is not important here, since the effect of a departure from symmetry can be reduced to the $k.V$-th part by an opposed feedback with a "degree of compensation" of $k.V$. The simple single-valve phase-sensitive rectifier circuit of Fig. 16 is therefore practicable, and is used in the amplifier shown in Fig. 27, which is designed to amplify either an input voltage of 10 mv to an output voltage of 30 v or an input current of 1 μA to an output current of 15 mA, the respective power amplifications being 4.5×10^9 and 2.25×10^9: in this amplifier the switch S changes over from voltage-compensation to current-compensation. The amplifier of Fig. 28, on the other hand, has an extra stage of a.c. amplification after the "chopper" and uses dry-plate rectifiers as its phase-sensitive rectifier: it is designed to have a specially high input resistance (over 250 megohms) for measurements of the e.m.f. of diodes, p_H determinations, etc. It will amplify an input of 0.5 v to an output of 2 v, with power amplification of 6×10^6. It is accurate within 0.5%, compared with the 1% of the other type.

2634. The Generation of Intermodulation Frequencies [Paper to Radio Interference Conference].—H. J. Reich. (*Communications*, Oct. 1941, Vol. 21, No. 10, pp. 12, 14, and 26, 28.)

2635. Rectilinear Rectification applied to Voltage Integration. — Stevens. (*See* 2887.)

2636. Calibrated Differential Negative Resistances [and Their Use for Measuring Purposes].—A. Pinciroli. (*Alta Frequenza*, Nov. 1941, Vol. 10, No. 11, pp. 644–660.)

For previous work *see* 2686 of 1941. Author's summary :—"The possibility is shown of obtaining, with the help of a valve with differential negative transconductance, of the retarding-field type, a variable differential negative resistance which is permanent in time and very constant with respect to supply voltages. The various arrangements tried are shown and some measured results given [the circuits of Figs. 8a and 16 are considered the most advantageous].

"A new arrangement is proposed for the measurement of the equivalent resistance of a parallel oscillatory circuit. This is based on the use of a differential negative resistance calibrated at an acoustic frequency : the apparatus is very simple and allows the measurements to be made very quickly." For Latmiral's method with a dynatron *see* 3117 of 1936 : and *see* 2637, below.

2637. Reactive Component and Variability with Frequency of Negative Resistances.—G. Francini. (*Alta Frequenza*, Nov. 1941, Vol. 10, No. 11, pp. 661–664.)

Among the various ways of obtaining differential negative resistances, the method of the retarding-field valve has a special importance because of its high constancy, greatly superior to that of secondary-emission valves. The constancy is particularly high when the voltages applied to the electrodes have certain values which can be determined experimentally. Such arrangements have been applied to the measurement, by neutralisation, of the equivalent resistance of oscillatory circuits : in particular, Pinciroli uses for this purpose a variable negative resistance so stable as to preserve a calibration made at some acoustic frequency (2636, above). In this connection it is desirable to know (a) the value of the parasitic capacitance associated with the resistance, since this, coming in parallel with the circuit under measurement, will affect the resonance frequency and consequently the result of the measurement, and (b) the frequency at which the value of the negative resistance begins to depart from that measured at an acoustic frequency.

The writer, therefore, has made measurements on the circuits shown in Fig. 1a and Fig. 2 : the former is that given in Pinciroli's paper as Fig. 16 (*see* above abstract) while the latter is the circuit of Pinciroli's Fig. 8a modified so as to eliminate the battery between the second and third grids. Measurements at 100 kc/s, by two methods whose results agree, show that the parasitic capacitance is due essentially to the interelectrode capacitance, and can be reduced to the harmless value of 7.5 μμF by using an acorn valve (compared with 21.5 μμF for a type EF6) : "these results do not agree with those of other workers, but furnish a good confirmation of what has been said above." As regards the frequency-dependence of the negative resistance, with the circuit of Fig. 1a the measurements gave a definite relation between the relative variation of the negative resistance and the variation of the resistance R ; if the latter is of colloidal type this variation consists of a diminution, with increasing frequency, which amounts to several per cent. at 7 Mc/s in the case of resistances of some tens of thousands of ohms (Bressi, 4500 of 1938). The measured curve for Fig. 1a (Fig. 3) shows that the negative-resistance variation $\Delta r_n/r_n$ rose from zero at 2 Mc/s slowly to 4% between 6 and 7 Mc/s, and more quickly to 12% at 10 Mc/s : the circuit employed used an acorn valve. No curve is given for the circuit of Fig. 16 (or its variant Fig. 2), but it is mentioned that the relation is not so simple as that for the other circuit : on the other hand, the value of R is smaller for this circuit, so that its variations will be smaller also. To sum up, the method appears useful for frequencies up to some 10 Mc/s, or higher if a resistance of special type is available.

2638. Contribution to the Calculation of Leakage in Single-Phase and Multi-Phase Transformers with Several Windings on Each Core.—F. Fraunberger. (*Arch. f. Elektrot.*, 18th Oct. 1941, Vol. 35, No. 9, pp. 550–566.)

TRANSMISSION

2639. The Generation of Powerful Oscillations in the Region of Centimetric Waves by a Magnetron.—N. F. Alekseev & D. E. Malyarov. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 10, 1940, pp. 1297–1300.)

An investigation was carried out with an experimental magnetron model in which different types of electrodes could be tested. The model (Fig. 1) was attached to an oil diffusion pump. It was found that with a four-circuit water-cooled anode (Fig. 5) and using oscillations of the first order ($n=1$; one revolution of the electron takes place during one oscillation in the circuit) power outputs up to 300 w were obtained on a wavelength of 9 cm. With similar sealed-off models power outputs of the order of 100 w were obtained on the same wavelength. Experimental models of similar type were also constructed for shorter waves ; using oscillations of $n=\frac{1}{2}$, outputs of 2 w were obtained on a wavelength of 2.6 cm.

2640. An Electron-Beam Oscillator with a Retarding Field.—N. I. Ashbel. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 10, 1940, pp. 1301–1302.)

A description is given of a very simple oscillator operating with a retarding field on decimetric waves. A diaphragm D (Fig. 1) with an aperture in the centre is mounted across the tube. A tungsten-filament coil K inside a cylinder V is mounted on one side of the diaphragm, while a fourth electrode A in the shape of a hemisphere or a pot-cylinder opening towards the diaphragm is mounted on the other side of the diaphragm. V, D and A have negative, positive, and zero (or negative) potentials respectively. The electrons emitted from K are made to converge at D by the fields of V and D, and enter A in a divergent beam. A space charge of considerable density is formed inside A. The main difficulty in designing this oscillator is to ensure good focusing of the return beam at the aperture of D.

Experiments were carried out with oscillators of this type, and for power dissipation of the order of 30 w on the diaphragm an efficiency up to 4% was obtained on wavelengths from 35 to 60 cm. A description is also given of a modified model in which the Lecher conductors L connected to D and A in Fig. 1 are replaced by a concentric line partly formed by the electrodes themselves (Fig. 2).

2641. THE EXCITATION OF CAVITY RESONATORS BY SAW-TOOTH OSCILLATIONS.—W. Ludenia. (*E.N.T.*, Jan./Feb. 1942, Vol. 19, No. 1/2, pp. 7–15.)

" Recently the centimetric waves have achieved a considerable importance on account of their good quasi-optical properties. In particular, impulse-modulated transmitters are of great interest for many applications. Consequently the excitation of resonant circuits by pulse generators (' kipp ' generators) deserves a thorough investigation, since with such generators it is possible to obtain specially simple arrangements for the production of large pulse energies . . . For his investigations the writer used a gaseous-discharge gap with an oxide [apparently aluminium-oxide] cathode developed by himself: it will be reported on in detail elsewhere."

After a discussion of the theory of the saw-tooth oscillator and its voltage and current curves, the writer deals in section III with the excitation of resonant circuits by oscillations of this type. Such excitation depends very much on the saw-tooth-circuit discharge-time T_E. If the ohmic resistance R_E (Fig. 6) is small compared with the inductance L, C will no longer discharge aperiodically but in the form of a damped sinusoidal oscillation, whose decrement will depend chiefly on the resistance assumed by the " switch " S during the time T_R (Fig. 5): it will also be the smaller, the smaller the ohmic resistance is compared with L. The values of C and L determine the frequency of the excited oscillation according to the formula $N=1/\tau=1/2\pi\sqrt{CL}$. Since current and voltage are approximately 90° out of phase, T_E must be about a quarter of the oscillation period τ: that is, the discharge-time must be about four times smaller than the period of the resonant circuit to be excited. If the " switch " resistance is very high during the time $\tau/2$ (as in the case of a quenched gap) a secondary circuit can be tightly coupled (Fig. 7) and an efficient energy transfer obtained, but this point is not discussed any further because only the single circuit of Fig. 6 is actually used for the excitation of resonant circuits of extremely high frequency.

The problem, then, is the production of saw-tooth oscillations of large energy with extremely short discharge-time T_E. It is seen in section IV that the internal resistance of a gaseous-discharge gap increases linearly as T_E decreases (eqn. 30, Fig. 9), so that the efficiency η (eqn. 31) decreases linearly with decreasing T_E. Measurements were made with a 25μ gap in a particular circuit where T_E was 5×10^{-8}s and the corresponding gap resistance was 1 ohm: this circuit was suitable for exciting a circuit of $\tau=4T_E=2\times10^{-7}$s, giving a wavelength of 60 m (*not* 15 m as given in the text). On the other hand, if $T_E=10^{-10}$s, so that the excited wavelength is 12 cm ($\tau=4T_E=4\times10^{-10}$s, so that $N=2500$ Mc/s), the gap resistance rises to the large value of 500 ohms. Calculating the efficiency by eqn. 31 this gives, for a load of 50 ohms such as would be provided by a well radiating oscillator, $\eta=50/550=$ about 9%.

This 9% efficiency is the value quoted in the author's summary and elsewhere, as holding for a 12 cm wave. The validity, however, of such a calculation of efficiency by eqn. 31 in the present case is discussed on pp. 10 (following Fig. 9) to 11, where a comparison is made with the case of a magnetron. " Quite generally it can be said that with an intermittent gaseous discharge a much worse thermal efficiency must occur than with a non-intermittent cathode-heating such as is possible for electronic valves, but that the energy conversion ratio (useful-output/d.c.-input) for very small τ (for instance less than 10^{-10}s) is distinctly better with the gaseous discharge gap, because of the technically possible small path-lengths of, or under, 10μ. " If, in place of a gas-gap, a vacuum gap is employed, when the electrodes are cold the discharge of C will only occur if the electrodes are in galvanic contact. The internal resistance of such a vacuum gap is then practically zero and the discharge takes place practically without inertia, since the path-length is also zero when the electrodes are touching. With a very good vacuum it is thus possible to attain, even with discharge-times of 10^{-10}s (corresponding to an excited wave of 12 cm), an internal resistance R_s of only about 1 ohm, so that low-damping circuits can be excited " [whereas when the gas-gap resistance was 500 ohms for the 12 cm wave, it would have been useless to employ a low-damping circuit: p. 10, and later in this abstract]. With vacuum contact-gaps the work function θ of the electrons (eqns. 36, 37) does not come into the question, so that the equation relating the energy E applied to the gap to the useful output E_N can now be written $E=kE_N$, where k depends only on the circuit losses, which can be kept small: efficiencies of more than 50% are thus obtained " [a footnote here states that investigations on these lines are still in progress, so that the various points are merely mentioned].

The writer continues: " For a gas-gap the internal resistance is given by $R_s=cA$, where A is the electrode spacing. At a critical point P, R_s rises very steeply: measurements show that P occurs when A is approximately 100μ if $\lambda=1$ m, and when A is about 25μ if $\lambda=10$ cm. For a pressure of one atmosphere the corresponding striking voltages U_z are about 900 and 400 volts. By increasing A beyond the critical point P the value of U_z can be increased, but R_s then increases so steeply that the energy is reduced. With vacuum contact-gaps U_z has theoretically no upper limit and with a very good vacuum can reach ten or more times the value for a gas-gap at atmospheric pressure: the stored-up energy in the condenser can thus be raised a hundred-fold or more [here again the footnote is referred to] . . . Investigations show that the internal resistance R_s of a gas-gap is independent of the gas pressure, so that a higher efficiency cannot be obtained by decreasing the pressure. On the other hand, for a constant A the striking voltage U_z increases in proportion to the gas pressure, so that much higher maximum values can be obtained for the mean energy E [over the whole period of the saw-tooth oscillation] than at normal pressure" [this is a point singled out in the author's summary, but again the footnote is referred to].

A discussion on pp. 11–12 on the charging time T_L and the deionising time T_J, together with the comparative performances of an aluminium-oxide and a tungsten cathode, leads to the conclusion that the former is superior, but that at atmospheric pressure the highest permissible continuous load for it is about 10 w, which at 12 cm wavelength with the 9% efficiency previously arrived at yields about 0.9 w of h.f. output. "At a gas pressure of 10 atmospheres an output of about 20 w is to be expected." From the relations obtained in this sub-section it follows that for gas-gaps, as λ decreases, the efficiency decreases linearly and the max. energy according to the square law. "With vacuum contact-gaps the efficiency decreases little and the max. energy linearly. When success is obtained in constructing vacuum contact-gaps with a very high saw-tooth frequency ($n > 10^5$ c/s), which seems quite possible, it will be feasible to generate centimetric waves of high steady output (in certain conditions some hundreds of watts) with good efficiency (up to or over 50%)".

Sections V and VI deal shortly with the theory of cavity resonators and their excitation by saw-tooth oscillations of extremely short discharge-times: the theoretical treatment is based on the two papers by Borgnis and Schriever dealt with in 61 of 1941 and back reference. Fig. 14 shows the gas-gap method of exciting the H_1 wave in a cylindrical cavity resonator: the current-pulse flowing during the discharge-time T_E excites the CL circuit to damped sinusoidal oscillations which excite the cavity resonator: since, as shown above, the resistance of the gap is very high for centimetric waves, the damping of the CL circuit is so great that the damped oscillations are practically extinguished after two periods: there is no advantage therefore is making C large compared with L, and CL is actually formed by an open radiator, the dipole D (with the gas-gap at its mid-point) perpendicular to the cavity axis, at a distance of about $\frac{1}{4}\lambda$ from the back wall W_2. The space W_2D then acts as a practically loss-free oscillatory circuit. If the cavity diameter is greater than $\lambda/2$, part of the energy oscillating in W_2D will emerge into the rest of the cavity, the space DW_1 (D, being a dipole turned to $\lambda/2$, acts as a good reflector). The damping of these oscillations depends chiefly on the resistance presented by D at the movement of reflection: this is identical with the ionising resistance of the "switching" gap, and since this is high for a gas-gap, part of the oscillation energy will be absorbed by D on reflection. In spite of the damping thus produced, the DW_1 oscillations will be much less damped (Fig. 15, curve II) than the original train (curve I). These oscillations swing between D and W_1 and emerge through the apertured stop B into open space. If the distance DW_1 is so chosen that at about every five periods a new wave-train of the form II arrives at W_1, the waves emerging through B will be still more undamped (curve III). This process could be continued by adding another cavity resonator, but the losses would also be increased, the more so the higher the reflection loss in D: so that in this respect also the vacuum contact-gap would be superior, since its resistance would be zero after the discharge of C. The simplest plan is to couple, instead of another cavity resonator, a cavity line whose high-pass-filter action can be used to remove all the longer waves from the frequency spectrum emerging through B, so that the final waves are practically monochromatic.

