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Editor
HUGH S. POCOCK

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

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EXPERIMENTAL WIRELESS

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Editorial.

The Selectivity of Broadcast Receivers.

THE discussion on this subject which took place at a meeting of the Wireless Section of the Institution of Electrical Engineers on 24th February reminded us of a remark which was made apropos of a joint discussion on the Universe held under the ægis of one of the sections of the British Association in September. It was to the effect that if the six contributions were added together and the sum divided by six, the answer was nought. The discussion on selectivity centred around several distinct points, but the opinions on most of these points were very diverse, and in many cases diametrically opposed. In his brief summing up Professor Fortescue, who also opened the discussion, very rightly appealed for the elimination of the awful terms used by some of the speakers and for the use of decent English in describing technical work. We wish to support this plea very strongly; the remarks of some of the speakers were couched in such a jargon that one could only try to guess their meaning. Although there were differences of opinion, most of the speakers adopted a scientific attitude to the problem; the school which regards—or should we say regarded?—side-bands as a product of the imagination, invented for the restraint of radio-communication, was not represented; nor apparently were those who claim to have made the greatest advances in the construction of ultra-selective receivers.

The first question was the upper limit of audio-frequency which should be retained to give realistic reproduction, and there was general agreement that this was in the neighbourhood of 8,000 or 10,000, although higher figures were mentioned. There is also no doubt that pleasing results can be obtained with a lower limit, but whether it is better to fix it at 3,000 to 4,000 and eliminate all interference, or at 6,000 to 8,000 and put up with some interference from stations on neighbouring wavelengths, is a matter of taste. It would be very interesting to make tests with a receiver which could be adjusted to either of these two conditions. It should be quite feasible if the receiver were made for one fixed frequency, or it might be possible to incorporate such an adjustment in the intermediate stage of a super-heterodyne receiver, or in the tone-correcting stage of a very sharply tuned receiver. One could then get as good quality as the interference permitted, assuming that the quality existed in the transmission and that the loud speaker was capable of reproducing it.

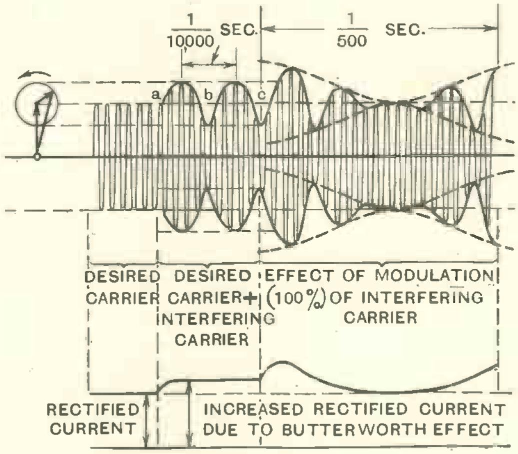
There was general agreement that the

present spacing of allocated frequencies should on no account be reduced, but, if possible, increased.

No definite answer was given to the question which has been discussed so much lately, *viz.*, whether it is possible for a receiver to discriminate between a side-band of the carrier to which it is tuned and a wave of the same frequency and amplitude from some other source. If this power of discrimination exists it can only be due to two closely connected causes, *viz.*, the existence in the case of the desired side-band of a similar side-band on the other side of the carrier, and a certain phase relationship between the three which may not exist when the wave reaches the receiver, but which certainly existed when it left the transmitter. It is difficult to imagine any other characteristic which would enable a receiver to distinguish friend from foe among the multiplicity of electromotive forces to which it is subjected. Any wave, whether due to an undesired carrier or one of its side-bands, will produce beats with the desired carrier, *i.e.*, will cause its amplitude to vary, and a similar wave, equally spaced on the other side of the desired carrier, will double the amplitude of the variations and modify the envelope of the beats in a manner which we shall consider later. So far as its effect on the desired carrier is concerned, a disturbing carrier is in a very different position from its associated side-bands ; the carrier is usually much stronger than any of its side-bands and is of constant frequency, so that it produces a sustained loud note, whereas its side-bands are weaker and intermittent and consequently produce a subdued twittering background. It does not appear possible that a receiver could discriminate between them, the fact that one is strong and the other weak being merely due to the nature of the disturbing wave and not to any discriminating power of the receiver.

The Secret of the Stenode and Autotone.

There is, however, another possible cause of interference which we must consider. A disturbing carrier near the limit of the audible wave-band produces a very high note, and if it is modulated at a low audible frequency, each of its side-bands, considered separately, also produces a very high note, but the three, considered together, constitute a wave, the amplitude of which is varying at a low audible frequency, and which, when compounded with the desired carrier, gives a resulting radio-frequency wave of a complex nature, the amplitude of which is changing at the low audible frequency.



A study of the Figure will throw considerable light on the principle underlying those systems which seek to reduce interference by super-selectivity and tone-correction. It will also show what such systems can do and what they cannot do. The wave on the left of the Figure represents the desired carrier, assumed to be unmodulated ; we then show the effect of an interfering unmodulated carrier having at this stage, that is, after passing through the pre-detection stages, an amplitude of about a third of that of the desired carrier. We assume it to differ from the frequency of the latter by about 10,000. A consideration of the vector diagram on the extreme left will show why the resultant amplitude of the two vectors does not follow a sine curve, but a curve a b c of the type shown. The result of this is that the rectified current is increased as shown in the lower diagram. For a detailed discussion of this the reader is referred to Butterworth's article in November, 1929, and to the article by Colebrook and the Editorial in August, 1931. In the lower part of the Figure we have purposely omitted the 10,000 frequency fluctuations of the rectified current, as there is no difficulty in understanding them and they would only introduce unnecessary complication. They would, of course, produce a very high pitched heterodyne whistle. We then assume that the disturbing carrier is fully modulated at a frequency of 500, so that the small vector on the extreme left of the Figure varies slowly in magnitude between zero and twice its normal value, going through its complete cycle in 20 revolutions. When its magnitude is above the normal the rectified current is increased, and when it falls to zero the rectified current is that corresponding to the undisturbed carrier. Thus the mean rectified current varies in amplitude at a frequency of 500 as shown in the Figure and causes the modulation of the disturbing carrier to be heard in the receiver. If now we assume that by sharp tuning we decrease the amplitude of the disturbing carrier, which is 10,000 cycles away from resonance, to 5 per cent. of what its amplitude would be if it were at the resonant frequency, then the disturbing carrier and both its side-bands, which are 9,500 and 10,500 cycles away from resonance, are all reduced in about the same proportion, and although it retains its 100 per cent. modulation the disturbing carrier is reduced to 5 per cent. The small vector in the figure will thus be reduced to 5 per cent. of its length; the curve a b c will be reduced to 5 per cent. of its amplitude, and with it the heterodyne whistle, but the curve a b c will also be more nearly sinusoidal as its amplitude decreases, and the increase of rectified current shown in the lower part of the figure will be more than proportionately decreased (see Fig. 1b on p. 406 of August, 1931). The 500 cycle note will therefore be reduced to less than 5 per cent.

Effect of Tone Correction.

We must now consider the effect of tone-correction. To give a level response, the tone correcting stage must multiply a note of 10,000 cycles by 20, since we have assumed that it was cut down to 5 per cent. This will bring back the heterodyne whistle to its full strength and not only that due to the carrier but also those due to the side-bands of 9,500 and 10,500, and the three will combine to give a 10,000 frequency note with 500 beats per second, which is obvious from the Figure, in which we see the 10,000 cycle oscillation alternately growing and dying away.

It is very important to note, however, that the 500 cycle note which was reduced to less than 5 per cent. will only be multiplied by the correcting factor corresponding to this frequency and not by that corresponding to 10,000 cycles. This note and the modulation of the disturbing carrier in general is therefore not brought up to its original strength, but is greatly reduced, and herein lies the advantage of this method of reception. It must be noted, however, that we have assumed a perfect linear detector, and the extent to which the results obtained in practice will agree with our explanation will depend—among other things—upon the closeness with which the detector employed approximates to this ideal.

A Question and the Answer.

We have mentioned that the modulated disturbing carrier may be represented as three separate waves of 9,500, 10,000, and 10,500 frequency and we have seen that they produce in the receiver a note of 500 frequency. The question may be asked: If our desired carrier be modulated at the three frequencies of 9,500, 10,000, and 10,500 simultaneously, will this not produce a similar set of waves to those of the disturbing carrier, but on both sides of our desired carrier, and will this not produce a note of 500 frequency, perhaps of twice the amplitude? The answer is that each side-band will co-operate with its corresponding side-band on the other side of the carrier, so that in the vector diagram in our Figure there will be two small vectors rotating in opposite directions and giving a resultant which always lies along the carrier vector and varies sinusoidally, thus avoiding the peculiarity which gave rise to the non-sinusoidal curves a, b, c. There will consequently be no increase in the rectified current and no note of 500 cycles per second. If, however, due to distortion during transmission, the desired side-bands have lost the ideal phase relation with respect to the carrier, then it appears possible for these difference-tones to be produced and to account for some of the distortion which accompanies fading.

G. W. O. HOWE.

Tests on Five Ultra-short Wave Receivers.*

On Wavelengths from 7 to 13 Metres.

By R. L. Smith-Rose, D.Sc., Ph.D., A.M.I.E.E.. and H. A. Thomas, M.Sc., A.M.I.E.E.

(Wireless Division, National Physical Laboratory.)

SUMMARY.

In connection with an investigation on the propagation of ultra-short waves, information was required on the relative performance of various types of receivers, the particular wavelengths under consideration being 7, 9, 11 and 13 metres. Five receivers were available and these fall into three classes, one being of the simple retroactive detector type, two of the super-regenerative type, and two of the supersonic heterodyne type. Overall performance measurements were made on these receivers with the measuring apparatus already installed at the National Physical Laboratory, using a radio-frequency carrier oscillation with a 10 per cent. modulation at 1,000 cycles per second superimposed thereon. The results obtained on the various receivers are illustrated in the form of graphs showing the relation between the radio-frequency employed and the input voltage to a dummy aerial connected to the receiver, and under conditions which gave a constant output of 1 volt across a 10,000 ohm resistance in the anode circuit of the last stage. The relationship between the input and output voltages for each receiver is also illustrated graphically, and for the two supersonic heterodyne receivers selectivity curves for the intermediate frequency stages have been included. A field test was also carried out in which the output from the receiver was measured when receiving from a local portable transmitter. This test was made at only one frequency in order to check the relative accuracy of the measurements made in the Laboratory test.

A detailed discussion of the results of the tests is given in the paper, and this shows that both the super-regenerative and supersonic heterodyne types of receiver are much more sensitive than the simple retroactive detector. Where a high sensitivity is required over the range of wavelengths in question, the advantage appears to lie quite definitely with the supersonic heterodyne type of receiver which, it is contemplated, may be developed to a higher degree than is represented in the two receivers used for these tests. The tabulated results of the tests as obtained from the graphs show that the overall voltage amplification, under the conditions given above, may rise from about 860 for the simple retroactive detector type to 100,000 for the super-regenerative type, and to nearly three million for the supersonic heterodyne type. Some idea of the signalling range possibilities of the various receivers may be gained from the fact that the least sensitive of the five receivers has been successfully used for reception and direction-finding purposes at distances up to 20 miles from a half-wave transmitting aerial with a maximum current of half an ampere.

1. Introductory, with Description of Receivers Submitted for Test.

In connection with a general investigation of the propagation of ultra-short waves, definite quantitative information was required as to the performance of various receivers operating on the wavelength range of 7 to 13 metres. The five receivers which were available at the Laboratory for the purposes of this test fall into three well-defined classes, viz. :—(*a*) Simple retroactive detector, (*b*) Super-regenerative, and (*c*) Supersonic heterodyne.

(*a*) The one receiver in this class was of a simple two-valve type employing a retroactive detector stage and one stage of audio-frequency amplification. It has been used in the measurement of ground attenuation at distances up to half a mile and for direction-finding observations at distances up to twenty miles.

(*b*) In the super-regenerative class, two receivers were available, one of the self-quench (or squegger) type containing two valves and covering a rather limited wavelength range, while the other was of the separately quenched type containing three valves, and this set covered two wavelength ranges.

(*c*) In the supersonic heterodyne class, two receivers were tested. One of these was provided with 4 ranges self-contained, and

* MS. received by the Editor, May, 1931.

gave continuous operation on all wavelengths from 6 to 350 metres.

Full details of these five receivers are given in Table 1 above. Except in the case of the first receiver, no batteries are incorporated within the apparatus. The information provided in the last five columns of the table enables an idea to be formed of the relative sizes of the receivers.

TABLE 1.

MAIN DETAILS OF THE FIVE ULTRA-SHORT WAVE RECEIVERS SUBMITTED FOR TEST.

Receiver No.	Type.	Frequency Range in Megacycles per second.	Number of Valves.	Number of Controls.	Overall Dimensions. Tuning Panel Vertical. Height ins.	Width ins.	Depth ins.	Volume cu. ins.	Weight: lbs.
1	2 Stage with Retro-active Detector.	24–42 (1 range)	2	2	25.25	12.5	10	3,160	30 (including batteries).
2	Super-regenerative	22–30 (1 range)	2	3	10.5	9.5	6	599	7.5
3	Super-regenerative	19–53 (2 ranges)	3	3	11.25	21.25	10.75	2,574	40
4	Supersonic Heterodyne	3–50 (4 ranges)	7	4	29	30.5	8	7,080	131
5	Supersonic Heterodyne	13–45 (1 range)	5	5	9	37.5	12.5	4,100	45

These five receivers have been submitted to two types of test. In the first place, an overall performance measurement has been carried out in which the relation between the voltage applied at the input terminals of the receiver to the output power has been determined over the working range of the instrument. The second test was made in the field and comprised a measurement of the output from each receiver when responding to waves from a distant and controllable transmitter.

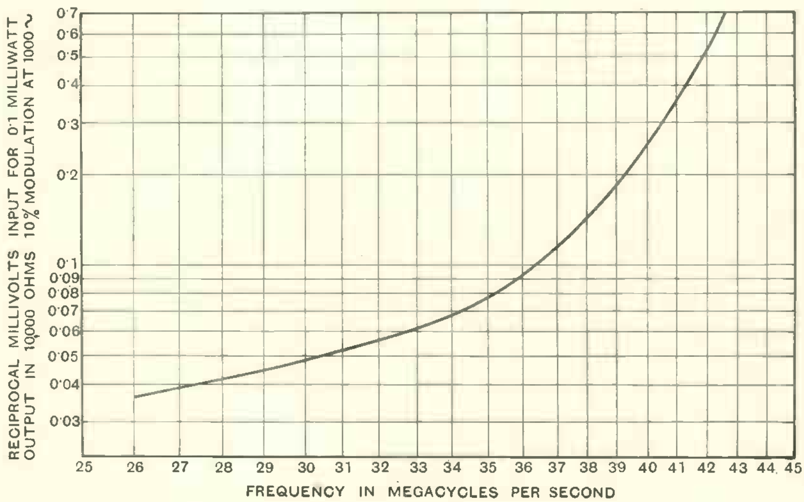


Fig. 1.—*Overall performance characteristic of two-valve receiver No. 1 (maximum retroaction).*

2. Description of Laboratory Tests.

The laboratory tests made on the receivers consisted of two parts, first a measurement of the overall sensitivity, and second, a measurement of the proportionality of input to output for each receiver. The general method of carrying out these tests was to apply to the input end of the receiver a known modulated radio-frequency voltage and measure the resulting audio-frequency voltage obtained in the output circuit of the receiver. In order to obtain a comparative measure of performance of the receivers, it was necessary to standardise both the input and output circuit arrangements and this was done as follows. The receivers were provided with terminals for connection to an aerial and suitable earth in the usual manner.