Finally, section VII describes such an "8 cm" generator and the results obtained with it: the gas-gap dipole S has (for some reason) a natural wave-length λ of about 13 cm and is placed at 3 cm from the back wall W_2: the distance SW_1 is $3\frac{3}{4}\lambda$, or 48 cm: the adjustable stop B leads to the high-pass tube F (cut-off at 8.5 cm) terminating in a horn radiator. The power applied to the exciter is (according to eqn. 42) 4 w, which at an efficiency of 9% would give a dipole power of about 0.35 w: comparative measurements with a 10 cm magnetron gave a value of 0.4 w, agreeing quite well with the calculated value. The power emerging through the fully opened stop B was found to be 0.2 w: the 8.5 cm power, after passage through the high-pass filter, was about 0.05 w. "Even this small amount of power was quite enough to cover a range of 3 km, using no reflectors and only a simple crystal detector with l.f. amplification (the transmitter being in this case note-modulated). As will be shown in a later paper on the reception of centimetric waves, the distant action of saw-tooth transmitters is considerably greater than that of undamped transmitters, so that the same ranges can be attained with definitely smaller powers." The transmitter and its corresponding receiver (Fig. 18, with cavity resonator and horn collector) are known as "Type OZ." Fig. 20 gives the measured resonance curves, curve a showing the broad wave spectrum emitted by the dipole itself, curve b the narrower spectrum emerging through the stop B, and curve c the sharp curve after passage through the high-pass filter. Corresponding standing-wave curves measured in a Lecher system are seen in Fig. 21.

2642. FREQUENCY-MODULATED AND AMPLITUDE-MODULATED TRANSMITTERS OF THE MONTH [especially the New (Doherty) "Grounded Plate" Amplifier (instead of Grounded-Filament), for F.M. at W71NY].—L. Winner: A. A. Skene (*Communications*, Dec. 1941, Vol. 21, No. 12, pp. 14–15 and 24.)

2643. A MODULATION AMPLIFIER OF HIGH QUALITY [for 3 kW: Six Stages, without Coupling Transformers (giving Small Phase Differences even at High Frequencies, and allowing High Negative Feedback without fear of Oscillation)].—L. Rubin & L.C. Zonneveld. (*Alta Frequenza*, Nov. 1941, Vol. 10, No. 11, pp. 699–701: summary, from *Philips Transmitting News*.)

2644. A GERMAN PORTABLE TRANSMITTER [Single-Valve, for Agents].—(*Electronic Eng:g*, Jan. 1942, Vol. 14, No. 167, p. 596.)

2645. THE "BATTLESHIP" V.F.O. [Variable-Frequency Oscillator: Further Development of

Goodman's Design (1646 of 1941), with Particular Attention to Mechanical Stability].—P. H. Bloom. (*QST*, May 1942, Vol. 26, No. 5, pp. 44–49.)

RECEPTION

2646. Notes on 225-Mc. Converter Design [using Ordinary Parts available to Amateurs].—A. Bent. (*QST*, May 1942, Vol. 26, No. 5, pp. 56–57 and 78, 86.)

2647. Notes on Superheterodyne Receivers for $2\frac{1}{2}$ Metre Waves [especially the Double-Conversion System].—E. P. Tilton. (*QST*, May 1942, Vol. 26, No. 5, pp. 54–55 and 96, 98.)

2648. Mobile 30–40 Mc. Receiver for the U.S. Forest Service [for Fire Tank Trucks, Highway Patrolmen, etc: specially designed to overcome Ignition Interference without Recourse to Frequency Modulation: "Usable Sensitivity" around 1 μV: Manual & Spot-Frequency Tuning].—H. K. Lawson & L. M. Belleville. (*Electronics*, Jan. 1942, Vol. 15, No. 1, pp. 22–25 and 98, 99.)

Apart from economic reasons connected with existing equipment in the Forest Service, "frequency-modulation technique has not advanced sufficiently far to date to permit design of a reliable portable unit that can compete in size, weight, cost and over-all low power consumption with the portable units now in service." The receiver has a complete r.f. tuning head connected by flexible leads to the amplifier unit.

2649. A Hiss-Silencer for Communication Receivers [Forestry Service Receivers, where Super-Regenerative First Detector is necessary, but Hiss on Prolonged "Stand-By"s is Annoying: Valve & Relay Combination].—E. F. Whiddon. (*Electronics*, Sept. 1939, Vol. 12, No. 9, pp. 56, 58.)

2650. Radio Uses of Powdered-Iron Cores [Survey of Recent Developments & Future Extensions].—(*Electronics*, Feb. 1942, Vol. 15, No. 2, pp. 35–37 and 93..95.)

2651. Wireless in the *Luftwaffe*: More Details of the Equipment used in German Aircraft.—(*Wireless World*, June 1942, Vol. 48, No. 6, pp. 133–134.)

2652. Short-Wave Coil Winding Data [Table, for Standard "Eddystone" Formers].—(*Electronic Eng:g*, Feb. 1942, Vol. 14, No. 168, p. 646.)

2653. A Superheterodyne Tracking Solution [including the Trimmer Problem as encountered in Receivers using Permeability Tuning: Treatment leading to Simpler & More Practical Design Equations].—R. de Cola. (*Electronics*, Feb. 1942, Vol. 15, No. 2, pp. 29–30 and 91, 92.)

2654. A Simple Expander [with Negative Feedback from Output Transformer controlled by Small Lamp].—W. Bacon. (*Electronics*, Dec. 1941, Vol. 14, No. 12, pp. 50 and 54..58.)

2655. Distortion in Radio Receivers: a Summary of the Chief Obstacles to Perfect Reproduction.—S. W. Amos. (*Electronic Eng:g*, March 1942, Vol. 14, No. 169, pp. 686..691.)

2656. Multiple Receiver Response in Strong R.F. Fields [Paper to Radio Interference Conference].—R. N. Plank. (*Communications*, Dec. 1941, Vol. 21, No. 12, pp. 8–11 and 26..35.)

2657. The Generation of Intermodulation Frequencies [Paper to Radio Interference Conference].—H. J. Reich. (*Communications*, Oct. 1941, Vol. 21, No. 10, pp. 12, 14, and 26, 28.)

2658. Interference-Reducing Antenna Systems: Overcoming Electrical Noise Problems in Reception [Survey].—A. Crossley. (*QST*, May 1942, Vol. 26, No. 5, pp. 25–26 and 100, 102.)

AERIALS AND AERIAL SYSTEMS

2659. Feeding the Coaxial Dipole [1450 (and 1449) of 1939] with an Open-Wire Line.—H. R. Gebhardt. (*QST*, May 1942, Vol. 26, No. 5, p. 58.) Instead of the customary coaxial cable.

2660. Graphs for Transmission Lines [Parallel-Wire or Coaxial-Cylinder].—B. Salzberg. (*Electronics*, Jan. 1942, Vol. 15, No. 1, pp. 47–48.)

2661. Impedance Determinations of Eccentric Lines, *and* Graph of Impedance of Eccentric-Conductor Cable.—Brown: Barclay & Spangenberg. (*See* 2617.)

2662. The Electrical Oscillations of a Perfectly Conducting Prolate Spheroid [of Eccentricity nearly Unity: Forced Oscillations shown to be decomposable into "Harmonics" corresponding to Different Modes of Vibration, Each Harmonic being quantitatively connected with Certain Portion of Impressed Field driving the Aerial: etc.].—R. M. Ryder. (*Journ. Applied Phys.*, May 1942, Vol. 13, No. 5, pp. 327–343.)

For other recent treatments of the problem, mentioned here, *see* 959 & 3196 of 1938 and 1888 of 1941. "The present theory may be regarded as a justification and expansion of the sinusoidal current assumption for resonant antennas; particularly for the radiation field this assumption is better than might, at first, be expected. Our principal extension is to relate the amplitude and phase of the current to the driving field." Two minor points which emerge are discussed, relating respectively to the higher resonances and to the case of a vertical aerial $\frac{3}{4}\lambda$ long, resonating to an impressed third harmonic (concealment of nodes).

2663. The Concepts of Radiation Impedance and Gain applied to Multiple Radiating Systems for Short Waves.—V. Gori. (*Alta Frequenza*, Nov. 1941, Vol. 10, No. 11, pp. 665–689.)

"Certain recent publications relating to radiating systems for short and ultra-short waves, composed of a number of dipoles arranged according to definite geometrical configurations, show that the principles on which their behaviour is based (above all the prediction of their efficiency) have sometimes not been mastered to the extent necessary to avoid ambiguities and errors. It seems therefore worth while examining and illustrating—with a character and scope essentially practical — some ideas regarding the radiation impedance (mutual and self) of radiating systems, and the so-called power gain associated with this . . ."

Accordingly, the writer goes on to examine, "from a physico-mathematical viewpoint" and starting from the Maxwell-Lorentz equations, the concept of radiation impedance in general, mutual and self-impedance of radiation in a local sinusoidal régime, and the gain attainable with a system of oscillators: the important gain equation (42) is obtained. He then applies his results to a comparison of the gain of a system of two pairs of "double dipoles" arranged in vertical orthogonal planes (Fig. 5) and excited to give a practically circular horizontal radiation, with that of an omnidirectional Marconi-Franklin aerial of equal height, consisting of two vertical equiphase elements, superposed with coincident axial direction. The latter system is found to have a power gain of 1.47, considerably larger than the value of 1.18 found for the former: this result is discussed in p. 684. Then follows a similar comparison of the R.C.A.-Brown "turnstile" aerial for ultra-short waves (2595 of 1936) with the Franklin type. The writer points out that in Fig. 7 (derived from Brown's paper) the origin of the Franklin curve coincides with $H/\lambda=0.5$, as it has to do from the fact that the power gain represented by the ordinates is defined as the gain over a vertical half-wave aerial; whereas the origin of the turnstile curve coincides with $H/\lambda=0$: for equal abscissae, therefore, the ordinates of the two curves are not truly comparable (there is a mistake in the labelling of the horizontal axis in this diagram: it should be H/λ). For a true comparison between a turnstile element and a Franklin element this must be allowed for, and when this is done the latter is seen to have the larger gain. If it is argued that the diagram nevertheless shows indisputably that for *aerials of the same height* ($n+1$ elements of turnstile, n of Franklin) the turnstile is superior, the writer replies that for practical purposes height is not the true criterion: the question of surface or volume also comes in. But putting this point aside, the only practically useful way of comparing two systems is to take equal numbers of elements, and for two elements the Franklin aerial has a gain of 1.47 as compared with 1.21 for a two-element turnstile. But (as the curves show) the gain of the turnstile aerial increases more rapidly with an increasing number of elements than does that of the Franklin aerial: the writer shows that this is quite logical, since in the turnstile the *mean* radiation resistance of each oscillating element decreases with the number of elements, while in the Franklin aerial it increases: and this mean radiation resistance occurs in the denominator of the generalised expression for the gain (eqn. 42 and footnote 28).

2664. Improvement in Transmitting Aerials of Short Electrical Length.—G. Monti Guarnieri. (*Alta Frequenza*, Nov. 1941, Vol. 10, No. 11, pp. 690–691: summary only.)

Advantages of use of "electrical length" K of an aerial, expressed in degrees or radians (formulae thus obtained are independent of working wavelength): definition of factor of merit as ratio between horizontal field and power dissipated in the various loss resistances: examination of various types of aerial with small electrical lengths shows that the "vertical stalk" type gives the lowest factor of merit, owing to the high losses in the base insulator and the high tuning reactance required: top-loading by a capacitive armature reduces both defects and improves the current distribution, thus increasing the electrical length and the efficiency. A special condition of top loading can be obtained by the algebraic summation of a capacitive reactance due to an armature and an inductive reactance due to a coil. By varying the latter, the complex inductance can be adjusted so that there is a node of potential and an antinode of current at the base, with a disappearance of dielectric losses at the base and an important increase in equivalent electrical length. In a particular example, an aerial of electrical length 15° had its factor of merit increased in this way from 0.274 mv/m/w for the simple "stalk" aerial to 1.28 mv/m/w, with a consequent gain of 13.5 db. The Magneti Marelli firm obtain this result by means of a permeability-tuned reactance with adjustable iron core. The electrical and mechanical characteristics of this arrangement are particularly valuable for mobile stations, where a short aerial is so important.

2665. Interference - Reducing Antenna Systems: Overcoming Electrical Noise Problems in Reception [Survey].—A. Crossley. (*QST*, May 1942, Vol. 26, No. 5, pp. 25–26 and 100, 102.)

VALVES AND THERMIONICS

2666. Amplifier Valve with Double Cathode Connections, for Metric Waves [Type EF51].—M. J. O. Strutt & A. van der Ziel. (*Alta Frequenza*, Dec. 1941, Vol. 10, No. 12, pp. 752–753: summary, from *Rev. tech. Philips*, Dec. 1940, Vol. 5, p. 361 onwards.)

The advantages of this valve, especially with regard to the input resistance, are discussed. The damping resistance proceeding from the coupling between the circuit of the control grid and that of the anode (due to the auto-induction of the cathode circuit) can be eliminated by providing the cathode with two connections, one going to the control-grid circuit and the other to the anode circuit. This arrangement, embodied in the EF51, enables this valve to give results down to 1.5 m which are greatly superior to those obtained with acorn pentodes, and comparable with those of the push-pull EFF50; with the advantage, over the latter valve, that the amplification can be varied by regulating the transconductance. Practical circuits are shown.

2667. Operation of Power Triodes in Ultra-High-Frequency Circuits [Practical Hints for Use of Types HK-54 & HK-254 at 30–200 Mc/s].—W. G. Wagener. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 81..84.)

2668. A Limitation of the Diode: Improving the Circuit for Higher Modulation Levels [Recent Patent, No. 539 596].—F. E. Terman. (*Electronic Eng:g*, Feb. 1942, Vol. 14, No. 168, pp. 642–643.)

2669. Secondary Electron Problems in Beam Tetrodes [and "a Purely Destructive Criticism of Existing Theories of the Critical-Distance Beam Tetrode"].—J. H. O. Harries. (*Electronic Eng:g*, Jan. 1942, Vol. 14, No. 167, pp. 586–587.)

"The values of potential minimum deduced by the published theories [*e.g.* Salzberg & Haeff, 1428/9 (and 3213) of 1938] are quite incapable of preventing a dynatron characteristic being formed and do not fit the facts in other ways . . . What is hoped will prove to be an adequate theory is in course of preparation."

2670. Data Sheet XX: Calculation of Shot Noise, *and* XXI & XXII: Calculation of the Space Current in Diodes and Triodes.—(*Electronic Eng:g*, Feb. 1942, Vol. 14, No. 168, pp. 633 and 634: pp. 633 and 635, 636.)

2671. Excitation of the Anode Effect [called by Obolensky (1932 Abstracts, p. 286) Negative Grid Polarisation].—P. L. Copeland & G. G. Carne. (*Phys. Review*, 1st/15th May 1942, Vol. 61, No. 9/10, pp. 635–642.) A summary was dealt with in 1368 of May.

2672. Corrections to "Circle Diagrams for Tube Circuits."—A. Nims. (*Electronics*, Oct. 1939, Vol. 12, No. 10, p. 49.) *See* 3589 of 1939.

2673. The Valve Equivalent Circuit and Its Limitations [Correspondence].—(*Wireless World*, June 1942, Vol. 48, No. 6, pp. 145–146.) Prompted by Boyland's article in the May issue: *see* also July issue.

2674. Cathode Design [Illustrated Survey].—O. W. Pike. (*Communications*, Oct. 1941, Vol. 21, No. 10, pp. 5–8 and 28.) From the Vacuum Tube Eng. Dept., General Electric Company.

2675. Improved Alloy Wire for Grids [Calmolloy Molybdenum-Alloy Wire to eliminate Non-Uniformity, Microphonics, etc., in Grids].—J. Kurtz. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 54..62.)

2676. Thermal-Delay Relays in Tube Circuits [giving Time for Filaments to Warm Up: Measurements on Protection given by Simple & Lock-Out Circuits].—W. Bacon. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 58..64.)

2677. Gaseous Tubes, and How to Treat Them [Correct Interpretation of Rating Information, and Other Precautions to obtain Long Life & Satisfactory Operation].—W. W. Watrous & D. E. Marshall. (*Electronics*, Jan. 1942, Vol. 15, No. 1, pp. 42–46 and 110..112.)

2678. The Possibility of Control of a Mercury-Vapour Discharge by Interaction between Grid and Anode [Experimental Investigation].—G. Manz. (*Arch. f. Elektrot.*, 17th Nov. 1941, Vol. 35, No. 10, pp. 567–590.)

In the special tube used for the main experiments, the grid (which had a single hole only, of diameter varying from 2 to 6 mm) was close to the anode, the best separation depending on the diameter of the grid hole: for a 4 mm diameter it was 0.7 mm. The rise in the discharge voltage (by amounts up to 50 v) produced by a negative voltage on the grid is attributed to the formation of a positive anode drop (close to the anode) resulting from a constriction of the discharge by Langmuir layers. No extinction of the arc is thus produced, but if a capacitance of suitable value is connected across the discharge there will be set up in the region of anode drop (with its steeply falling characteristic) a succession of medium-frequency oscillations which will extinguish the arc. With a 0.5 μF condenser, a 3 A anode current was extinguished by a grid voltage of −60 v, the grid current being 3 mA. No tests were made with arcs of higher current strength, but it seems probable that with the insertion of a choke into the grid circuit (which was found to improve the extinguishing action) larger currents could be controlled. *Cf.* 2806, below.

2679. The Secondary Emission of Sublimated Antimony Layers.—P. Görlich. (*Physik. Zeitschr.*, 20th April 1942, Vol. 43, No. 7/8, pp. 121–123.)

"The antimony-caesium layers described by us (3093 of 1941: and *cf.* 172 of January) have, as is well known, an unusually high photoelectric sensitivity in the visible part of the spectrum. It is found in general that composite layers with high photoelectric output give also a high secondary-emission output. Naturally, therefore, various workers have examined the antimony-caesium layers with regard to their secondary-emission output (2867 of 1939: 2260 of 1940: 3099 of 1941: and Morgulis, ref. "2" [*see* also 171 of January]). The results have confirmed, for the antimony-caesium layer, the parallelism of the two types of emission—from which, however, it must not be deduced that the emission mechanisms are the same.

"The values given by the various writers for the secondary-emission coefficient differ among themselves rather noticeably. This is probably due to different methods of preparing the composite layers, and perhaps to different percentage compositions: also, of course, the influence of gases on the layers is of greater importance than it is for photoelectric emission. We considered it necessary, therefore, to carry out some clarifying investigations on unalloyed sublimated Sb layers (long-wave photoelectric limit 307.5 mμ), since these might be expected to lead also to new knowledge on the alloyed layers.

"It was found that an antimony layer deposited on a silver base gave an unexpectedly high max. s.e. coefficient of 2.30 (primary voltage 120 v) when the layer had its optimum thickness [around 380 mμ, just where the film begins to be non-transparent to light: Fig. 2. The s.e. coefficient still varies, at this thickness, with the nature of the base material, but as the thickness is increased beyond this value the coefficient becomes smaller until it reaches a constant value of about 1.60 and is also independent of the base material]. As the primary voltage is increased the coefficient falls only slowly (Fig. 1), so that from the flat shape of the curve it can be deduced that a heightened sensitivity and consequently a greater s.e. output could be attained by an introduction of foreign atoms. Since, naturally, such added metal could be (in addition to inert or heavy metals) either alkaline or alkaline-earth metals, a direct connection with the antimony-caesium layers seems to be established".

The writer goes on to discuss the above-mentioned dependence of s.e. coefficient on the base material; he concludes that the boundary layer between the base and the deposited layer varies in the "sharpness" of its structure according to the material of the base. "A layer with varying foreign-metal concentration is formed, which can be reached by the primary electrons only if these have a sufficiently high velocity. In our opinion it is possible to explain in the same way the dependence on base material of the external photo-electric effect, particularly in modern composite photocathodes. The investigation of the introduction of silver into the antimony layer actually gave an increase of s.e. output, so that the above assumption receives support. The introduction of silver, or the use of silver alloys, seems in most cases to lead to an increased absorption of the primary and secondary electrons (Görlich, 3054 of 1941: Friedheim & Weiss, 1065 of April), so that to obtain the maximum emission the silver concentration must be kept within certain limits".

The writer then quotes various recent papers concerning the dependence on base material and on layer thickness, and goes on to mention that he has already shown (3054 of 1941) that sublimated alkaline-earth layers can be sensitised in a h.f. glow discharge. The same method failed when applied to antimony layers (which gives no support to Bruining's idea that the writer's effect with alkaline-earth films was due to inadequate outgassing). On the other hand, if the antimony layer is exposed to the atmosphere for sixteen hours, the s.e. coefficient falls from 2.04 (*Sb* on *Pt*) to only 1.32, so that such a layer is not, without special treatment, suitable for commercial purposes. Treatment with a h.f. glow discharge, however, then raises the coefficient: the discharge does not, as in the previous case, only produce a structural change, but must be assumed also to set free the gas adsorbed at the layer surface. Finally, he discusses some results on the transformation of antimony from the amorphous to the crystalline state: they support Was's conclusion (2534 of 1939) that adsorbed gases reduce the action of the forces of adhesion and thus promote crystallisation. It is not yet certain which phase gives the higher secondary emission.

2680. FIELD EMISSION FROM TUNGSTEN AND THORIATED-TUNGSTEN SINGLE CRYSTALS [Experimental Investigation & Discussion of Results: Pattern Types in Electron-Projector Images (3350/1 of 1941) form Sensitive Test for Clean Tungsten Surface: Variations of Emission Intensity with Crystallographic Direction are Greater than in Thermionic Emission: Comparison of These Variations with Theory & with Other Workers' Results: etc.].—J. H. Daniel. (*Phys. Review*, 1st/15th May 1942, Vol. 61, No. 9/10, pp. 657–667.)

2681. THE V^3I RELATION FOR VAPORISING MOLYBDENUM [V^3I does Not remain Constant, but Decreases with Time (0.49–0.85% for 500 Minutes of Operation): Discussion of Reason].—F. T. Worrell. (*Phys. Review*, 1st/15th April 1942, Vol. 61, No. 7/8, pp. 520–524.)

2682. THE TEMPERATURE SCALE, THERMIONICS, AND THERMATOMICS OF TANTALUM.—M. D. Fiske. (*Phys. Review*, 1st/15th April 1942, Vol. 61, No. 7/8, pp. 513–519.)

2683. THERMIONIC PROPERTIES OF THE IRON GROUP.—H. B. Wahlin. (*Phys. Review*, 1st/15th April 1942, Vol. 61, No. 7/8, pp. 509–512.) A summary was dealt with in 1534 of May.

2684. CONTACT POTENTIALS: PART I—GENERAL PRINCIPLES: PART II—THE VOLTA EFFECT.—Chalmers. (*See* 2848.)

ACOUSTICS AND AUDIO-FREQUENCIES

2685. A COUPLING-FREE "BUS-BAR" CIRCUIT FOR ALTERNATING-CURRENT SOURCES IN COMMUNICATION TECHNIQUE.—John. (*See* 2629.)

2686. A HIGH-GAIN AUDIO-FREQUENCY AMPLIFIER FOR THE INVESTIGATION OF WEAK SIGNALS [primarily for Bioelectric Potentials: Amplification up to 10^7, practically Constant from below 50 c/s to 20 kc/s: Low Inherent Noise (below Thermal Noise of Nerves): Output drives Two Oscilloscopes and (through Power Amplifier) a Loudspeaker: for Inputs 10–100 μV].—E. N. Rowland & W. Burns. (*Journ. of Scient. Instr.*, June 1942, Vol. 19, No. 6, pp. 85–88.)

2687. CAN SOUND-ON-FILM SUPPLANT THE RECORD? [for Home Gramophones: Pros & Cons: Practicability of using Considerably Narrower Sound Tracks, running at Lower Speeds: Commercial Handicaps, particularly the Patent Situation: etc.].—R. H. Cricks. (*Electronic Eng:g*, April 1942, Vol. 14, No. 170, pp. 708–710 and 726.)

2688. A FIVE-HOURS CONTINUOUS-TAPE RECORDER [with Diamond Stylus and Yielding Bed (giving Scratch-Reducing Form of Groove): Amateur 16 mm Acetate Film: Sapphire

Pick-Up Needle which does Not reach Bottom of Groove (*cf.* 735 of March): for Speech (36 Feet/Minute) and Music (48 Feet/Minute)].—Fonda Corporation. (*Electronics*, Sept. 1939, Vol. 12, No. 9, p. 72.) *Cf.* 1094/5 of 1941.

2689. The Audograph, a Recording Machine of New Design [for Paper-Thin Acetate Discs suitable for Posting like Letters: Completely New Features (Record passes under Stylus rather than Stylus over Record, etc.): Constant Surface Speed].—Gray Mfg. Company. (*Electronics*, Oct. 1939, Vol. 12, No. 10, pp. 60..62.)

2690. A New Temperature-Controlled Crystal Cutting-Head.—D. W. Aldous: Brush Development Company. (*Electronic Eng:g*, Jan. 1942, Vol. 14, No. 167, p. 605.)

2691. Erratum: The Correlation between Elastic Deformation and Vertical Forces in Lateral Recording.—S. J. Begun & T. E. Lynch. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, p. 392.) *See* 1398 of May.

2692. "Schallaufzeichnung" [Sound Recording (on Discs): Book Review].—H. Güttinger. (*E.T.Z.*, 4th Dec. 1941, Vol. 62, No. 48/49, p. 968.) From the Tobis laboratories.

2693. A Simple Expander [with Negative Feedback from Output Transformer controlled by Small Lamp].—W. Bacon. (*Electronics*, Dec. 1941, Vol. 14, No. 12, pp. 50 and 54..58.)

2694. Automatic Record Changers [Survey].—(*Electronics*, Feb. 1942, Vol. 15, No. 2, pp. 24–28.)

2695. A Transcription Control Box [for Broadcasting from Dual-Turntable Equipment].—E. L. Marven. (*Electronics*, Dec. 1941, Vol. 14, No. 12, pp. 58..66.)

2696. Super-Cardioid Directional Microphone [Single-Unit Uniphase Moving-Coil Microphone: Its Design & Advantages].—B. B. Bauer. (*Electronics*, Jan. 1942, Vol. 15, No. 1, pp. 31–33 and 91..93.) *See* also 133 of January.

2697. Distortions which are produced by the Finite Transmission Width of Physical Apparatus: with Application to Periodic Analysis.—Meyer-Eppler. (*See* 2854.)

2698. Distortion of Sounds recorded on Film due to Slant of the Recording or Reproducing Slit.—J. F. Schouten. (*Alta Frequenza*, Nov. 1941, Vol. 10, No. 11, p. 701: short summary, from *Rev. tech. Philips* of April 1941.)

2699. Foundations of Stereophonic Reproduction for Sound-Films, in which the Conditions in the Recording Studio are reproduced in the Auditorium.—H. Warncke. (*E.T.Z.*, 21st May 1942, Vol. 63, No. 19/20, pp. 244–245: summary, from *Akust. Zeitschr.*, Vol. 6, 1941, p. 174 onwards.)

2700. Dynamic Auditory Localisation: I—The Binaural Intensity Disparity Limen [Experimental Investigation with View to settling the Question of the Relative Importance of Intensity-Disparity & Phase-Disparity].—A. Ford. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 367–372.) Leaving "no convincing impression that all disparity cues can be converted to intensity effects by means of the Wilson & Myers postulate."

2701. The Change of Phase caused by Impedance Deafness [in Otosclerotic Patients].—K. Lowy. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 389–392.) *See* 1717 of June.

2702. Experiments on the Pellet-Type of Artificial Drum [Definite Effect in improving Speech Understanding: Mechanism of Action: Effect of Increased Mass].—K. Lowy. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 383–388.)

2703. Relation of Audiogram Measurements to Hearing-Aid Characteristics based on Commercial Experience.—F. W. Kranz & C. E. Rudiger. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 363–366.) A summary was referred to in 1375 of May.

2704. A Method for Measuring the Percentage of Capacity for hearing Speech [based on Measurements of the Five Necessary Criteria].—E. P. Fowler. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 373–382.)

2705. Two or More Loudspeakers at the Amplifier Output.—E. de Gruyter. (*Bull. Assoc. suisse des Élec.*, 25th Feb. 1942, Vol. 33, No. 4, pp. 103–107: in German.)

Apart from the serving of several different rooms, the use of two or more loudspeakers has great advantages in improving the reproduction in a single room, either when they cover the same frequency range or when the range is extended by a combination of high-note and low-note speakers. The writer deals more fully with the first case. He considers the problems arising when (*a*) the amplifier has no matching transformer but all the loudspeakers are so provided: (*b*) the amplifier, but none of the speakers, has a matching transformer: and (*c*) the (at first sight) pretty hopeless case where no matching transformer at all is provided. This happens most frequently, even when the receiver is specified as having "provision for external loudspeaker" and the result is a reduced and distorted output.

If four loudspeakers are used this last problem can be solved by a series-parallel connection: if only three are to be employed, the fourth can be represented by a resistance and a 75% output can thus be obtained without distortion. With two loudspeakers of similar impedance and power the "Dividor" arrangement of Fig. 4, patented by the writer, is recommended. Each end of the output-transformer winding Z_b is connected to one terminal of a loudspeaker (impedance Z_L) and to one end of a potentiometer D whose slider goes to earth and to the other two terminals of the loudspeakers. Calculation and tests have shown that the best compromise between matching and efficiency is that Z_L should be about equal to Z_b (presumably already fulfilled for the internal speaker) and D to $4Z_b$. Calculation (not given here) shows that for a three-quarters rotation of the potentiometer knob the loudspeaker outputs vary almost linearly from 1 : 5 to 5 : 1, and that the sum is constantly equal to two-thirds of the applied power. Fig. 5 shows the writer's "transformer-dividor", embodying an output transformer with provision for various matching arrangements: it is only 9 cm high and 7 cm in diameter and deals with 12 watts. For the expert a more complex model (circuit Fig. 6) is provided: here D is split into two logarithmic control resistances with a switch: if this is open the two loudspeakers are paralleled, each with a series resistance, while if it is closed they are in series, each with a shunt resistance. This gives wide possibilities of variation, of which good use can be made by a trained musical ear. It is stressed that the same makes and types of loudspeakers should on no account be used; otherwise, although the stereophonic effect would remain, the advantage of smoothing out individual resonance points would be entirely lost. The polarity of the speakers must be considered: if they are in the same room, the diaphragms must vibrate in phase, while if they are arranged in an opening between two rooms an opposed phasing is desirable to give a directional effect. A simple way of testing whether a connection gives in-phase or opposed-phase reproduction is described at the end of p. 106. The final section deals briefly with arrangements for combining low-note and high-note speakers (Fig. 7). The paper is partly based on Wünsch's work, 3004 of 1940.

2706. Transients in Non-Uniform Lines [including Application to Exponential Horn].—Zin. (*See* 2615.)

2707. On the Calculation of the Sound Field immediately in Front of a Circular Piston Diaphragm.—H. Stenzel. (*Ann. der Physik*, 29th April 1942, Vol. 41, No. 4, pp. 245–260.)