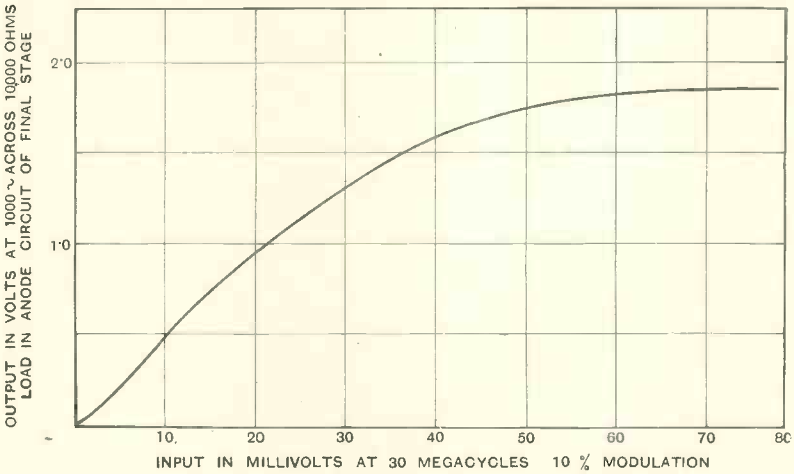


Fig. 2.—*Input-output characteristic of two-valve receiver No. 1 (maximum retroaction).*

Now for the lowest wavelength of 7 metres in the range under consideration, the length of a quarter-wave aerial would be 1.75 metres, and this would be the aerial giving maximum current at the base when set parallel to the electric force of the arriving waves. It was, therefore, decided to take as the standard aerial for the purpose of these tests a vertical straight rod aerial of length 1.5 metres, which leaves for the earth connection a maximum length of 0.25 metre. At wavelengths above 7 metres a longer aerial would be used in practice, but there are obvious reasons for taking constant aerial conditions in these tests. The above aerial dimensions are convenient also, since the effective height will be about 1 metre, so that it is easy to transfer input e.m.f.s directly into field strengths. Such an aerial system will have an effective capacity of about 20 micro-microfarads and a radiation resistance of the order of 20 to 40 ohms over the frequency range 23 to 43 megacycles per second. For the laboratory tests, therefore, a dummy aerial circuit was made up, consisting of an air condenser having a capacity of 20 micro-microfarads in series with a non-reactive resistance of 25 ohms, these two components being built up in a screened box and connected in series with the lead to the aerial terminal of the receiver.

For the output circuit, a non-reactive resistance of 10,000 ohms connected in the anode circuit of the last stage was employed. This value was chosen as being representative of the impedance of a pair of high resistance head-telephones at the modulation frequency of 1,000 cycles per second used throughout the tests.

Although every possible precaution was taken with the testing apparatus to avoid the effect of spurious e.m.f.s, and also to ensure that the various quantities involved

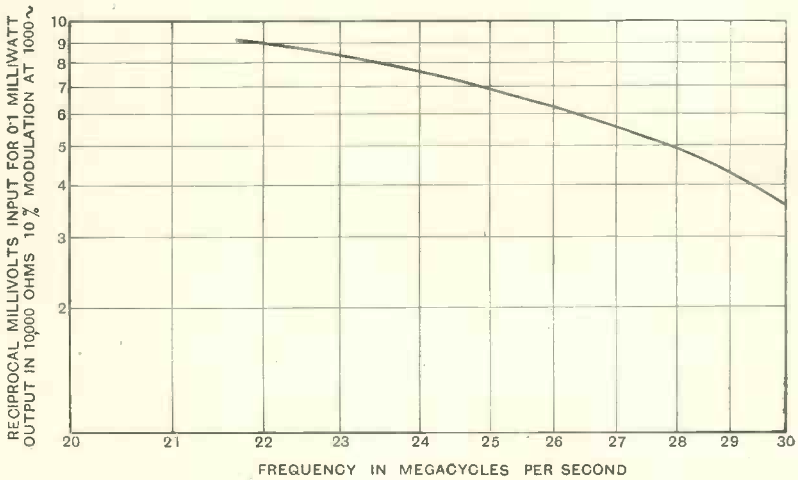


Fig. 3.—*Overall performance characteristic of two-valve quench receiver No. 2.*

were measured as accurately as possible, it is considered unlikely that the overall accuracy of the measurements is greater than about 20 per cent. One of the chief difficulties experienced was in the adjustment of the receivers, which adjustment in most cases was very critical. This fact made it very difficult to obtain readings which could be repeated with some degree of reliability.

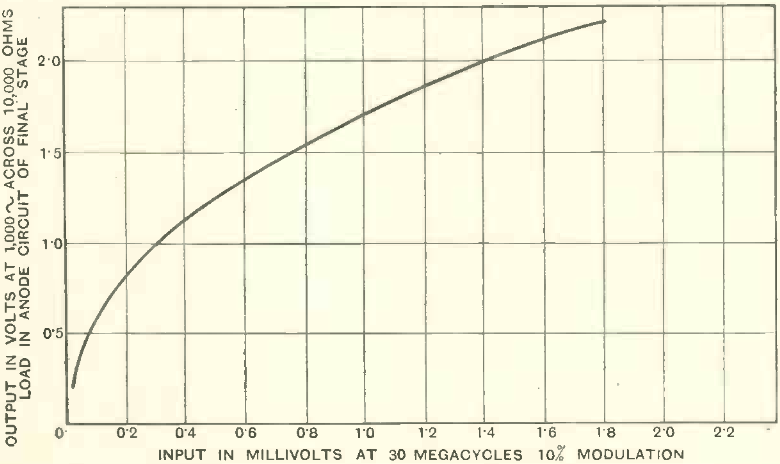


Fig. 4.—*Input-output characteristic of two-valve quench receiver No. 2.*

(*a*) *Sensitivity Tests.*

In these tests the input voltage was supplied through the dummy aerial to the receiver by means of known resistance attenuators, which were specially designed for the very high frequencies used, and gave a known input subject to the calibration of the non-contact type of thermo-junction employed remaining valid at these frequencies. In the absence of any superior method of current measurement the calibration has been assumed to be independent of frequency.

The sensitivity of the receivers tested has been expressed in terms of the reciprocal milli-volts input required at the various radio-frequencies to give an output of one volt across a non-inductive resistance of 10,000 ohms in the anode circuit of the last stage: this corresponds to an output power of 0.1 milliwatt. A value of 10 per cent. modulation at a frequency of 1,000 cycles per second was used throughout the tests. In those cases where a telephone transformer is incorporated in the receiver, the output was suitably modified according to the measured ratio of this transformer so as to give the equivalent of one volt in the anode circuit of the final stage. It was considered preferable to use the reciprocal milli-volt scale of input, since by so doing an increase in amplification is represented by an increase in the ordinate on the curve, which is easier to interpret than if a direct milli-volt scale had been used.

Owing to the comparatively large amount of background noise experienced with some of the receivers, it was found necessary to use a very selective audio-frequency filter

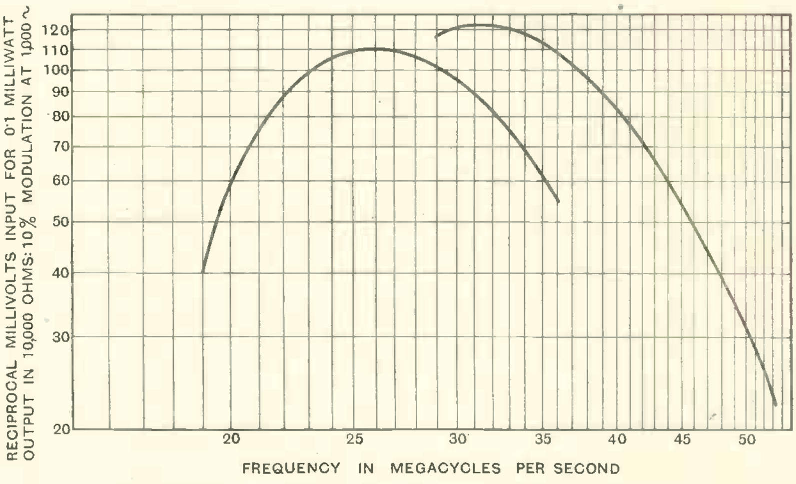


Fig. 5.—*Overall performance characteristic of three-valve quench receiver No. 3.*

connected between the output terminals and the valve-voltmeter used to measure the output : by this means only the modulation frequency output was measured.

The measured overall performance characteristics of the five receivers tested are shown in Figs. 1, 3, 5, 7 and 10. These graphs will be discussed in Section 4.