McLachlan (1933 Abstracts, p. 43) gave a general formula for the case when $2\pi a/\lambda \leq 2$ (a = diaphragm radius): King (1934 Abstracts, p. 622) then gave a general solution, for an arbitrary point of observation, in the form of an integral, and developed from this the solution for points in the diaphragm plane, in the form of infinite series. The present writer, with the help of more general formulae, calculated a series of examples for $2\pi a/\lambda \leq 10$ (in his book: *see* 3048 of 1940). Finally, Thoma (Karlsruhe Dissertation, 1940) investigated the connection between the formulae developed by Backhaus (1930 Abstracts, pp. 458–459), King, and the present writer. All these derivations were rather unsuitable for practical calculation for largish diaphragms, either because they converged too slowly, so that too many terms had to be worked out, or because the functions emerging for larger values of $2\pi a/\lambda$ were not available in the tables. Schoch has recently called attention to this fact, and has pointed out that in such cases it is of advantage to synthesize the field out of two components, a plane wave and a diffraction wave proceeding from the edge of the diaphragm (*Akust. Zeitschr.*, Vol. 6, 1941, p. 318 onwards).

"In the following paper it is shown that the solution given by King and that given by Schoch in the form of an integral both lead to the same series development, and that this is advantageous for a strict calculation of the sound field in the diaphragm plane even for larger values of $2\pi a/\lambda$. As an example, the cases where κa = 10, 20, 40, 60, for the region $0 \leq \kappa\rho \leq 20$ (where $\kappa = 2\pi/\lambda$ and ρ is the distance of the point of observation from the middle of the diaphragm) are calculated and represented in curves. Finally, it is shown that an expression for the one sound-pressure component, previously given by the writer (1478 of 1935) can be derived directly from King's integral".

2708. "Virtual" Masses and Moments of Inertia of Discs and Cylinders in Various Liquids.—Y. T. Yu. (*Journ. Applied Phys.*, Jan. 1942, Vol. 13, No. 1, pp. 66–69.)

2709. Note on the Bending of Thin Uniformly Loaded Plates bounded by Cardioids, Lemniscates, and Certain Other Quartic Curves.—Bibhutibhusan Sen. (*Phil. Mag.*, April 1942, Vol. 33, No. 219, pp. 294–302.)

2710. Acoustic Filtration by Membranes.—L. W. Labaw. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 353–359.) A summary was dealt with in 1413 of May.

2711. Acoustic Filtration in Parallel-Conduit Structures [Measurements on Five Quincke-Herschel Tubes in Series, and Comparison with Theory (116 of 1941): Good Agreement].—L. W. Labaw. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 345–352.) A summary was referred to in 3072 of 1941.

2712. Electronic Vibrato Control for Amplifiers.—B. Ephraim. (*Electronics*, Feb. 1941, Vol. 14, No. 2, pp. 52..56.)

2713. Power and Realism: Estimating the Watts required for a Given Sound Intensity.—G. E. Morison. (*Wireless World*, June 1942, Vol. 48, No. 6, pp. 130–132.)

2714. A Contact-less Volume Control [for Electric Organs, where Conventional Volume Controls soon become Noisy: Use of Variable Grid Bias on Variable-Mu Valve, by Transformer with Adjustable Coupling].—H. S. Polk. (*Electronics*, Sept. 1939, Vol. 12, No. 9, pp. 40..44.)

2715. Two-Channel Concert Reproduction for the Cymbalo [Stringed Instrument played with Hammers, having Limited Volume & Contrast-Range, and therefore drowned in a Large Orchestra].—E. Thienhaus. (*E.T.Z.*, 21st May 1942, Vol. 63, No. 19/20, pp. 245–246: summary, from *Akust. Zeitschr.*, Vol. 6, 1941, p. 34 onwards.)

2716. The Theory and Practice of the Excitation of Piano Strings: III.—N. I. Yakovlev [Jakovlev]. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 10, 1940, pp. 957–969.)

In the present paper the case is considered when the hammer is separated from the string after the second but before the third reflection of the impulse from the nearer end of the string. Conclusions based on this and previous papers (184 & 2292 of 1940) are enumerated.

2717. Resonance Characteristics of a Cornet, *and* Vibration of the Walls of a Cornet.—J. G. Woodward: H. P. Knauss & W. J. Yeager. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 156–159: pp. 160–162.) A summary of the second paper was referred to in 3394 of 1941.

2718. Lip Vibrations in a Cornet Mouthpiece, *and* Directivity and the Acoustic Spectra of Brass Wind Instruments: *also* Some Characteristics of the Tuning of Valved Wind Instruments.—D. W. Martin: R. W. Young. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 305–308 & pp. 309–313: p. 333.)

2719. Calculation of the Scale of Brass Instruments.—A. Belov. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 11, 1941, pp. 1035–1049.)

2720. A Music-Proof Field Pick-Up System [at Sporting Events, etc., where Certain Music is Not Available for Broadcasting].—G. Rider. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 64..68.)

2721. A Flexible Studio Control Console.—H. Klimpel. (*Electronics*, Feb. 1941, Vol. 14, No. 2, pp. 44..48.)

2722. New Principles of Construction of Studio Electroacoustical Installations [Concert Studios of A.V.R.O., Hilversum].—F. de Fremery & J. W. G. Wenke. (*Alta Frequenza*, Dec. 1941, Vol. 10, No. 12, pp. 751–752: summary, from *Rev. tech. Philips*, May 1941, Vol. 6, p. 139 onwards.)

2723. "Acoustics of Buildings" [Book Review].—F. R. Watson. (*Journ. Franklin Inst.*, March 1942, Vol. 233, No. 3, pp. 291–292.)

2724. "Practical Acoustics and Planning against Noise" [Book Review].—H. Bagenal. (*Proc. Phys. Soc.*, 1st July 1942, Vol. 54, Part 4, No. 304, p. 390.)

2725. The Measurement of Flow Resistance of Porous Acoustic Materials [Accurate Method: Danger of Serious Errors with Previous (Comparative) Methods: Variation of F.R. with Air-Velocity: Direct Correlation between Steady-State F.R. & Resistive Component of Acoustic Impedance: Applications of Method: etc.].—R. L. Brown & R. H. Bolt. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 337–344.)

2726. The Behaviour of Elastic Materials used for the Insulation of Mechanical Vibrations.—Rama. (*See* 2874.)

2727. An Analyser for Sub-Audible Frequencies.—H. H. Scott. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 360–362.) A summary was dealt with in 1587 of May.

2728. On the Theory of Phase Compensation [in Pupinised Lines: Calculation of Most Economical Combination of Compensating Elements to give a Predetermined Transit-Time Curve].—M. Wald. (*E.N.T.*, Jan./Feb. 1942, Vol. 19, No. 1/2, pp. 1–7.)

2729. National Research Council Activities: the Work of the "O.M. Corbino" Electroacoustical Institute, 1941 [including Barbier's Work on Conversion of Supersonic Images into Optical Images (with Investigation of Effect of Electric Field on Supersonic Velocities in Strongly Polar Liquids) and Barone's Results in Optical Telephony using Light Modulation by means of Supersonic Waves: etc.].—(*La Ricerca Scient.*, Feb./March 1942, Vol. 13, No. 2/3, pp. 142–147.) *See* 2867, 2871, & 2730, below.

2730. A Standard-Frequency Generating Equipment for Supersonic and Other Frequencies [giving Precision Frequencies in Steps from 50 c/s to 5000 kc/s, starting with a Thermostatically-Controlled Quartz Oscillator for 100 kc/s].—A. Barone. (On p. 144 of the paper dealt with in 2729 above.)

2731. A Comparison of Optical and Electromechanical Methods of studying Ultrasonic Fields.—W. Garten. (*Phys. Review*, 1st/15th March 1942, Vol. 61, No. 5/6, pp. 391–392: summary only.)

2732. Propagation of Supersonic Waves in Liquid Mixtures, and Intermolecular Forces: I—Alcohols in Water [Experiments & Theory].—R. Parshad. (*Indian Journ. of Phys.*, Oct. 1941, Vol. 15, Part 5, pp. 323–336.)

"Some very new and interesting results have been found. In mixtures of alcohols and water there are maxima of velocity and minima of compressibility. In other mixtures have been found minima of velocity and points of inflection".

2733. An Improved Apparatus for Supersonic Velocity and Absorption Measurements.—D. Telfair & W. H. Pielemeier. (*Review Scient. Instr.*, March 1942, Vol. 13, No. 3, pp. 122–126.) Used, for instance, in 1432 of May.

2734. Absorption Measurements of Supersonic Waves in Electrolytically Conducting Solutions [with Sound Intensities measured by Sound Pressures altering Capacitance between Light & Heavy Suspended Plates].—W. Rüfer. (*Ann. der Physik*, 29th April 1942, Vol. 41, No. 4, pp. 301–312.)

2735. Supersonic Absorption and Stokes' Viscosity Relation.—L. Tisza. (*Phys. Review*, 1st/15th April 1942, Vol. 61, No. 7/8, pp. 531–536.)

2736. Heat-Conduction Damping of Pulsating Gas Bubble in Liquid which Resonates to Supersonic Wave.—Z. Saneyosi. (*Electrotech. Journ.* [Tokyo], March 1941, Vol. 5, No. 3, pp. 49–51.)

PHOTOTELEGRAPHY AND TELEVISION

2737. Distortions which are produced by the Finite Transmission Width of Physical Apparatus: with Application to Periodic Analysis.—Meyer-Eppler. (*See* 2854.)

2738. Television Picture Storage: a New Method of Electronic Storage Excitation of Television Receiving Screens [Combination of Supersonic Light Control with Electronic Scanning, using an Image-Converter Tube and giving a System equivalent to Several Hundred Independent Beams].—A. H. Rosenthal. (*Electronic Eng:g*, Jan. 1942, Vol. 14, No. 167, pp. 578–580 and 600.) The scheme briefly dealt with in a previous paper (1439 of May).

2739. Optical Method for Increasing the Depth of Field [" IR " System using Succession of " Diffo " (Differential Focuser) Plates].—A. N. Goldsmith. (*Electronics*, Dec. 1941, Vol. 14, No. 12, pp. 44 and 46..50.) *See* also 2758 of 1941, and *cf.* 1729 of June.

2740. Magneto-Optical Properties of Ferromagnetic Suspensions [of Fe_2O_3 in Nujol: Average Particle Radius about 10μ: Theoretical Considerations: Measurements, showing that Effect is Not due entirely to Orientation of Permanent Dipoles (Heaps, Elmore, 2326 [and 3499] of 1940 and 489 of February) but also to Anistropic Polarisability of the Particles].—H. Mueller & M. H. Shamos. (*Phys. Review*, 1st/15th May 1942, Vol. 61, No. 9/10, pp. 631–634.) Agreeing with Benedikt's conclusions, 1535 of May.

2741. The Secondary Emission of Sublimated Antimony Layers [in Connection with Sb–Cs Photocathodes].—Görlich. (*See* 2679.)

MEASUREMENTS AND STANDARDS

2742. Dispersion Measurements in Liquids by Drude's Second Method on Wavelengths 8–150 cm, and Their Difficulties.—Klages. (In paper dealt with in 2599, above.)

2743. Measuring Instruments for Current and Voltage: I—Survey of the Most Useful Types [for Frequencies from 0 c/s to 300 Mc/s, with References to Papers in Same Journal]: II—Survey of Accessories and Special Equipments.—F. Moeller. (*Arch. f. Tech. Messen*, April 1942, Part 130, J 70-4, Sheets T39-40: May 1942, Part 131, J 70-5, Sheet T48.)

2744. The Measurement of Small Alternating-Current Powers [with Wattmeter: by Three-Voltmeter and Three-Ammeter Methods: by Compensation Methods: with the Vector-Meter: by Bridge Circuits: Survey].—J. Bubert. (*Arch. f. Tech. Messen*, Jan. 1941, Part 115, V 3412-1, Sheets T3-4.) A summary was referred to in 1132 of April.

2745. Thermal Power-Meters [Survey].—J. Fischer. (*Arch. f. Tech. Messen*, March 1942, Part 129, J 716-1, Sheets T27-28.)

2746. Temperature Probe and Radiation Receiver [Calculation of Stationary Temperature & Heat Relations, & Measuring Error: Differential Equations for Temperature along the Probe (Linear, for Small Amounts of Heating: Non-Linear, for Large: Approximate Integration of Latter Equation, giving Temperature at Free End].—J. Fischer. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 22, 1941, pp. 316–323.)

2747. A Thermo-Electronic Indicator of Radiant Energy: Preliminary Communication.—L. Goncharski. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 10, 1940, pp. 1303–1304.)

The indicator consists of a vacuum glass envelope 4 (Fig. 1) in which two electrodes are mounted: a thin metallic film (cathode) 1, for example a film of silver deposited on a thin layer of mica, and an anode 2 made of a nickel wire. The side of the cathode facing the anode is covered with material having a low work function (*i.e.* it is sensitised). The indicator is kept in a thermostatically controlled oven 3, at a temperature at which a definite electron current flows from the cathode to the anode. The radiant energy to be measured is projected on the cathode and as a result of the rise in the cathode temperature the current increases.

2748. Compensation Circuits for Thermo-elements, for the Elimination of Cold-Junction Effects, *and* The Compensation-Temperature Regulator.—Siemens & Halske. (*Arch. f. Tech. Messen*, Jan. 1941, Part 115, J 2402-1, Sheet F1: Feb. 1941, Part 116, J 063-4, Sheet F2.)

2749. Meters for Use over a Wide Frequency Range [Frequency-Compensation for A.C. Instruments].—C. H. Sturm. (*Electronics*, Oct. 1939, Vol. 12, No. 10, pp. 56, 57.) Summary of German paper dealt with in 4091 of 1939: " practical and comprehensive ".

2750. Phase-Adjusting Circuits for Measuring Purposes: I [Survey]: II—90° Circuits: Effect of Loading, Frequency Compensation.—H. Poleck. (*Arch. f. Tech. Messen*, March 1942, Part 129, Z 61-3, Sheets T29-30: May 1942, Part 131, Z 61-4, Sheets T49-50.) *See* also 2779 of 1941.

2751. A Circuit-Continuity Test for the Cross-bar System [Open & Closed Circuits distinguished (where Current-Flow Criterion is Unreliable because of Wide Variations in Resistance & Leakage) by Phase-Difference Method].—A. F. Burns. (*Bell Lab. Record*, May 1942, Vol. 20, No. 9, pp. 229–235.)

2752. Calibrated Negative Resistances and Their Use in measuring Equivalent Resistances of Oscillatory Circuits.—Pinciroli. (*See* 2636.)

2753. Characteristics of Glow-Discharge Tubes for Measuring Purposes.—Glaser. (*See* 2803.)

2754. A New Principle for Stable Direct-Current Amplification [for Measuring Purposes & Process Control].—Eberhardt & others. (*See* 2633.)

2755. An Ultra-Sensitive Bridge [Valve Bridge, primarily for Measurement of Vacuum by Positive-Ion Collection at Anode of Valve].—J. E. Jennings. (*Electronics*, Sept. 1939, Vol. 12, No. 9, pp. 38, 40.)

2756. Electronic Attenuator [primarily for Receiver Measurements: Automatic Adjustment as Circuits are brought near Resonance].—F. A. Schaner. (*Electronics*, April 1941, Vol. 14, No. 4, p. 68.)