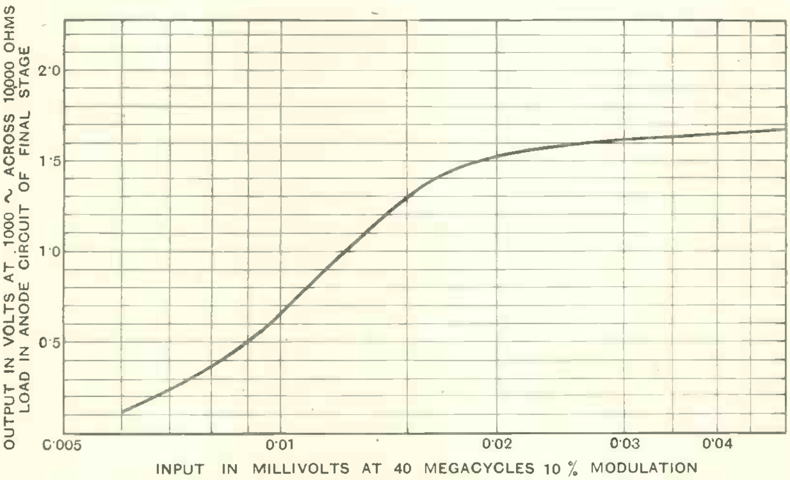


Fig. 6.—*Input-output characteristic of three-valve quench receiver No. 3.*

(b) Proportionality of Input and Output.

In the case of each receiver, a characteristic was obtained showing the relationship between the input in milli-volts and the output in volts. The results are shown by the graphs in Figs. 2, 4, 6, 8 and 11.

(c) Selectivity Characteristics.

For the two supersonic - heterodyne receivers, selectivity characteristics of the intermediate frequency amplifiers were also obtained, and these are reproduced in Figs. 9 and 12. Selectivity characteristics at the ultra-short wavelengths were not taken owing to the difficulties of obtaining such characteristics with the present form of the testing apparatus.

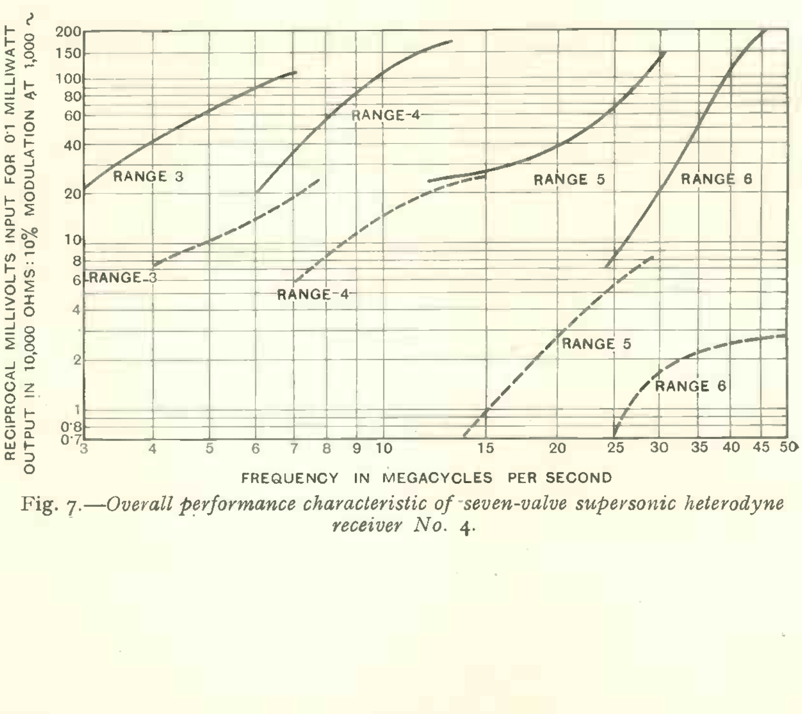


Fig. 7.—*Overall performance characteristic of seven-valve supersonic heterodyne receiver No. 4.*

3. Description of Field Tests.

In order to ascertain whether the relative sensitivity of the various receivers as given by the Laboratory measuring apparatus was borne out in practice when receiving signals, a field test was arranged in which each receiver was connected in turn to an aerial and the signal output due to a distant transmitter was measured. The receiving aerial consisted of a straight vertical rod 1.5 metres long and was connected to the appropriate input terminal of the receiver. The earth terminal of the receiver was connected by a short lead to a copper screen about 1 metre square. A rotatable loop was used as the transmitting aerial and this was supplied from a two-valve generator modulated by the output from a beat tone oscillator. The field intensity at the receiver due to this transmitter could be varied by (*a*) altering the distance of transmission over the range of 30 to 150 metres employed, (*b*) by rotating the loop, (*c*) by varying the

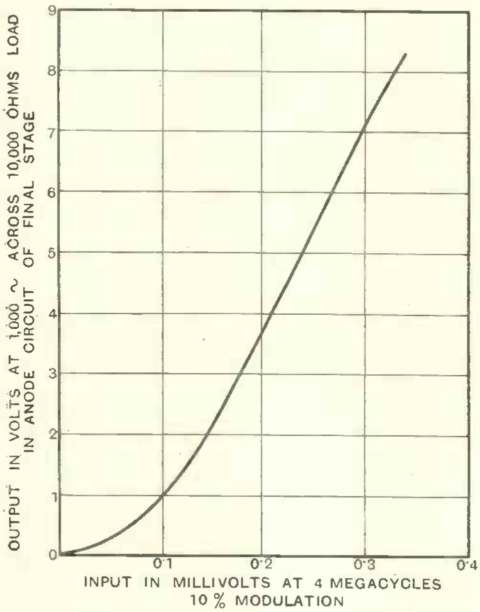


Fig. 8.—*Input-output characteristic of seven-valve supersonic heterodyne receiver No.* 4.

modulation percentage. In each case a calibration was carried out to ascertain the law of variation. By this means the relative input was measured to the various receivers to enable them to give the standard output of 1 volt through the 10,000 ohm resistance.

in terms of the simple two-valve receiver No. 1. This table also contains extracts from the results obtained in the laboratory tests at different frequencies. The results obtained in the two tests at the same frequency are seen to be substantially in agreement within the limits of accuracy claimed for either measurement. This field test thus provides a confirmation of the general accuracy of the laboratory tests, which may therefore be discussed in more detail in the next section.

4. Discussion of Results.

(*a*) *General.*

Although it is probable that small variations in the design, construction, and even manipulation of individual receivers might produce relatively large changes in the overall performance, there are a few very definite general conclusions which may be drawn from the results of the tests described in this paper.

In the first place, it is seen that the simple receiver comprising a retroactive detector and one stage of audio-frequency amplification is easily surpassed in sensitivity by either the super-regenerative or the supersonic heterodyne type, both of which can be made to operate well on the frequency band in question, viz., 23 to 43 megacycles per second. Over this range of frequencies, however, the sensitivity of the simple two-valve receiver tested rose very rapidly with increasing frequency, so that at 44 megacycles per second the sensitivity was 36 times

TABLE 2.

Receiver No.	Order of Sensitivities in Laboratory Tests. All receivers at maximum sensitivity for 1 volt output.							Relative Sensitivity measured in Field Test at Frequency of 28 mc/s.
	Frequency in Megacycles per second.							
	20	24	28	32	36	40	44	
1	—	—	1.0	1.3	2.2	6.2	36.0	1
2	—	180	110	—	—	—	—	75
3	1,400	2,500	2,500	2,900	2,600	2,000	1,400	2,300
4	950	1,400	2,700	3,800	1,400	2,900	4,300	2,500
5	29,000	50,000	64,000	69,000	69,000	62,000	50,000	—

These field tests were carried out at a frequency of 28 megacycles per second, and the results obtained are shown in the last column of Table 2 as relative sensitivities

as great as at 28 megacycles per second (see Fig. 1 and Table 2). Moreover, the proportionality of output to input over a considerable range for this receiver (Fig. 2, has been found to be useful in the carrying out of field intensity measurements in connection with the study of the attenuation of ultra-short waves transmitted along the ground.

Next, the results obtained on receiver No. 3 show that it is possible to construct a receiver operating on the super-regenerative principle which will be very sensitive at the very high radio-frequencies employed (Fig. 5 and Table 2). This set has the disadvantage of possessing a rather unpleasant background noise except when a signal is being received, a defect which is apparently inherent in receivers of this type.

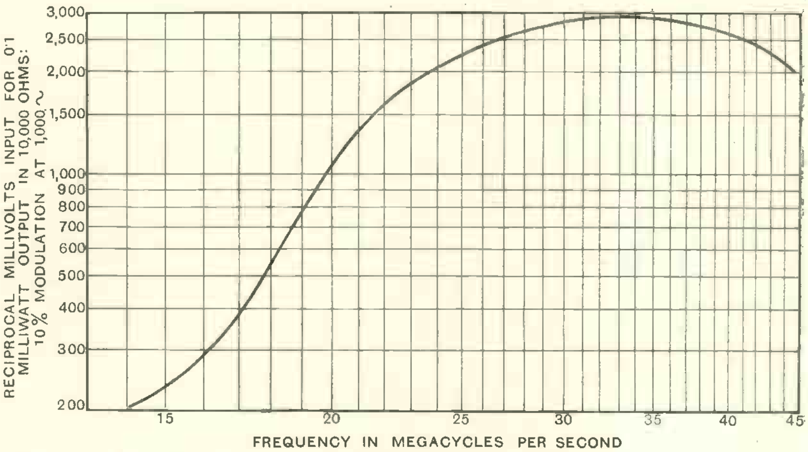


Fig. 10.—*Overall performance characteristic of five-valve supersonic heterodyne receiver No. 5 (maximum retroaction).*

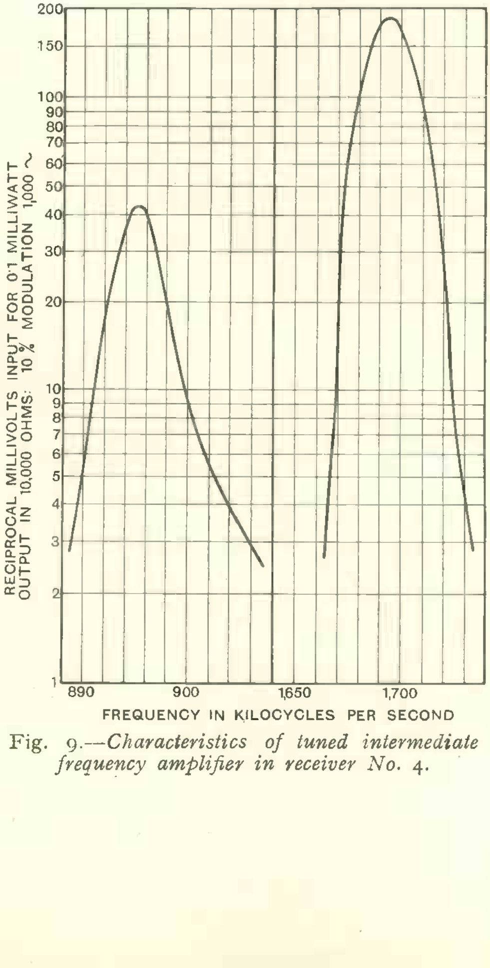


Fig. 9.—*Characteristics of tuned intermediate frequency amplifier in receiver No. 4.*

Finally, the tests show that where high sensitivity is required in conjunction with flexibility and ease of manipulation, the supersonic heterodyne receiver is the type to use. Although moderately high sensitivity is obtained in receiver No. 4, it is probable that some of this has been sacrificed in favour of stability, robustness and ease of control, all of which qualities are possessed by the set tested to an admirable degree. Where less stringent demands are made in this direction, a considerably higher sensitivity can be obtained, as indicated in the case of the set No. 5. It is probable that the performance of these supersonic heterodyne receivers would be considerably improved by fitting a control for the amplitude of the oscillator so that the set may be operated under the conditions of optimum heterodyne.

(*b*) *Relative Sensitivities of Receivers for Communication.*

It is seen from Table 2 that, while at the frequency of 28 megacycles per second chosen for the field test, the ratio of sensitivities of the best to the worst is 64,000 : 1, this value is reduced to 50,000 : 36 (= 1400:1) at the frequency of 44 megacycles per second, at which the simple two-valve receiver is much more sensitive. The sensitivities of the other receivers lie between these extremes.

In considering the relative utility of the sets tested for use in signal communication purposes, it is necessary to take account of the background noise developed by the receiver in the head telephones. A simple test showed that the minimum signal output which was comfortably readable against the receiver background noise was 0.1 volt for receiver No. 1, 0.2 Volt for Nos. 2 and 3, and 0.5 and 2.0 volts respectively for supersonic heterodyne receivers Nos. 4 and 5. From the input-output characteristics given in Figs. 2, 4, 6, 8 and 11, it is possible to correct the relative sensitivities given in Table 2 for the above minimum outputs instead of a uniform output of 1 volt. This correction has been made in Table 3, which gives the relative sensitivity values for the five receivers operating on the four wavelengths for which the results of these tests are particularly applicable. Table 3 also shows the power gain in decibels appropriate to each receiver with the values of input and output resistances employed in the tests.

Thus, the voltage amplification of the No. 5 supersonic heterodyne receiver is nearly three million times, corresponding to a power gain in excess of 100 decibels. These values refer to the case of 10 per cent. modulation as employed throughout the tests, and would be correspondingly increased for higher modulation percentages. Although the background noise has been shown to be a distinct disadvantage of some of the receivers, particularly No. 5, this defect can be removed, for Morse signalling purposes, by the application of an audio-frequency stage of high selectivity.

TABLE 3.

SHOWING RELATIVE SENSITIVITIES OF RECEIVERS AFTER CORRECTION FOR BACKGROUND NOISE.

Receiver No.	Relative maximum sensitivities at frequencies in megacycles per second of :				At most sensitive point between 23 and 43 megacycles per second and for 10 per cent. modulation.	
	43	33	27	23	Voltage amplification.	Power Gain : decibels.
1	22.0	1.6	1.0	—	860	32
2	—	—	250	370	8,200	52
3	350	650	590	540	122,000	76
4	760	180	360	230	180,000	79
5	4,800	6,000	5,400	3,800	2,900,000	103

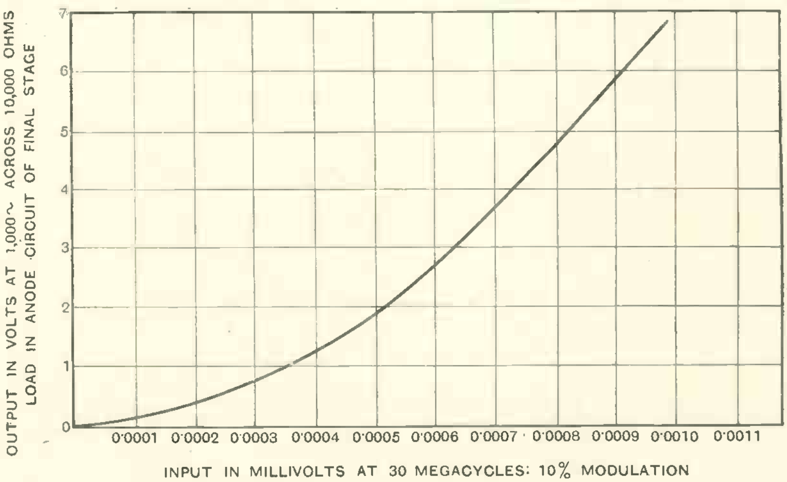


Fig. 11.—*Input-output characteristic of five-valve supersonic heterodyne receiver No. 5 (maximum retroaction).*

It was not considered that any very useful purpose could be served by extending the tests to cover practical reception from a transmitter at relatively large distances, on account of the great variations in effective signalling range which are produced by natural and artificial obstacles on the ground itself. Some idea of the possibilities of the use of these receivers for communication purposes may, however, be obtained from the following experience which has been obtained with

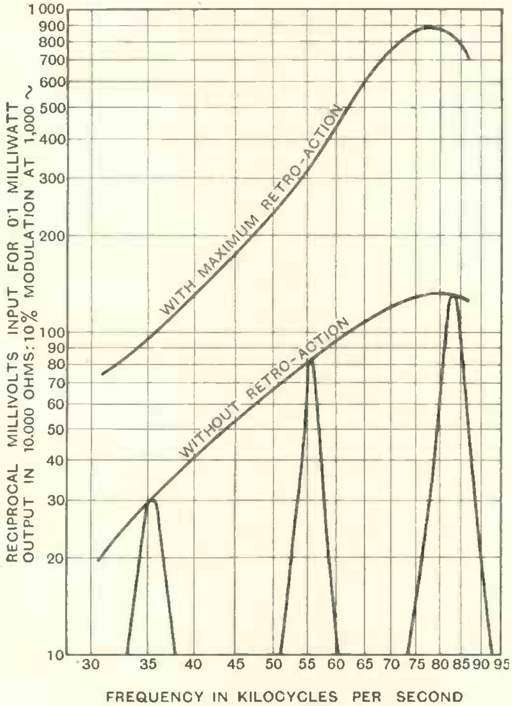


Fig. 12.—*Characteristics of intermediate frequency amplifier in receiver No. 5.*