2757. Apparatus for the Production Measurement of the Temperature Coefficients of Condensers [particularly H.F. Ceramic Types: 5–3000 pF, Coefficients $5–800 \times 10^{-6}$].—F. Lieblang. (*Arch. f. Tech. Messen*, Feb. 1941, Part 116, Z 136-4, Sheets T26-27.)

For production testing, eighteen test circuits are arranged around a circular table, with the c.r. oscillograph equipment rotatable at the centre. The final test temperature is reached in about 15 minutes, so that each circuit can deal with about 4 condensers an hour, giving about 70 per hour for the whole equipment, with only one operator. Values are accurate within $\pm$ 1.5%, allowing for the readings being taken before the Lissajous' figures have come quite to rest. The paper ends with a description of a single equipment for laboratory use (Fig. 5): this employs the same electrical method but has a much wider range and higher accuracy (within $\pm$ 0.1%).

2758. Measurements with a "Vibrating Voltmeter" [for High & Very High Voltages].—W. Gohlke & U. Neubert. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 23, 1942, pp. 70–76.)

From the Motor Research Institute of the Hermann Göring Aircraft Research Establishment: further development of the instrument dealt with in 1457 of 1941. In addition to the advantages there mentioned, the device is specially suitable for remote indication, since the amplifier valve can be mounted directly on the voltmeter and the indicating apparatus can be at practically any desired distance.

2759. High-Voltage Testing at Low Power [High Voltage & High Current provided by Two Separate Generators acting in Succession].—Westinghouse Company. (*Electronics*, Oct. 1939, Vol. 12, No. 10, pp. 42, 44.)

2760. Unit comprising R.M.S. and Valve Average Voltmeters [primarily to measure Max. Instantaneous Flux Density and Form Factor, in Investigation of Watts-Loss in Transformer Core or Core Material].—Met.-Vickers Elec. Co. (*Journ. of Scient. Instr.*, June 1942, Vol. 19, No. 6, p. 95.)

2761. The Production of Magnetic Fields, Constant in Space and Time, for Measuring Purposes: Parts III & IV [Survey].—Neumann. (*See* 2823.)

2762. The Measurement of Iron-Cored Choke Inductance: "In-Action" Bridge Method [simulating Conditions of Actual Use] eliminates Questionable Results in Development and Design.—E. H. Meier & D. L. Waidelich. (*Communications*, Nov. 1941, Vol. 21, No. 11, pp. 5–7 and 29.)

2763. Measurement of a Mutual Inductance and Resistance by a Ballistic Method.—E. Tyler: N. F. Astbury & L. H. Ford. (*Phil. Mag.*, June 1942, Vol. 33, No. 221, pp. 431–450.)

Astbury & Ford's method (2010 of 1938, where the second author's name was accidentally omitted) was designed to give C in terms of M. "M may, however, be obtained independently of C if we resort to a multiple condenser charge–discharge method for supplying the steady primary current to the mutual inductance, and calibrate the galvanometer for charge sensitivity with the same capacitance". Further, a method is given for measuring an unknown resistance, based on the theoretical result given in an appendix to the paper cited. Various types of vibrator, to provide the several precisely known frequencies employed (from 22.31 to 241.3 c/s) are described and illustrated.

2764. A Note on Building Up Laboratory Sub-Standards.—T. H. Turney. (*Electronic Eng:g*, Feb. 1942, Vol. 14, No. 168, pp. 644–645.)

2765. Quartz Clocks: IV—Results over Prolonged Runs [Survey].—A. Scheibe. (*Arch. f. Tech. Messen*, Feb. 1942, Part 128, J 153-4, Sheets T19-20.)

2766. A.C. Resonant Pendulum without Iron.—D. K. Weimer & H. P. Knauss. (*Phys. Review*, 1st/15th April 1942, Vol. 61, No. 7/8, p. 544: summary only.)

2767. A Precision Seconds-Counter [primarily for Meter-Checking: Scale Division represents 0.01 s: Error never above 0.004 s: driven by 50 c/s Supply from Frequency Standard].—G. Torzo. (*Alta Frequenza*, Dec. 1941, Vol. 10, No. 12, pp. 763–767.)

2768. THE MEASUREMENT OF SHORT INTERVALS OF TIME [of the Order of a Millisecond: Long Survey].—N. La Barbera. (*Alta Frequenza*, March/April 1942, Vol. 11, No. 3/4, pp. 116–156.)

Oscilloscopic and oscillographic methods (including the writer's very simple method using one pair of deflecting plates only—no time base): other electro-optical methods (including Crehore's "polarisation photochronograph"): electro-mechanical devices (spark chronographs, etc.): ballistic-galvanometer methods (including Turner's kallirotron applied to projectile-velocity measurements, and Bradford's chronoscope): null methods (bridge and opposition): time-spread methods: automatic methods: direct-reading methods (*see* for example 1589 of May) and the writer's direct-reading apparatus for measuring relay closing-times by a condenser-charging method using an electrostatic voltmeter. *Cf.* 2903, below.

2769. A SIMPLE RESISTANCE–CAPACITANCE OSCILLATOR [Single Triode (Low-Impedance) with Four-Stage *R–C* Network between Grid & Anode: can be plugged-in in place of First Valve in Existing Amplifier, to give Tone Generator].—W. Bacon. (*Electronic Eng:g*, April 1942, Vol. 14, No. 170, p. 707.)

2770. PRINTING METHOD, USING SMALL HAND-OPERATED PRESS AND PANTOGRAPH DEVICE, FOR ACCURATELY CALIBRATED SCALES OF WIDE-BAND OSCILLATOR.—(*Bell Lab. Record*, May 1942, Vol. 20, No. 9, pp. 227–228.)

SUBSIDIARY APPARATUS AND MATERIALS

2771. PROBE MEASUREMENTS IN RAREFIED AIR IONISED BY A BEAM OF ELECTRONS.—Székely & Zauner. (*Ann. der Physik*, 9th April 1942, Vol. 41, No. 3, pp. 225–232.)

For the purposes of investigating the h.f. conductivity of ionised air an apparatus was available which had been employed by other workers (reference "1") for measuring the ionising power of electron beams of various velocities: it consisted of an earthed brass chamber into which the beam was introduced through a narrow capillary tube in the wall. Since, for the interpretation of the h.f. measurements, it was desirable to know as much as possible about the nature of the ionisation produced by the beam, preliminary probe measurements were made, "the results of which were so interesting, apart from the question of the h.f. investigations, that they appear to deserve a separate paper."

Authors' summary:—"The state of ionisation produced in rarefied air (0.01 to 0.10 mm Hg) by an electron beam [10^{-7}–10^{-6} ampere, 150–1000 electron-volts, more or less homogeneous according to the accuracy of centering, etc.] appears to be very similar to the so-called plasma state observed in highly ionised metallic vapours and inert gases (carrier densities greater than $10^{10}/cm^3$). It is therefore deduced that the probe characteristics in weakly ionised air (carrier densities about $10^5/cm^3$) show the same course as in the much more strongly ionised plasmas. The carrying out of probe measurements also in the case of a weak ionisation of a gas by an electron beam seems therefore capable of investigating accurately the state of ionisation and its variation with special conditions of the beam and of other experimental factors.

"Of special interest appears the fact, established by the probe measurements, that a Maxwellian velocity distribution of the plasma electrons occurs not only when the plasma is built up of the secondary electrons produced in the gas (electron temperature 20 000° K: Frey, 286 of 1938), but also when the slow secondary electrons caused by the ionisation of the gas atoms are mixed with the faster electrons produced by the impact of the primary electrons on the solid walls: there is then a much higher temperature for the plasma electrons—40 000 to 150 000° K, according to the nature of the point of impact."

2772. ON THE SPACE-CHARGE EFFECT ON A RAY OF CHARGED PARTICLES FROM AN APERTURE OF RECTANGULAR CROSS SECTION.—Houtermans & Riewe. (*Arch. f. Elektrot.*, 15th Dec. 1941, Vol. 35, No. 11, pp. 686–691.)

From the von Ardenne laboratories. The problem of the space-charge action on an electron or ion beam limited by a circular aperture was dealt with by Watson and others (reference "1"), taking into consideration the relativity effect which causes an electrodynamic attraction of the current threads. and opposes the electrostatic repulsive action, "For many electron- and ion-optical problems particularly in the discussion of the relations in mass-spectrographs of high intensity, the case where the beam is limited by a rectangular aperture, and especially a long slit, is of a certain importance."

Authors' summary:—"For a rectangular electron beam the repulsive forces acting in the middle of the sides near the stop are first calculated, and thus the transverse accelerations of an outer particle at the middle of the side, on the assumption that the beam length is large compared with the dimensions of the stop. It is found that for a long slit ($\alpha = a/h \ll 1$) the beam undergoes no spreading in its 'height' [*i.e.* in its longer dimension], while the spreading in the cross direction can be dealt with as single-dimensional problem [eqn. 20]. This transverse spreading is calculated exactly: for an arbitrary initial aperture angle ϕ [eqn. 28] a parabola is obtained [Fig. 3]. The rectangular slit is dealt with approximately for not too small values of α: an estimate of the spreading at the middle of the sides and at the corners is given, and it is shown that equal relative spreadings are obtained at such distances from the stop as are proportional to $\sqrt{\alpha}$". A footnote refers to Thompson & Headrick's treatment of a long slit (136 of 1941) in connection with television kinescopes, where the same conclusions are reached.

2773. ERRORS IN PHOTOGRAPHY OF CATHODE-RAY-TUBE TRACES: THE EFFECTS OF SCREEN CURVATURE.—Moss & Cattanes. (*Electronic Eng:g*, April 1942, Vol. 14, No. 170, pp. 720–721.) From the Cossor laboratories.

2774. ELECTROSTATIC ELECTRON LENSES WITH A MINIMUM OF SPHERICAL ABERRATION [Axial Potential chosen to give Minimum Aberration, and Corresponding Lens designed by Calculation of Position of Equipotential Surfaces in Space: Possibility of Further Reduction by Use of Axial Potential composed of Series of Peaks of Varying Amplitude: etc.].—Plass. (*Journ. Applied Phys.*, Jan. 1942, Vol. 13, No. 1, pp. 49–55.)

2775. EXPERIMENTAL INVESTIGATIONS ON THE APERTURE ERROR OF ELECTROSTATIC LENSES [and Comparison with Aberration Theory].—Gobrecht. (*Arch. f. Elektrot.*, 15th Dec. 1941, Vol. 35, No. 11, pp. 672–685.)

Among other results, "lenses of short length have high spherical aberration. This decreases rapidly at first, then more slowly, with increasing length of lens. The spherical aberration, however, does not depend only on the total length of the lens, but also on the lengths of the individual electrodes. There is a minimum value of spherical aberration when the length of the outer electrodes amounts to about 30% of the whole length."

2776. CORRECTION TO "REMARKS ON THE CONSTRUCTION OF MODERN CATHODE-RAY OSCILLOGRAPHS".—Pieplow. (*Arch. f. Elektrot.*, 15th Dec. 1941, Vol. 35, No. 11, p. 694.) *See* 502 of February.

2777. CATHODE-RAY POLAR-DIAGRAM INDICATOR [for Automatic Recording of Nyquist Diagrams of Filters, Artificial Lines, etc.].—I.T. & T. Laboratories, Paris. (*Electronics*, Oct. 1939, Vol. 12, No. 10, pp. 46, 47.)

2778. RESOLVING POWER AS A FUNCTION OF INTENSITY [and the Merling-Eisenberg Results on Virus Details resolved on Reduction of Intensity: the Rayleigh Criterion & Its Modification].—Ramsay & others. (*Journ. Opt. Soc. Am.*, May 1942, Vol. 32, No. 5, pp. 288–292.) For previous work *see* 1969 of 1941.

2779. LUMINESCENT SCREENS: BRITISH PATENTS [Nos. 501 490. .504 354].—(*Electronics*, Sept. 1939, Vol. 12, No. 9, pp. 84. .89.)

2780. CHEMILUMINESCENCE OF ADSORBED DYE-STUFFS.—Kautsky & Müller. (*Naturwiss.*, 15th May 1942, Vol. 30, No. 20/21, p. 315.) Further development of 1746 of 1941.

2781. THE H.T. VOLTAGE-DIVIDER FOR CATHODE-RAY OSCILLOGRAPHS [Experimental Investigation to test Various Theoretical Conclusions].—Höhl. (*Arch. f. Elektrot.*, 15th Dec. 1941, Vol. 35, No. 11, pp. 663–671.)

These direct comparative tests show that while the mixed ohmic-capacitive divider is actually the best, since it is suitable for the slowest as well as the quickest processes, its form is complicated and the correct adjustment of the two components is difficult. On the other hand, except in the most extreme cases the simple ohmic divider will give perfectly correct results: surge fronts with a steepness of 10^{-8} s have been recorded true to form. Thus for the standard "VDE" surge of 0.5×10^{-6} it is better to use the ohmic divider, since the half-value period of 50×10^{-6} begins to be a slow process for a capacitive divider and may introduce errors.

2782. A HIGH-VOLTAGE OHMIC DIVIDER WITH TRIPLE SCREENING.—Balygin. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 10, 1940, pp. 1027–1037.)

Cathode-ray oscillographs used with impulse generators for observing wave-form normally require voltages of the order of 1–3 kv. It is therefore necessary to divide the high voltage generated, and the writer deals with the design and practical applications of a divider consisting of three cylindrical concentric spools (Fig. 1) on which resistance wire is wound. Of these spools the inner serves as the divider proper and the other two as screens.

2783. AN IMPROVED HARD-VALVE TIME BASE [Reid's Modification of Original "Squegger" Circuit (2451 of 1938) further altered, giving Sweep Voltage up to or over Half the Anode Voltage, Speeds up to 2–3 Mc/s, Practically Invisible Fly-Back, etc.].—Saunders. (*Electronic Eng:g*, Jan. 1942, Vol. 14, No. 167, p. 598.)

2784. THE THYRATRON TIME-BASE CIRCUIT: AN INVESTIGATION INTO THE CHARACTERISTICS OF A GAS-DISCHARGE TRIODE USED AS A TIME-BASE DISCHARGE VALVE.—Puckle. (*Electronic Eng:g*, March 1942, Vol. 14, No. 169, pp. 664–666.) Based on an appendix to the paper referred to in 1145 of April.

2785. SINGLE TIME-PROPORTIONAL DEFLECTION IN OSCILLOGRAPHIC PROCESSES [New Time-Base Circuit giving less than 1% Departure from Linearity].—Höhl. (*Arch. f. Elektrot.*, 17th Nov. 1941, Vol. 35, No. 10, pp. 591–592.)

"The starting point is the well-known use of the middle straight portion of a sinusoidal oscillation for the recording of periodic processes. For the recording of non-recurrent processes only the straight part of the first half-oscillation is used. The fly-back of the ray must be eliminated by special means (Rogowski). Now if the time-base condenser is discharged not simply through an ohmic resistance but also through an inductance, an oscillatory circuit is obtained. The condenser voltage follows the law $u_c = U \cdot e^{-t/2T} \cos \omega t$. The transient voltage is thus a harmonic oscillation whose value decreases exponentially.

"Since, however, only the straight portion of the discharge curve, from 1 to 2 (Fig. 2), which alters as linearly as possible with time, is to be employed, the parts of the discharge curve coming after the first half-oscillation must be prevented from influencing the time base. Since the ray-locking action does not work quickly enough to prevent this, other precautions must be taken. The solution is to damp the oscillation so much that the voltage after a half-oscillation is so small that it has no effect, or only a very slight effect, on the time base." The circuit (built up symmetrically to give a finer trace) is shown in Fig. 3. Each main lead, after branching off first to one electrode of the spark gap and then to one plate of the ray-locking system, contains half the inductance followed by half the ohmic resistance and then branches off to one side of the condenser and to one plate of the deflecting system.

Fig. 4 shows a record of a 10^7 c/s wave. The departure from linearity is much smaller than that given by an exponential discharge, because the second term of the Taylor's series drops out and the third term exerts a vanishingly small influence on the first; whereas with the exponential discharge the second term remains to influence the first. The linearity is the better, the higher the time-base voltage, since then the used part of the discharge curve more nearly approaches the ideal. Deflection velocity is given by the frequency of the transient voltage, which can be varied by adjusting the condenser and the damping resistance, keeping the inductance unchanged. "A serviceable time-base, free from the need for special calibration, is thus provided for quantitative investigations".

2786. Inverted Valve Voltmeter with Negligible Input Current, for driving Electro-Magnetic Oscillograph in Dielectric-Loss Measurements where No Charge must be taken from Condenser.—Whitehead & Eager. (In paper dealt with in 2814, below.)

2787. A Well-Tested Photographic Recorder [for Counter-Tube Impulses, etc.].—Kolhörster & Lange. (*Physik. Zeitschr.*, 20th April 1942, Vol. 43, No. 7/8, pp. 123–125.)

The printing recorder dealt with in 859 of March, using Morse tape, has many advantages such as cheapness of the record material; but where a large number of records have to be made simultaneously (in the Dahlem Institute, for instance, up to 20) the corresponding multiplication of printing recorders raised difficulties as regards accommodation. The writers have therefore developed a photographic recorder in which the various counter-mechanisms are photographed at the desired intervals of time on a common film. This apparatus is described in full and illustrated by photographs.

2788. Materials and Devices of Falling Resistance/Temperature Characteristic [Survey: Electronic Semiconductors, Ionic Conductors (Ag_2S, U_3O_8), Tellurium, Silicon, Boron Patents: Commercial Resistors (Urdox, Thermistors, etc.): Applications (including to Radio Purposes as Continuously Variable Resistances, etc.)].—Sillars. (*Journ. of Scient. Instr.*, June 1942, Vol. 19, No. 6, pp. 81–84.)

2789. Thermal-Delay Relays in Tube Circuits.—Bacon. (*See* 2676.)

2790. The Sunvic Hot-Wire Vacuum Switch [and Its Applications, including Its Special Suitability for Thyratron Circuits].—Woolnough. (*Electronic Eng:g*, Feb. 1942, Vol. 14, No. 168, pp. 625–627.)

2791. Relay using Current only when Operating.—Automatic Electric. (*Scient. American*, April 1942, Vol. 166, No. 4, p. 204.)

2792. A Heavy-Duty Contact Material [Elkonite D56, a Silver-Nickel Combination produced by Methods of Powder Metallurgy: Advantages, including Greater Resistance to Sticking or Welding].—(*Journ. of Scient. Instr.*, June 1942, Vol. 19, No. 6, pp. 94–95.)

2793. Ballast Tubes [Iron-Wire Barretters] as Automatic Voltage Regulators [in Many Applications].—Taylor. (*Electronics*, Jan. 1942, Vol. 15, No. 1, pp. 26–30.)

2794. An Electronic Over-Voltage Relay [using the Type 885 Grid-Controlled Rectifier].—Kretschmar. (*Electronics*, Feb. 1941, Vol. 14, No. 2, pp. 48..52.)

2795. A Voltage Stabiliser for a D.C. Generator [supplying Magnetic Field for Cyclotron: Power Valve as Variable Shunt Resistance across Generator Field Coils: Control within 1 in 2000].—Schwarz. (*Review Scient. Instr.*, May 1942, Vol. 13, No. 5, pp. 213–214.)

2796. The Rheotron, a New Electronic Tool.—Kerst. (*Electronics*, Feb. 1942, Vol. 15, No. 2, pp. 22–23.) *See* also 1778 of June.

2797. Canal-Ray Positive-Ion Sources [Detailed Study of Output from Cathode-Glow Discharge Tubes with Canal drilled through Cathode: Positive-Ion Yields up to 2 mA: Effects of Focusing Diaphragm in the Source: etc.].—Craggs. (*Proc. Phys. Soc.*, 1st May 1942, Vol. 54, Part 3, No. 303, pp. 245–265.)

2798. Developments in Ion Accelerating Tubes, *and* An Apparatus for the Direct Determination of Slow Neutron Velocity Distributions.—Manley, Haworth, & Luebke. (*Review Scient. Instr.*, Dec. 1941, Vol. 12, No. 12, pp. 587–590: pp. 591–597.)

2799. A Scheme of High-Voltage Electrostatic Generator with an Earthed Metallic Axis.—Joffé & Hochberg. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 11, 1941, pp. 617–618.)

2800. Mercury Diffusion Pumps [Specification of Two New Models].—(*Journ. of Scient. Instr.*, March 1942, Vol. 19, No. 3, p. 46.)

2801. An Ultra-Sensitive Bridge [for Measurement of Vacuum].—Jennings. (*See* 2755.)

2802. Photoelectric Effects on Neon Tubes [Need for Elimination of Effect in Some Uses of Neon Tubes].—Baker. (*See* 2901.)

2803. Characteristics of Glow-Discharge Tubes for Measuring Purposes [with Data for Various Fillings & Cathode Materials: Survey].—Glaser. (*Arch. f. Tech. Messen*, Feb. 1941, Part 116, J 832-2, Sheets T24-25.) Supplement to J 832-1, where the significance of such data was discussed.

2804. Gaseous Tubes, and How to Treat Them.—Watrous & Marshall. (*See* 2677.)

2805. Cathode Design [Illustrated Survey].—Pike. (*Communications*, Oct. 1941, Vol. 21, No. 10, pp. 5–8 and 28.) From the Vacuum Tube Eng. Dept., General Electric Company.

2806. THE MERCURY ARC CATHODE [Conduction Electrons selectively heated to about 4000° K by Electron Bombardment: Thermionic Emission: Observations of Velocity of Spot pushed along Circular Track by Magnetic Field: Rôle of Righi-Leduc Effect: Arc Extinction by 10^{-7} sec. Pulses: Estimated Thermal Gradient: etc.].—Smith. (*Phys. Review*, 1st/15th April 1942, Vol. 61, No. 7/8, p. 545: summary only.) From the Raytheon laboratories.

2807. THE POSSIBILITY OF CONTROL OF A MERCURY-VAPOUR DISCHARGE BY INTERACTION BETWEEN GRID AND ANODE.—Manz. (*See* 2678.)

2808. ELECTROSTATIC ARC-EXTINCTION ON THE "STARVATION" PRINCIPLE: CORRESPONDENCE.—Wehner: Meinhardt. (*Arch. f. Elektrot.*, 15th Dec. 1941, Vol. 35, No. 11, pp. 692–694.) Criticism of Meinhardt's paper (2819 of 1941), and reply.

2809. A NEW APPROACH TO THE STUDY OF ARC-BACK [Necessity for Tests under Transient, Not Static, Conditions of Inverse Current: Results pointing to Insulating Patches (formed by Ion Bombardment) on Anode Surface as Principal Cause: Implications: Equation for Arc-Back Probability: etc.].—White. (*Journ. Applied Phys.*, April 1942, Vol. 13, No. 4, pp. 265–273.)

2810. ON THE BACK-FIRING IN MERCURY RECTIFIERS.—Petukhov. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 11, 1941, pp. 235–241.)

2811. "MERCURY-ARC CURRENT CONVERTERS: SECOND EDITION" [Book Review].—Rissik. (*Engineering*, 5th June 1942, Vol. 153, p. 443.)

2812. ON THE VALIDITY OF PEEK'S CORONA-LOSS LAW [Failure in the Practically Important Lower Region of the Characteristic Curve: Explanation].—Prinz. (*Arch. f. Elektrot.*, 31st Dec. 1941, Vol. 35, No. 12, pp. 705–714.) For the writer's new loss law *see* 2822 of 1941.

2813. POTENTIAL DISTRIBUTION AND BREAKDOWN IN CABLES AND BUSHES UNDER DIRECT-CURRENT POTENTIALS [Analysis, with Conclusions as to Polarity Effect, Time Effect, etc: based on the Writer's "Gleitionen" (Readily Mobile Cation) Theory of Insulating Materials].—Böning. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 22, 1941, pp. 312–315.) *See*, for example, 2540 of 1941 and back reference.

2814. D.C.–A.C. CORRELATION IN DIELECTRICS [Experimental Checking of Böning's Proposed Method of computing A.C. Dielectric Loss from D.C. Data (Return-Voltage Curves): Complete Failure for Impregnated-Paper Condensers, owing to Space Charges].—Whitehead & Eager. (*Journ. Applied Phys.*, Jan. 1942, Vol. 13, No. 1, pp. 43–49.) *See* 4556 of 1938: *also* 2786, above.

2815. CAUSE AND NATURE OF SURFACE-LEAKAGE CURRENTS [occurring occasionally in Low-Voltage Apparatus even in Clean, Dry Condition].—Vieweg & Klingelhöffer. (*E.T.Z.*, 21st May 1942, Vol. 63, No. 19/20, pp. 237–241.)

After a discussion of the nuisance caused by this phenomenon and the difficulty in dealing with it owing to imperfect knowledge of its cause, the writers review previous work by themselves and other workers. They then describe experiments with knife-edge electrodes between which the surface of the insulating material under investigation is moistened with a salt solution. In this way they find it easy to distinguish between "leakage-proof" and "leakage-subject" materials. Under the action of electrostatic forces the drop divides into two parts separated by a fine, almost dry channel cutting right across the path between the knife edges. If the first spark across this channel heats the surface below it enough to make it conduct, a surface-leakage current is started at that point: from both ends of the bridge thus formed, more sparks follow, growing stronger and stronger, and in a few tenths of a second a leakage path is made from one electrode to the other. On the other hand, if the material is "leakage-proof" the first spark across the channel will improve the insulation at that point of the channel and the next spark will occur at another point. Thus a row of little sparks, at right angles to the electrode/electrode direction, indicates a "leakage-proof" material.

The difference in behaviour is no doubt partly due to the fact that a given spark will heat up different materials to a different extent, the temperature rise being lowest for materials of high specific heat and high thermal conductivity. But since the variations of these properties are by no means large, they cannot play a predominant part. Much more important are the differences in the resistance/temperature characteristics of the products of combustion. With organic materials the resistance of the ash falls steeply with increasing temperature (Fig. 7) so that at 700–800° C the leakage-path conducts well; whereas the curve for ceramic materials, or organic materials with inorganic fillings (*e.g.* curve "X"), has only a gentle slope. The matter is complicated, however, by the fact that some organic materials, such as the urea-product resin of curve "K", have steep slopes but are nevertheless "leakage-proof": microscopic investigation shows that the leakage-path is not maintained because the ash formed by sparking, although conductive, is of such small volume that the path gets interrupted. Aniline resins are on the border line, since their ash particles are of a crumbling nature rather than of the fibrous type of the curve "S" material (*see* also the ash-volume diagram, Fig. 10): these resins therefore have a certain amount of "leakage-proofness". Finally it is pointed out that other factors influence the behaviour of a material, such as points of inflection in the resistance curves, softening points as in polyamides, explosive combustion of the decomposition gases, etc. In the present condition of materials technique, the constructor must make use of skilful shaping and design to eliminate surface-leakage.

2816. CERAMIC INSULATING MATERIALS OF POWER AND COMMUNICATION ENGINEERING [Survey].—Weicker. (*E.T.Z.*, 7th May 1942, Vol. 63, No. 17/18, pp. 207–210.)

Including a table of data (DIN grouping: tan δ at 800 c/s and 1 Mc/s: dielectric constant: temperature coefficient of capacitance: thermal expansion) of a number of recent materials, including Tempa T. Ergan, a porous material specially for valve construction, is mentioned. The DIN table (2533 of 1941) is specially referred to, and the importance of precision coils with sintered metallic deposits as windings is stressed: a spherical ceramic variometer on these lines is seen in Fig. 4.

2817. PLASTICS IN THE RADIO INDUSTRY: CONCLUSION—THE ELECTRICAL PROPERTIES OF PLASTICS.—Couzens & Wearmouth. (*Electronic Eng:g*, March 1942, Vol. 14, No. 169, pp. 667–671.) For previous parts *see* 1506 of May.

2818. MICA PRODUCTION [and the Threat to India].—(*Science*, 8th May 1942, Vol. 95, Supp. pp. 10, 12.)

2819. BEHAVIOUR OF SULPHUR IN RUBBER [Fundamental Studies of Rates of Diffusion, etc.].—Winspear. (*Bell Lab. Record*, April 1942, Vol. 20, No. 8, pp. 190–194.) To serve as a basis for improved compounding practices and specifications.

2820. BRITTLE TEMPERATURE OF RUBBER [Natural & Synthetic].—Selker. (*Bell Lab. Record*, March 1942, Vol. 20, No. 7, pp. 175–177.)

2821. THE DISPERSION OF ULTRA-SHORT WAVES IN POLAR LIQUIDS WITH MORE THAN ONE RELAXATION TIME.—Klages. (*See* 2599.)

2822. APPARATUS FOR THE PRODUCTION MEASUREMENT OF THE TEMPERATURE COEFFICIENTS OF CONDENSERS [and a More Accurate Model for the Laboratory].—Lieblang. (*See* 2757.)

2823. THE PRODUCTION OF MAGNETIC FIELDS, CONSTANT IN SPACE AND TIME, FOR MEASURING PURPOSES: PARTS III & IV [Survey].—Neumann. (*Arch. f. Tech. Messen*, Jan. & Feb. 1941, Parts 115 & 116, Z 60-3 & 60-4, Sheets T14-15 & T28-29: with 167 literature references.) For Parts I & II *see* 1940 issues.

2824. MAGNETO-OPTICAL PROPERTIES OF FERROMAGNETIC SUSPENSIONS [of Fe_2O_3 in Nujol].—Mueller & Shamos. (*See* 2740.)

2825. MEASUREMENT OF THE INITIAL INNER PERMEABILITY OF IRON OVER A WIDE RADIO-FREQUENCY RANGE [30 kc/s to 40 Mc/s: Disparity of Existing Results: Accurate Measurements, on Single Strand of Wire, by Change of Resonant Frequency of Coil on Introduction of Wire: Value approx. 60, No Dispersion Region].—Woods. (*Journ. Applied Phys.*, May 1942, Vol. 13, No. 5, pp. 314–319.)

2826. RADIO USES OF POWDERED-IRON CORES [Survey of Recent Developments & Future Extensions].—(*Electronics*, Feb. 1942, Vol. 15, No. 2, pp. 35–37 and 93..95.)

2827. THE MEASUREMENT OF IRON-CORED CHOKE INDUCTANCE.—Meier & Waidelich. (*See* 2762.)

2828. ALNICO: PROPERTIES, AND EQUIPMENT FOR MAGNETISATION AND TEST.—Smith. (*Gen. Elec. Review*, April 1942, Vol. 45, No. 4, pp. 210–213.)

2829. MAGNETISATION NEAR BOUNDARIES [Measurements on Silicon Iron, Pure Nickel, & Low Carbon Steel, to investigate Connection between Condition of Surface & Magnetic Properties: "Stray Flux" Hypothesis confirmed (Effect Smaller than supposed): Contradiction to Wall's Hypothesis (868 of March): etc.].—Wakelin. (*Journ. Applied Phys.*, April 1942, Vol. 13, No. 4, pp. 227–235.)

2830. "RESEARCHES ON THE STRUCTURE OF ALLOYS" [Book Review].—Hume-Rothery. (*Journ. of Scient. Instr.*, March 1942, Vol. 19, No. 3, p. 47.)