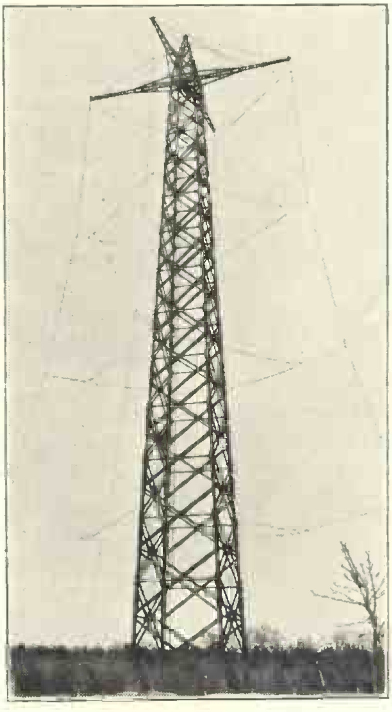
the simple two-valve type of receiver, which was shown to be the least sensitive of the five receivers tested. This receiver has been found to be very useful in making relative signal strength measurements at distances up to 600 metres from a low-power transmitter feeding a half-wave aerial with a maximum current of about half an ampere. The same receiver is capable of giving adequate reception of signals from this type of transmitter, both for communication and for direction-finding purposes, at ranges up to 20 miles when there is a clear optical path between transmitter and receiver. For transmissions directly along the ground under similar conditions, this range may be reduced to 3 or 4 miles.

The work described in this paper has been carried out for the Radio Research Board, and the authors are indebted to the Department of Scientific and Industrial Research for granting permission for its publication.

OVERCOMING "SKIP DISTANCE" EFFECT.

THE German short-wave station at Zeesen has been employed for a number of interesting tests, and preparations have recently been made to try out a new type of aerial by means of which it is hoped that short-wave transmissions will be receivable without the customary "skip distance" effect.

Zeesen has been very well received on its transmissions of 31.38 metres at great distances, but at short ranges reception has been very poor. The new arrangement of the radiating system aims at providing for the radiation to travel more or less parallel to the earth's surface. The aerial consists of a bird-cage arrangement, and a wooden mast carrying two pairs of cross-bars, one at the



The aerial system at Zeesen.

top and another at the height of 80 feet supports the aerial system stretched between the ends of these cross-bars.

A Note on

The Frequency Analysis of the Heterodyne Envelope.*

Its Relation to Problems of Interference.

By F. M. Colebrook, B.Sc., D.I.C., A.C.G.I.

(*Wireless Division, National Physical Laboratory.*)

SUMMARY.—The exact form of the envelope of the heterodyne combination of two sine waves, and its comparison with a pure tone modulated continuous wave, is a matter of some importance in connection with selective reception of radio communication.

The frequency analysis of the envelope is described in detail. It is shown that it can be represented as a Fourier series with a fundamental frequency equal to the difference of the frequencies of the constituent sine waves, and with appreciable harmonic content. The maximum equivalent amplitude modulation is just under 70 per cent., which is given by equal amplitudes of the two sine waves. A brief experimental verification of the analysis is given.

As a means of producing the equivalent of a single tone modulated wave of known characteristics, the heterodyne combination of two continuous waves is only satisfactory for small modulation percentages.

The modulation frequency output produced by the perfect rectification of a heterodyne combination is, in energy, less than a quarter of that given by a tone modulated continuous wave with similar constituent amplitudes.

The frequency analysis of the heterodyne envelope illustrates the effect known as the apparent demodulation of a weaker station by a stronger one. It is due to the difference between the partial derivatives of the constant term in the analysis, with respect to the constituent amplitudes.

The analysis also shows that a single side band system of broadcast transmission would not give, on rectification, a faithful reproduction of the original modulation, but would give rise to a number of extraneous difference frequencies, in addition to the introduction of harmonics.

1. Introductory.

THE form of the envelope of the interference pattern produced by the heterodyning of two radio-frequency currents or potential differences is a matter of some interest at the present time on account of its relation to the problem of the selective reception of modulated transmissions. There is, for example, the question of the difference between the response of a selective receiver to a carrier wave with its associated side-frequencies above and below the mean frequency, and the response of the same receiver to the heterodyne excitation due to the interference of adjacent carrier waves.

The subject has other practical aspects depending on the comparison between a pure tone modulated wave and a heterodyne combination. If, for example, the heterodyne combination can be interpreted as a pure tone modulated wave, then the use of two radio-frequency oscillators suggests itself as a convenient means of producing a modulated wave of accurately known characteristics, for test purposes. Such a practical application has, in fact, already been described in a paper by W. B. Medlam and U. A. Oschwald (Bib. No. 1). This paper, however, emphasises the need for a discussion of the subject, for it contains the incorrect statement that the heterodyne combination of two radio-frequency electro-motive forces is equivalent to 100 per cent. modulation by a tone of half the difference frequency.

A paper by F. E. Terman (Bib. No. 2) gives some account of the envelope of the heterodyne pattern, but detailed values are only given for the special case of equal amplitudes. An earlier paper by B. Van der Pol (Bib. No. 3) is also confined to this special case. For the general case Terman gives a binomial expansion which, however, is very deceptive in its convergency. An inspection of the coefficients suggests a fairly rapid convergency, but in fact the convergency is impracticably slow over much of the range required. A different method, developed by Vigoureux, based on the evaluation of the Fourier coefficient integrals by expansion in terms of Legendre coefficients, is used in the present paper.

* MS. received by the Editor, June, 1931.

2. Analytical Representation of the Heterodyne Interference Pattern.

Let $e_1 = \hat{e}_1 \sin \omega_1 t$

$e_2 = \hat{e}_2 \sin \omega_2 t$

then

$$e = e_1 + e_2 = \hat{e} \sin (\omega t + a)$$

where

$$\omega = (\omega_1 + \omega_2)/2$$

$$\tan a = \frac{\hat{e}_1 - \hat{e}_2}{\hat{e}_1 + \hat{e}_2} \tan \frac{(\omega_1 - \omega_2)t}{2}$$

and $\hat{e} = \{\hat{e}_1^2 + \hat{e}_2^2 + 2\hat{e}_1\hat{e}_2 \cos (\omega_1 - \omega_2)t\}^{\frac{1}{2}}$

It should be noted that the periodic variation of the phase angle a with a fundamental angular frequency $(\omega_1 - \omega_2)/2$ is equivalent to a certain degree of phase or frequency modulation. There is, however, no reason to suppose that this fact will play any part in the process of the rectification of the heterodyne combination, assuming the e.m.fs. e_1 and e_2 to be those actually operating on the terminals of the rectifier. In any such process it is the form of the envelope (*i.e.*, the variation of $\hat{e}$) that is significant.

Putting $\theta = (\omega_1 - \omega_2)t$

and $\hat{e}_2/\hat{e}_1 = r$; $r \leqslant 1$

$$\hat{e} = \hat{e}_1(1 + 2r \cos \theta + r^2)^{\frac{1}{2}}$$

We require, therefore, the Fourier analysis of the r, θ function as a series of multiples of θ. The integrals obtained by the usual

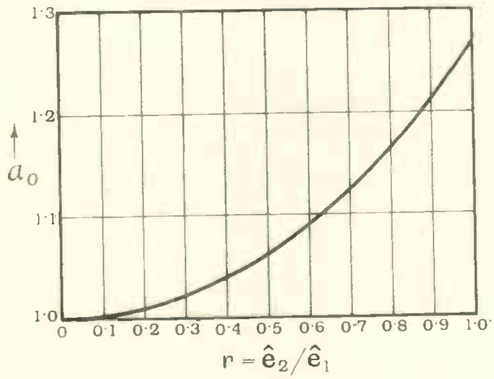


Fig. 1.—*Curve showing the variation of the effective carrier wave amplitude of a heterodyne combination.*

Fourier analysis cannot be directly evaluated and some form of expansion of the function suggests itself as an alternative.