2831. "DIE FABRIKATION VON TROCKENBATTERIEN UND BLEIAKKUMULATOREN" [Dry Batteries & Lead Accumulators: Book Review].—Drotschmann & Moll. (*Zeitschr. V.D.I.*, 16th May 1942, Vol. 86, No. 19/20, p. 319.)

2832. WIND-POWER INSTALLATIONS IN THE SOVIET UNION AND IN THE UNITED STATES OF AMERICA.—Stein. (*E.T.Z.*, 7th May 1942, Vol. 63, No. 17/18, p. 220: summary only.)

2833. PAPERS ON SKIN EFFECT.—Whinnery: Lettowsky. (*See* 2619 & 2620.)

2834. DATA SHEETS XXVI AND XXVII: SKIN EFFECT.—(*Electronic Eng:g*, April 1942, Vol. 14, No. 170, pp. 715–717.)

2835. ANALYSING INSULATED-WIRE REQUIREMENTS.—Zender. (*Communications*, Oct. 1941, Vol. 21, No. 10, p. 16.)

2836. NEW TOOLS FOR IDENTIFYING WIRES IN CABLE JOINTS [the "Swiffer" & the "Capacitance Probe"].—Sephton & Jackman. (*P.O. Elec. Eng. Journ.*, Jan. 1942, Vol. 34, Part 4, pp. 169–172.)

2837. THE RESONANCE MOTOR, A SPEED-REGULATED POLYPHASE INDUCTION MOTOR WITH SHUNT-WOUND BEHAVIOUR [*i.e.* Slight Variations of Slip for Large Changes in Load].—Jaeschke. (*Arch. f. Elektrot.*, 31st Dec. 1941, Vol. 35, No. 12, pp. 695–704.)

2838. HYSTERESIS FORCES AND THE HYSTERESIS MOTOR.—Jaeschke. (*Zeitschr. V.D.I.*, 4th April 1942, Vol. 86, No. 13/14, pp. 219–220: summary only.) *See* also 1543 of May.

2839. CONTACT IMPROVER [Special Burnisher for Commutators].—Ohio Carbon. (*Review Scient. Instr.*, March 1942, Vol. 13, No. 3, p. 134.)

2840. POROUS IRON BEARINGS [replacing Porous Bronze].—Keystone Carbon. (*Gen. Elec. Review*, April 1942, Vol. 45, No. 4, p. 249.) Addition to the "Selflube" series.

2841. SUBSTITUTE SOLDERS [for Economy in Tin].—Rhines & Anderson. (*Engineer*, 19th June 1942, Vol. 173, p. 524: summary only.)

2842. "TIN SOLDERS: A MODERN STUDY OF THE PROPERTIES OF TIN SOLDERS AND SOLDERED JOINTS" [Book Review].—Nightingale. (*Nature*, 4th July 1942, Vol. 150, p. 8.)

STATIONS, DESIGN AND OPERATION

2843. A 112-MC. TRANSMITTER-RECEIVER COMBINATION [readily Adaptable to Civilian Defence Needs].—Brannin. (*QST*, May 1942, Vol. 26, No. 5, pp. 18–21.) Using the receiver dealt with in 689 of March.

2844. SPECIAL EMERGENCY SERVICE [Network used by Los Angeles County Flood Control District: 16 Two-Way Units and Fleet of 48 Receiver-Equipped Trucks & Patrol Cars].—Kennedy. (*Communications*, Dec. 1941, Vol. 21, No. 12, pp. 12–13.)

2845. STANDARDISED MARINE RADIO UNIT [Transmitter (including Emergency Unit), Receivers (including Emergency Double-Circuit Crystal Receiver), Alarm & D.F. Arrangements, Generators, etc.].—Internat. Tel. & Radio Mfg. Corp. (*Electronics*, Jan. 1942, Vol. 15, No. 1, pp. 36–39.) *Cf.* 1816 of June.

2846. SPONSORED BROADCASTING: SUGGESTED USE OF "FORCES" WAVELENGTH AFTER THE WAR.—Chevallier. (*Electronic Eng:g*, March 1942, Vol. 14, No. 169, p. 663: summary only.)

GENERAL PHYSICAL ARTICLES

2847. EXPERIMENTAL PROOF OF "TURNOVER" PROCESSES AT THE TRANSITIONS BETWEEN NORMAL AND SUPERCONDUCTIVITY IN A MAGNETIC FIELD.—Justi. (*See* 2864.)

2848. CONTACT POTENTIALS: PART I—GENERAL PRINCIPLES: PART II—THE VOLTA EFFECT. Chalmers. (*Phil. Mag.*, June 1942, Vol. 33, No. 221, pp. 399–415: pp. 416–430.)

"We have seen that the phenomenon of the Volta effect can be given a consistent interpretation in terms either of the external potential differences, agreeing with the contact theory [Kelvin], or of the internal potential differences, agreeing with the chemical theory [Lodge]; each way of regarding the matter is correct provided the ideas of each are kept separate. We have seen, too, that the effect of replacing a vacuum by a dielectric does not affect the Volta potential difference, and that the ionisation method gives the same results as other methods; the relationship of the Volta effect with the Peltier effect and the photoelectric work function has also been discussed." For Parts III & IV (voltaic cell, concentration cell) *see* July issue, pp. 496–505 & 506–513.

2849. PHYSICS IN 1941 [Cosmic Rays, Electron-Acceleration, Electrical Breakdown, etc.].—Osgood. (*Journ. Applied Phys.* Jan. 1942, Vol. 13, No. 1, pp. 3–21.)

2850. "TABLES OF PHYSICAL AND CHEMICAL CONSTANTS, AND SOME MATHEMATICAL FUNCTIONS" [Ninth Edition: Book Review].—Kaye & Laby. (*Nature*, 25th April 1942, Vol. 149, p. 453.)

MISCELLANEOUS

2851. RECENT QUESTIONS ON THE OPERATIONAL CALCULUS.—Angelini. (*See* 2625.)

2852. ASYMPTOTIC SOLUTIONS OF LINEAR DIFFERENTIAL EQUATIONS.—Jeffreys. (*See* 2601.)

2853. HARMONIC ANALYSIS BY SECTIONAL INTEGRATION [including the Determination of Fourier Coefficients with the Planimeter, and the Martens Harmonic Analyser (Radial Planimeter)], *and* THE PRODUCT PLANIMETER [Various Types].—Willers. (*Arch. f. Tech. Messen*, May 1942, Part 131, V 3620-5, Sheet T45: Feb. 1942, Part 128, J 113-10, Sheets T15-16.) For other papers on planimeters by the same writer see *ibid.*, Parts 115 onwards of 1941.

2854. DISTORTIONS WHICH ARE PRODUCED BY THE FINITE TRANSMISSION WIDTH OF PHYSICAL APPARATUS: WITH APPLICATION TO PERIODIC ANALYSIS.—Meyer-Eppler. (*Ann. der Physik*, 29th April 1942, Vol. 41, No. 4, pp. 261–300.)

It often occurs that a physical process can be made susceptible to measurement by the determination of its average value over a certain interval in space or time. For example, in all spectral intensity measurements (on optical instruments, acoustic or electric filters) a finite spectral region must be present for the obtaining of a measurable intensity: monochromatic measurements are not possible, and the measured spectrum is always an impure one. In photographic and stroboscopic measurements of processes varying in time, a finite exposure is essential for obtaining an adequate image impression: a "motional blurring" is the result. In the recording and reproduction of sound-films, scanning slits of finite width are used: the note-frequency spectrum to be transmitted is thus limited to a certain extent towards the higher frequencies. In the formation of optical images and in projection processes, deterioration of image sharpness is produced by various causes (aberrations, diffraction, finite size of the light source) and shows itself by an all-round "motional blurring." All the above cases can be treated on the same fundamental principles: for this purpose the help of functional analysis is required, particularly the Fourier transformation.

The original energy distribution, in space or time, is represented by $J(x)$, where x is the coordinate of space or time: this is termed the "original function." By some process or other, mean values are now derived from the original function and temporarily attached to a certain argument. The smoothed energy distribution thus obtained, $E(x)$, is a more or less distorted image of the original function: it is termed the "image function." The "weighting function" $A(z)$, according to which the averaging has taken place, is considered throughout to have the properties of a physical "apparatus function," so that it is integrable between $-\infty$ and $+\infty$. The writer deals in turn with symmetrical and asymmetrical "apparatus functions," spectral functions with null points (and the three different ways in which such functions may occur), and multiple distortion (where the measurable image function gives a twice-distorted version of the original function: for example in a spectrometer, when a spectrum already once "contaminated" by the collimator slit is subjected to a second "contamination" by being scanned by the telescope slit).

Part II deals with physical methods for the representation of spectral functions. The first of these is the displaceable hyperbolic raster (Fig. 2a: Figs. 2b–e show records of spectra obtained with this): as modifications of this writer mentions Imahori's investigation of sound spectra with a sinusoidal test raster, and Germansky's optical method of Fourier analysis (1931 Abstracts, p. 227). The second method is that of the "projecting periodograph." Imahori's apparatus was really a periodograph for light intensities variable in time and of finite period (for he converted his "apparatus function" into the form of light-source variations): very often, however, the functions to be investigated are in the form of a curve or of a series of values, and the method of the displaceable raster and moving film would require a conversion into proportional light fluctuations. This difficulty is avoided by the projecting periodograph whose principle is shown in Figs. 3 & 4, and in which there are no moving parts, displacement in time being replaced by displacement in place. The "apparatus function" under examination is represented by a cardboard or metal-foil template-edge, uniformly illuminated by a long narrow light source through a ground-glass screen: at a suitable distance there is a line grating, and in order that the whole spectrum may be recorded simultaneously a photographic plate is fixed behind this grating at an angle to the optical axis. The spectrum is the more drawn-out, the more inclined the plate is to the optical axis, the coarser the grating, and the greater the distance between light source and grating. With such an apparatus, frequencies and phases can be obtained directly, while amplitudes can be derived from the photographic copy with the help of an optical wedge. A modification of this arrangement uses a point-source of light at an adjustable distance from the ground-glass screen; the width of the "analysis interval" then depends on this distance. A further refinement in which two coupled screens are used, one in front of the template and the other in front of the grating, provides the advantage of a "sliding interval."

2855. Quality Control in Industry [Opening Talk at Oxford Management Conference].—Rissik. (*BEAMA Journal*, June 1942, Vol. 49, No. 60, pp. 163–167.)

2856. "Strong" Design [in All Its Aspects (Technical Efficiency, Cost, Economy in Materials, etc.): System for Production Increase, illustrated by Application to Design of Circuit Breaker, including Its Insulators].—Kesselring. (*Zeitschr. V.D.I.*, 30th May 1942, Vol. 86, No. 21/22, pp. 321–330.)

2857. Illustrating the Technical Lecture.—Tompkins. (*Engineering*, 12th & 19th June 1942, Vol. 153, pp. 474–475 & 495.) *See* also issues for 3rd & 17th July, pp. 15 and 54.

2858. Projected Writing: for Use by Teachers and Lecturers [Writing, on Cellophane stretched over Plano-Convex Lens, simultaneously Projected onto Large Screen: the "Scriptoscope"]. — Katz. (*Scient. American*, March 1942, Vol. 166, No. 3, 140–141.)

2859. A Means of Increasing the Illusion of Depth in Photographs [for Scientific Instruction, etc: the Use of "Translites" (Film Transparencies)].—Rehman & Noback (*Science*, 1st May 1942, Vol. 95, pp. 463–464.)

2860. The Effective Presentation of Scientific Reports.—Potter. (*Science*, 15th May 1942, Vol. 95, pp. 503–504.)

Prompted by the correspondence dealt with in 2564 of August. "The best spokesman in the world to-day is President Roosevelt. He *reads* his fireside chats. Not every one can be a Roosevelt in radio or speaking style, but every one can say things simply. Every one can avoid the laziness, for that is what it is, of trying to kill two birds with one stone by reading a complex scientific article whose ultimate end is to appear in print in a scientific publication. . . ." It is suggested that the scientist should come to the meeting armed with two manuscripts—one for reading, the other for the "very few interested individuals" who apply for more details after the talk.

2861. "Jahrbuch des Elecktrischen Fernmeldewesens 1940" [Year-Book of Electrical Communications: Book Review].—Gladenbeck (Edited by). (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 22, 1941, pp. 324–325.) Including the work (and its significance) of the newly formed "Office for Wave Propagation" of the State Post Office.

2862. Communications in World War I and World War II.—McNicol. (*Communications*, Dec. 1941, Vol. 21, No. 12, pp. 5–7.)

2863. I.R.E. Convention [Jan. 1942, New York] outlines Radio's Expanding Rôle.—(*Electronics*, Feb. 1942, Vol. 15, No. 2, pp. 31–34 and 110..118.)

2864. Experimental Proof of "Turnover" Processes at the Transitions between Normal and Superconductivity in a Magnetic Field [Induced Noises as in Barkhausen Effect, showing Existence of Superconducting Micro-Domains in Intermediate State, and making way for Application of Magnetic Theory to Superconductivity].—Justi. (*Physik. Zeitschr.*, 20th April 1942, Vol. 43, No. 7/8, pp. 130–133.) For previous work *see* 889 of March and 2154 of July, and *cf.* 2319 & 3204 of 1941.

2865. A Thermo-Electronic Indicator of Radiant Energy.—Goncharski. (*See* 2747.)

2866. A Proposed Device for Landing Aircraft in Darkness [using Infra-Red Radiation].—Brod. (*Electronic Eng:g*, April 1942, Vol. 14, No. 170, p. 728.)

2867. The Conversion of Supersonic Images into Optical Images [by Scanning with help of Piezoelectric Pick-Up and using the Electrical Voltages to modulate a Reproducing Beam of Light].—Barbier. (*See* 2729: the relevant pages are pp. 144–145.)

2868. Optical Images formed by Conical Refraction [" Plate of Biaxial Crystal cut approximately Normal to the Axis of Single-Ray Velocity has the Remarkable Property of forming Optical Images of an Illuminated Object held in Front of It "].—Raman & Nedungadi. (*Nature*, 16th May 1942, Vol. 149, pp. 552–553.)

2869. Electronic Intrusion-Detection Systems [Photoelectric, Capacitance-Variation, & Acoustically-Actuated Alarms: Survey, including Recent Refinements adapting These Devices to Control of Sabotage].—(*Electronics*, Feb. 1942, Vol. 15, No. 2, pp. 38–43.) *Cf.* 1277 of April. For the " acoustic fence " see *Sci. News Letter*, 30th May 1942, p. 350.

2870. On the Measurement of the Modulation Characteristics of Light Sources, for Note-Frequency Alternating Currents [by an Indirect Method based on the Sudden Cutting-Off of a Direct Current and the Photoelectric Recording of the Decay Oscillogram].—Franke & Rothe. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 22, 1941, pp. 309–312.)

2871. Optical Telephony using Light Modulation with Help of Supersonic Waves.—Barone. (*See* 2729: the relevant pages are pp. 143–144: the work " has attracted great interest in military circles.")

2872. A Simple Light-Beam Communication System: Transmitting Voice with a Flashlight [Amplified Voice Currents superposed on Bulb Filament Current (Action Not Yet Understood): Range over Quarter Mile, could be increased to Several Miles if Flashlight Reflector were replaced by Large Parabolic Reflector].—Stevens & Stevens. (*QST*, May 1942, Vol. 26, No. 5, p. 13–14 and 98, 100.)

2873. Change in the Dielectric Constant of Liquids due to Flow [Effect common to Polar & Non-Polar Liquids, etc.].—Prasad & others. (*Sci. & Culture* [Calcutta], Aug. 1941, Vol. 7, No. 2, pp. 119–120.) *See* also 2268 of 1941 and back reference.

2874. The Behaviour of Elastic Materials used for the Insulation of Mechanical Vibrations [especially Porous Materials: Theoretical Treatment of Elastic-Wave Propagation: Apparatus for Measurement of Characteristic Values: Results].—Rama. (*Alta Frequenza*, Jan. 1942, Vol. 11, No. 1, pp. 5–41.) An English summary is given at the end of the journal.

2875. An Analyser for Sub-Audible Frequencies.—Scott. (*Journ. Acous. Soc. Am.*, April 1942, Vol. 13, No. 4, pp. 360–362.) A summary was dealt with in 1587 of May.

2876. Oscillation Coefficient and Oscillation Measurements on Autobahn Bridges [and the Photoelectric Oscillation Meter].—Risch & Weygandt. (*Zeitschr. V.D.I.*, 30th May 1942, Vol. 86, No. 21/22, pp. 349–350.)

2877. Measurements with a " Vibrating Voltmeter " [for High & Very High Voltages: used in Aircraft Engine Investigations].—Gohlke & Neubert. (*See* 2758.)

2878. Instrument, based on the Ionising Effect of Flame, for determining the Exact Initial Moment of Combustion in Diesel Engines.—Bertoli. (*La Ricerca Scient.*, Feb./March 1942, Vol. 13, No. 2/3, pp. 125–135.) In a report on researches on Diesel fuels.

2879. Angular Sweep Potentiometer [for Correlating the Angular Position of Rotating Shafts, etc., and Beam Position of Oscillograph].—Rowe Radio Research. (*Electronics*, Dec. 1941, Vol. 14, No. 12, p. 93.)

2880. Oscilloscope used for checking Speed of Small Motors.—Clough Brengle. (*Electronics*, Oct. 1939, Vol. 12, No. 10, pp. 47, 48.)

2881. Two-Stroke Petrol Engine weighing 7¼ Ounces and giving 1/5th Horse-Power, *and* Light-weight D.C. Motors [0.005–0.2 H.P., for 12 or 24 Volts] for U.S. Air Corps.—(*Scient. American*, Jan. 1942, Vol. 166, No. 1, p. 37: May 1942, No. 5, p. 253.)

2882. Coal Mine uses Radio for Communication [Trolley System carries H.F. Waves and supplies Power].—Given. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 70 and 71.)

2883. Electronic Typewriting-Speedometer [for Instruction, Speed Exhibitions, etc.].—Ephraim. (*Electronics*, Dec. 1939, Vol. 12, No. 12, pp. 32 and 38..42.)

2884. Direct-Current Amplifiers for *p*H Measurements with Glass Electrodes [Survey, including Limits of Photoelectric Compensators & Valve Amplifiers].—Naumann. (*E.T.Z.*, 21st May 1942, Vol. 63, No. 19/20, pp. 243–244: summary only.) For earlier work *see* 281 of 1941.

2885. A New Principle for Stable Direct-Current Amplification [for Measuring Purposes & Process Control].—Eberhardt & others. (*See* 2633.)

2886. A HIGH-GAIN AUDIO-FREQUENCY AMPLIFIER FOR THE INVESTIGATION OF WEAK SIGNALS [primarily for Bioelectric Potentials].—Rowland & Burns. (*See* 2686.)

2887. RECTILINEAR RECTIFICATION APPLIED TO VOLTAGE INTEGRATION [primarily for Nerve & Muscle Action Potentials: Practical Network for obtaining Necessary Linear Output from Commercial Bridge-Type Copper-Oxide Rectifier: the Complete Voltage Integrator].—Stevens. (*Electronics*, Jan. 1942, Vol. 15, No. 1, pp. 40–41.)

2888. ELECTRONIC SWITCHING IN MEDICAL RESEARCH: SIMPLIFIED APPARATUS FOR MULTIPLE RECORDING [Switch-Rate of 1000 p.s. for Electroencephalography, etc: Best Results from Clothier's Multivibrator Circuit (4655 of 1939)].—Dawson. (*Electronic Eng:g*, April 1942, Vol. 14, No. 170, pp. 722–723.)

2889. DESIGN CHART FOR R.F. HEAT-TREATMENT GENERATORS: ADDITION.—Mittelmann. (*Electronics*, Dec. 1941, Vol. 14, No. 12, p. 58.) *See* 342 of January.

2890. A PHOTOELECTRIC MEMBRANE MANOMETER [primarily for Cardiovascular Pressure Changes, but with Many Applications].—Gilson. (*Science*, 15th May 1942, Vol. 95, pp. 513–514.) Incidentally, a condenser-microphone device, in which the changing capacitance was made to frequency-modulate an oscillator, was successful also.

2891. A METHOD OF RECORDING LOW-INTENSITY FLASHES OF LIGHT [*e.g.* from Fireflies: using A.C. Photocell Bridge & C.R. Oscillograph, giving Complete Stability at High Sensitivities and suitable for Other Applications].—Butt & Alexander. (*Review Scient. Instr.*, April 1942, Vol. 13, No. 4, pp. 151–153.)

2892. PHOTOELECTRIC DEW-POINT RECORDER SAFEGUARDS AGAINST FREEZING [of Colorado Interstate Gas Company's Gas Lines].—Setter. (*Electronics*, Nov. 1941, Vol. 14, No. 11, pp. 72, 74.)

2893. PHOTOELECTRIC COOLING CONTROL [for Hot Ore on Conveyor: Cooling Water sprayed as needed].—Ewald. (*Electronics*, Nov. 1941, Vol. 14, No. 11, pp. 55 and 80.)

2894. ELECTRONIC PHOTOFLUOROMETER [primarily for Vitamin Analysis], *and* LUMETRON MODEL 4 PHOTOELECTRIC COLORIMETER.—Coleman Electric: Photovolt. (*Review Scient. Instr.*, April 1942, Vol. 13, No. 4, pp. 190–191: p. 191.)

2895. PHOTOELECTRIC COLORIMETER FOR RAPID REACTIONS [*e.g.* of Haematin Enzymes: Time Resolution of 0.01 Second].—Chance. (*Review Scient. Instr.*, April 1942, Vol. 13, No. 4, pp. 158–161.)

2896. A NEW TYPE OF MICROPHOTOMETER [giving Practically Instantaneous Record of Blackening Curve (*e.g.* of Photographic Plate: Object fixed to One Prong of Electrically-Driven Tuning Fork: Cathode-Ray Tube as Indicator, working from Caesium Photocell].—Fürth. (*Nature*, 27th June 1942, Vol. 149, p. 730.)

2897. A LINEAR DENSITOMETER [using Bridge-Type Circuit: Calibration Technique].—Tiedman. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 48..58.)

2898. A PHOTOELECTRIC SAFETY COUPLING [Photocell Device to guard against Over-Straining of Flexible Couplings for Diesel-Engine Drives, etc.].—Kuhn. (*E.T.Z.*, 7th May 1942, Vol. 63, No. 17/18, p. 210.)

2899. IMPROVED PHOTOTUBE REGISTER CONTROL [for Two-Colour Lithographic Press], *and* PHOTOTUBE INSPECTS OIL HOLES [in Shackle Bolts].—Westinghouse: Powers. (*Electronics*, Sept. 1939, Vol. 12, No. 9, pp. 44, 48: pp. 54, 56.)

2900. SPRAY CONTROL: PHOTOELECTRIC CELL SPEEDS SHELL PRODUCTION.—(*Scient. American*, Feb. 1942, Vol. 166, No. 2, p. 93.)

2901. PHOTOELECTRIC EFFECTS ON NEON TUBES [Variation of Breakdown Voltage of Commercial Types on Exposure to Light: Substitute for Phototube (but requires Extra Stage of Amplification): Need for Elimination of Effect in Some Uses of Neon Tubes].—Baker. (*Electronics*, Sept. 1939, Vol. 12, No. 9, p. 52.)

2902. PHOTOCELLS FOR THE ULTRA-VIOLET REGION [Thorium, 200–3750 AU: Tantalum, 2000–2950 AU (for Bactericidal Region): Platinum-Coated, below 2000 AU (Ozone-forming Region)].—Rentschler. (*Journ. Applied Phys.*, May 1942, Vol. 13, No. 5, p. 302.) In a paper by Paulus on bactericidal radiation.

2903. PHOTOFLASH-SYNCHRONISER TESTER [Combination of Phototube, Two Gaseous Tetrodes, Receiving Triode, & Milliammeter, for Measurement of Time Intervals 10–45 Milliseconds].—Marsal. (*Electronics*, Jan. 1942, Vol. 15, No. 1, pp. 34–35.) Using the basic circuit of the chronoscope (2497 of 1941).

2904. THE MEASUREMENT OF SHORT INTERVALS OF TIME.—La Barbera. (*See* 2768.)

2905. A NEW STROBOSCOPE FOR THE LABORATORY: ELECTRICAL DISCHARGES CONTROLLED BY A THYRATRON.—Sackmann. (*Comptes Rendus* [Paris], 8th Dec. 1941, Vol. 213, No. 23, pp. 866–868.)

2906. MERCURY SENSITISATION AND THE OPTICAL AND X-RAY LATENT IMAGES.—May. (*Journ. Opt. Soc. Am.*, April 1942, Vol. 32, No. 4, pp. 219–223.)

2907. TRENDS IN THE TECHNIQUE OF INDUSTRIAL RADIOGRAPHY [Intensifying Screens: Focal Spot Size: Variable Illumination: Gamma-Ray Films: etc.].—Seeman. (*ASTM Bulletin*, March 1942, No. 115, pp. 21–26.)

2908. NEW RADIOGRAPHY UNIT AIDS INDUSTRY [General Electric Million-Volt Industrial X-Ray Unit].—General Electric (America). (*Electronics*, Nov. 1941, Vol. 14, No. 11, pp. 36–37 and 110, 111.) *See* also 1242 of April.

2909. MICRORADIOGRAPHY BY REFLECTION [with Applications to Metallurgy: No Need for Preparation of Sections: suitable also for Macroradiography].—Trillat. (*Comptes Rendus* [Paris], 8th Dec. 1941, Vol. 213, No. 23, pp. 833–836.)

2910. A NEW SYNTHESIS OF X-RAY DATA FOR CRYSTAL ANALYSIS.—Yü. (*Nature*, 6th June 1942, Vol. 149, pp. 638–639.) *See* also issue for 27th June, p. 729.

2911. TRIVISION [System of X-Ray Photography showing Three Dimensions in Single Picture]. —Winnek. (*Science*, 8th May 1942, Vol. 95, Supp. p. 10.)

2912. BERYLLIUM WINDOWS FOR X-RAY TUBES [Thin Commercial Foils].—British Unicorn Ltd. (*Journ. of Scient. Instr.*, June 1942, Vol. 19, No. 6, p. 95.) *See* also 2304 of 1941.

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2914. AN X-RAY SPECTROGRAPH OF HIGH LUMINOSITY FOR CHEMICAL ANALYSES.—Protopopov. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 10, 1940, pp. 1281–1288.)

2915. A GRID-CONTROLLED X-RAY-DIFFRACTION TUBE [with Electron-Flow governed by Square-Wave Generator].—Eisenstein. (*Review Scient. Instr.*, May 1942, Vol. 13, No. 5, pp. 208–212.) So that flow occurs only when voltage is high enough to excite the K series.

2916. A NEW X-RAY PHOTOGRAPHIC PAPER ["Kryptoscreen", with White Fluorescent Pigment below Sensitive Emulsion].—Ilford, Ltd. (*Nature*, 18th July 1942, Vol. 150, p. 88.)

2917. A VACUUM-TUBE INTENSITY METER [for X-Ray Intensity Measurements with a Thimble Ionisation Chamber].—Taft. (*Review Scient. Instr.*, May 1942, Vol. 13, No. 5, pp. 234–235.)

2918. COUNTER TUBES IN X-RAY TECHNIQUE, *and* LIGHT COUNTERS [Use of Counter Tubes for Measurement of Ultra-Violet & Visible Light].—Neuert. (*Arch. f. Tech. Messen*, Jan. 1942, Part 127, V 61-2, Sheets T4-5: March 1942, Part 129, V 422-4, Sheet T24.) *See* also R. Jaeger's survey of X-ray intensity measurement, *Arch. f. Tech. Messen*, Jan. 1941, Part 115, Sheets T6-7.

2919. PROPORTIONAL COUNTER AMPLIFICATION AT LOW VOLTAGES [and the Gas-Amplification Factor].—Rose & Ramsey. (*Phys. Review*, 1st/15th April 1942, Vol. 61, No. 7/8, pp. 504–509.) A short account was referred to in 2223 of July.

2920. A COMPLETE PROPORTIONAL COUNTER ARRANGEMENT FOR COSMIC-RAY MEASUREMENTS.—Weisz & Ramsey. (*Review Scient. Instr.*, June 1942, Vol. 13, No. 6, pp. 258–264.)

2921. A SPHERICAL COUNTER-TUBE FOR RADIATION-PROTECTION MEASUREMENTS [Sensitivity to below 10^{-7} r/s: Spontaneous Pulses 3–4 per Minute: Working Voltage 900 V: Bakelite Construction].—Rajewsky & others. (*Naturwiss.*, 29th May 1942, Vol. 30, No. 22, p. 332.)

2922. A TRANSPORTABLE EXPANSION CHAMBER FOR DEMONSTRATION PURPOSES [Total Weight only 9.3 kg.].—Kunze. (*Physik. Zeitschr.*, 15th Dec. 1941, Vol. 42, No. 23/24, pp. 405–409.)

2923. "THE CHEMICAL ASPECTS OF LIGHT" [Book Review].—Bowen. (*Nature*, 27th June 1942, Vol. 149, p. 714.)

2924. A SYSTEM OF PHOTOMETRIC CONCEPTS [including Tables of Usual Names in Various Languages, Proposed International Names, & Recommended Radiometric & Photometric Units].—Parry Moon. (*Journ. Opt. Soc. Am.*, June 1942, Vol. 32, No. 6, pp. 348–362.)

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2926. LONG OPTICAL PATHS OF LARGE APERTURE [primarily for Absorption Cells].—White. (*Journ. Opt. Soc. Am.*, May 1942, Vol. 32, No. 5, pp. 285–288.)

2927. MICROFILM READER [Inexpensive Instrument].—Spencer Lens. (*Review Scient. Instr.*, June 1942, Vol. 13, No. 6, p. 271.) *Cf.* 1249 of 1941.

2928. THE AMPLIDYNE GENERATOR [Principle & Applications, for Industrial Control Purposes].—Adkins. (*B.T-H. Activities*, July 1942, Vol. 17, No. 7, pp. 170–172.) *See* also 2498 & 3700 of 1940 and 645/6 of 1941.

2929. OPERATORS IN THE MAKING [Expert's Views on Men *versus* women, Best Ages, Methods of Training].—(*Wireless World*, July 1942, Vol. 48, No. 7, pp. 168–169.)

2930. GEOLOGICAL APPLICATION OF NUCLEAR PHYSICS [Survey, and Future Possibilities]. —Goodman. (*Journ. Applied Phys.*, May 1942, Vol. 13, No. 5, pp. 276–289.)

2931. METEORITES WEIGHING LESS THAN 1/300TH OF AN OUNCE DETECTED BY MAGNETIC NEEDLE.—Leonard. (*Sci. News Letter*, 25th April 1942, Vol. 41, No. 17, p. 265.) "Under certain conditions, meteorites can be discovered when buried ten or twelve feet in the ground."