An obvious method is the re-arrangement of the function in the form :—

$$(1 + 2 r \cos \theta + r^2)^{\frac{1}{2}} = (1 + r^2)^{\frac{1}{2}}\left(1 + \frac{2r \cos \theta}{1 + r^2}\right)^{\frac{1}{2}}$$

followed by the binomial expansion of the

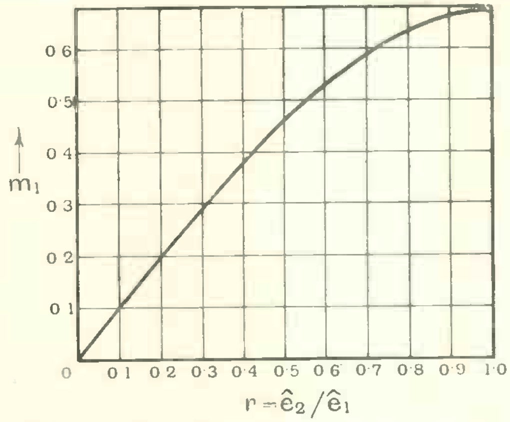


Fig. 2.—*Curve showing the variation of the effective modulation ratio of fundamental beat frequency in a heterodyne combination.*

function of θ in powers of θ, these being then converted to multiples of θ by the usual trigonometrical formulae ; but, as already pointed out, the resulting series, though convergent, is, for the larger values of r, very deceptive in convergency, for the higher order terms, though very small, decrease very slowly.

A more accurate and convenient method of analysis was worked out by a colleague of the writer, P. Vigoureux. The detail of this is given in an appendix. The results obtained are expressed as follows :—

$$(1 + 2r \cos \theta + r^2)^{\frac{1}{2}} = a_0(1 + m_1 \cos \theta - m_2 \cos 2\theta + m_3 \cos 3\theta - m_4 \cos 4\theta + \text{etc.} \ldots)$$

The values of a_0 and of the m coefficients up to m_4 for values of r from 0 to 1 in steps of 0.1 are shown in Table I on the opposite page and in the curves of Figs. 1 to 5. The root mean square values

$$M = (m_1^2 + m_2^2 + m_3^2 + m_4^2)^{\frac{1}{2}}$$

are also shown in the table and in the curve of Fig. 6.

3. Experimental.

Some degree of experimental confirmation of the above analysis was obtained as follows.

The e.m.fs. e_1 and e_2 were applied separately and then together to the terminals of a calibrated valve rectifier giving approximately linear rectification. The frequency difference was 1,000 cycles (the radio frequencies being about 300 kilocycles per second). As the recording instrument was a direct current microammeter, it gave readings proportional to the mean value of the rectified response in each case, *i.e.*, readings proportional to $\hat{e}_1$, $\hat{e}_2$ and $a_0\,\hat{e}_1$, the last being the mean value of e. The results obtained were as follows :—

TABLE I.

r	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
a_0	1.002	1.010	1.023	1.038	1.063	1.088	1.124	1.164	1.208	1.272
m_1	0.100	0.198	0.288	0.378	0.455	0.526	0.581	0.628	0.660	0.668
m_2	0.0025	0.0099	0.0215	0.0374	0.0548	0.0745	0.0946	0.1132	0.1283	0.1336
m_3	0.0001	0.0010	0.0031	0.0073	0.0135	0.0217	0.0320	0.0440	0.0525	0.0566
m_4	0.0000	0.0002	0.0005	0.0020	0.0042	0.0084	0.0147	0.0228	0.0288	0.0318
M	0.0999	0.1985	0.2890	0.3795	0.4585	0.5318	0.5897	0.6400	0.6750	0.6843

$\hat{e}_1$	$\hat{e}_2$	$a_0\hat{e}_1$ measured.	$a_0\hat{e}_1$ calculated.
7.70	3.65	8.25	8.12
7.50	3.15	7.83	7.83
7.63	2.70	7.90	7.88
8.18	3.53	8.58	8.55
6.95	3.15	7.30	7.29

In addition the peak value of the alternating voltage developed across a pure resistance with approximately linear rectification was also measured by a second calibrated rectifier. This peak value can be calculated from the above analysis, for it is proportional to

$$a_0\hat{e}_1(1 + m_1 - m_2 + m_3 - m_4 \text{ etc.})$$

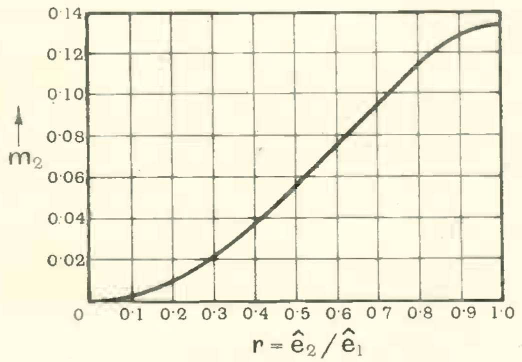


Fig. 3.—*Curve showing the variation of the effective modulation ratio of the second harmonic of the beat frequency in a heterodyne combination.*

The agreement between measured and calculated values was not so good in this case, possibly on account of the fact that the second rectifier was operating at voltages rather too small to give a response accurately proportional to peak voltage.

Measured Value of peak voltage. Volts.	Calculated Value. Volts.
15.14	15.05
12.45	13.15
10.75	11.55
14.80	14.80
12.45	12.90

It is not considered necessary to give full experimental details, since the measurements are only of subsidiary interest in the present paper.

4. Practical Conclusions.

(*a*) *Production of a modulated radio-frequency electro-motive force by the heterodyning of two radio-frequency oscillators.*

In the absence of any convenient and accurate method of measurement of modulation percentage, the production of a modulated wave of accurately known characteristics is a matter of some difficulty. A method commonly employed is to determine the radio-frequency amplitude—static anode potential characteristic of an oscillator or amplifier under conditions such that this is practically a straight line, and then to superimpose on the static anode potential an audio-frequency voltage of known magnitude. It is then assumed that the modulation frequency variation of radio-frequency amplitude can be calculated by multiplying the slope of the above characteristic by the peak value of the modulation frequency voltage. This, however, tacitly assumes that the characteristic involved does not depend on the rate of variation of anode potential. A consideration of an extreme case, *e.g.*, the modulation of a quartz controlled oscillator, suggests that in fact this assumption is not justified, though the error may be small under normal practical con-

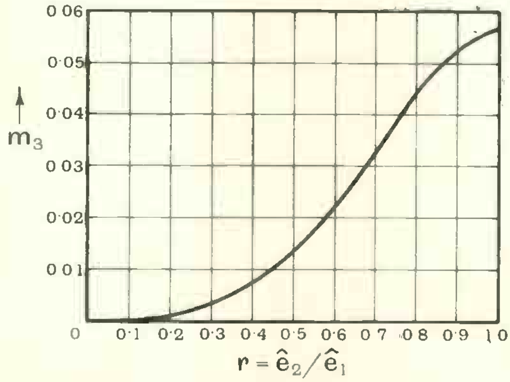


Fig. 4.—*Curve showing the variation of the effective modulation ratio of the third harmonic of the beat frequency in a heterodyne combination.*

ditions. On this matter there appears to be no information available, but it is reasonable to suppose that the well-known phenomenon, known colloquially as "side-band cutting" in reception, has its counterpart in the generation of modulated waves. In reception the effect depends on the decrement of the receiving system, but it is not immediately obvious what is the corresponding factor in a maintained oscillating system. This matter, however, is outside the scope of the present paper. The immediate point is whether the heterodyning of two radio-frequency oscillators with easily measurable relative amplitudes provides a practicable means of producing a modulated wave of known characteristics. The above analysis gives the answer to this question. The resultant of the process is not equivalent to a pure tone modulated wave, but is in effect a continuous wave with a certain degree of phase modulation and with amplitude modulation by a more or less distorted wave-form of fundamental beat frequency. The amount of the departure from purity in the wave form depends on the relative amplitudes. Thus with a ratio of ten to one the second harmonic is only 2.5 per cent. of the fundamental, but with equal amplitudes it is about 20 per cent. It is interesting to note, in addition, that the highest modulation percentage obtainable is about 70 per cent., when the constituent oscillations are of equal amplitude. This is the case which, according to Medlam and Oschwald (see the paper referred to above) gives 100 per cent. modulation at twice the beat frequency. Actually it gives about 70 per cent. modulation at the beat frequency but with a distorted wave form.

Thus the heterodyne method of producing a known modulated wave is only suitable for very small modulation percentages, not exceeding about 20 per cent., and even under these conditions the modulation wave form will contain up to 4 per cent. of second harmonic. The modulation percentage will be very approximately equal to the ratio of the constituent radio-frequency amplitudes.

(*b*) *Interference.*

From the point of view of interference some interest attaches to the comparison between a pure tone modulated wave and a heterodyne combination of the type discussed above, which typifies the effect of two adjacent carrier waves.

The system of carrier and side frequencies represented by $\hat{e}\cos\omega t$ and $(m\hat{e}/2)\cos(\omega \pm n)t$ gives an envelope $\hat{e}(1 + m\cos nt)$, and perfect

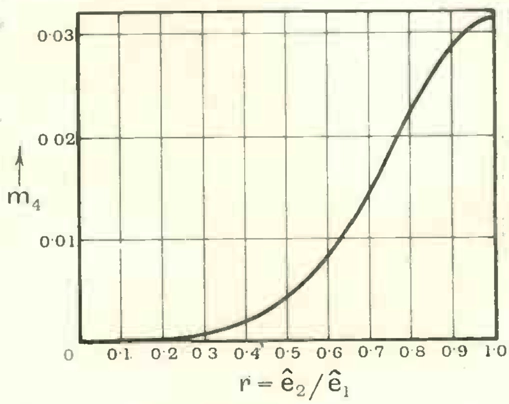


Fig. 5.—*Curve showing the variation of the effective modulation ratio of the fourth harmonic of the beat frequency in a heterodyne combination.*

rectification gives a modulation frequency response proportional to $m\hat{e}$. With a carrier and a single side frequency only the response at the beat frequency given by perfect rectification will be proportional to $m\hat{e}/2$ if m is small, and less than this as m approaches unity. Thus for m equal to unity (100 per cent. modulation in the carrier and double side frequency system), the beat frequency responses given by the double and single sideband systems will be as 1 to 0.45. Thus the audio-frequency response given by an interfering carrier would be less than a half in potential (*i.e.*, less than one-quarter in energy) of that given by the two side frequencies each of amplitude equal to that of the interfering carrier frequency. The potential differences here considered are assumed to be those applied to the terminals of the rectifier, but it should be noted that the same conclusions will be true of the whole process of reception, irrespective of the selectivity of the tuned receiving circuit, provided the latter is such as to give side frequency responses of equal amplitude and symmetrical phase with respect to that of the carrier.

The above discussion applies to cases in which the interfering carrier wave is sufficiently close in frequency to that of the wanted station to give an audible beat note on rectification. If the frequency difference is supersonic and the rectification system such that it is capable of faithful reproduction of modulation frequencies, but will record only the mean value of variation in amplitude at supersonic frequency, another effect becomes operative, also tending to a diminution of the interfering effect of the weaker station. This is an effect which has been studied in some detail by Beatty and Butterworth under the title "The apparent demodulation of a weak station by a stronger one" (Bibliography Nos. 4 and 5). Further papers on this subject by Dr. G. W. O. Howe and the present writer are also listed in the bibliography (Nos. 6 and 7).

The above-mentioned publications make it unnecessary to consider the apparent demodulation effect in detail, but for the sake of completeness it may be pointed out that the present paper contains the data required for a quantitative evaluation of the effect. It depends on the variation of the continuous component a_0 with respect to the constituent amplitudes $\hat{e}_1$ and $\hat{e}_2$. Let a_0 be written $a_0(\hat{e}_1, \hat{e}_2)$ to emphasise its functional dependence on the constituent amplitudes. Further, let $\hat{e}_1$ be the potential difference produced at the terminals of a perfect rectifier by the carrier wave of the desired transmission, and let $\hat{e}_2$ be the similar potential difference due to the carrier of an interfering modulated transmission, the frequency difference between the transmissions being supersonic. Then the modulation

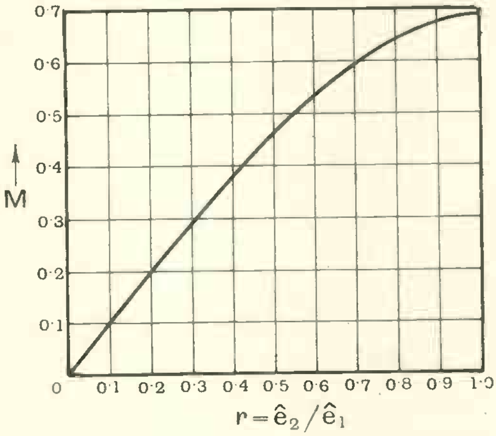


Fig. 6.—*Curve showing the root-mean-square value of the effective modulation ratio of a heterodyne combination.*

frequency output derived from $\hat{e}_2$ will be proportional to $\partial a_0(\hat{e}_1, \hat{e}_2)/\partial \hat{e}_2$. If $\hat{e}_1$ is not present it will be proportional to

$$\partial a_0(0, \hat{e}_2)/\partial \hat{e}_2.$$

The apparent demodulation effect arises from the fact that the first of these derivatives is very considerably smaller than the second if $\hat{e}_2$ is small compared with $\hat{e}_1$, so that the presence of $\hat{e}_1$ has the effect of greatly reducing the modulation frequency output derived from $\hat{e}_2$.

(*c*) *Single and double side band systems for telephony.*

The suppression of one of the two sets of side bands in telephony or broadcast transmissions offers obvious advantages in the matter of interference. There are, however, certain other considerations which arise from the foregoing analysis of the heterodyne envelope.

In the first place, it has already been pointed out that for equal field intensities the single side band system would give available for reception rather less than a quarter of the energy of the double side band system. This, however, would not be a serious drawback, as it would presumably be possible to increase the intensities in the single side band system for a given total output power of the transmitter.

A more important consideration is the question of fidelity of reproduction. It has already been shown that the linear rectification of two radio-frequency waves does not give a pure tone of the difference frequency. Thus, for example, a single side band transmission derived from, say, a hundred per cent. pure tone modulated transmitter by the suppression of one of the side frequencies would give a single side band of half the amplitude of the carrier. The linear rectification of this as shown in Table I would give a second harmonic of just over 10 per cent. superimposed on the original modulation tone. That, however, is not the only source of distortion. The combination of three pure radio-frequency sine waves in the same manner as described in section 2 gives as the resultant amplitude

$$\hat{e} = \{\hat{e}_1^2 + \hat{e}_2^2 + \hat{e}_3^2 + 2\,\hat{e}_1\,\hat{e}_2\cos(\omega_1 - \omega_2)t + 2\,\hat{e}_1\,\hat{e}_3\cos(\omega_1 - \omega_3)t + 2\,\hat{e}_2\,\hat{e}_3\cos(\omega_2 - \omega_3)t\}^{\frac{1}{2}}$$

Thus, assuming that ω_1 was the original carrier frequency, the linear rectification of this resultant will reproduce not only the original modulation frequencies $(\omega_1 - \omega_2)$ and $(\omega_1 - \omega_3)$, with the distortion already indicated, but will also reproduce the extraneous difference frequency $(\omega_2 - \omega_3)$, which is the difference of the original modulation frequencies. A generalisation of this shows that all the difference frequencies of the original modulation will appear in the rectified output. The same is obviously true for square law rectification, except that the harmonic distortion already referred to will not be present in this case, since the output will be proportional to e^2.

It would appear that this fact is not of great importance in relation to the transmission of commercial telephony, for the system has been found to give intelligible speech. As applied to broadcast systems, where faithful reproduction of music was required, it might be more important.

In conclusion, the writer wishes to acknowledge his indebtedness to Mr. P. Vigoureux, of the Electrical Measurements and Standards Division, National Physical Laboratory, for the assistance already referred to in the text and to Mr. B. J. Byrne of the Wireless Division, National Physical Laboratory, who made the necessary calculations.

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

Appendix.

Outline of Vigoureux's expansion for the frequency analysis of the heterodyne envelope.

$$(1 + 2r\cos\theta + r^2)^{\frac{1}{2}} = a_0 + \sum_1^\infty a_n \cos n\theta$$

where

$$a_0 = \frac{1}{2\pi}\int_0^{2\pi}(1 + 2r\cos\theta + r^2)^{\frac{1}{2}}d\theta$$

$$a_n = \frac{1}{\pi}\int_0^{2\pi}(1 + 2r\cos\theta + r^2)^{\frac{1}{2}}\cos n\theta d\theta$$

$$= (-1)^n\frac{2}{\pi}\int_0^{\pi}(1 - 2r\cos\theta + r^2)^{\frac{1}{2}}\cos n\theta d\theta$$

$$= (-1)^n\frac{2}{\pi}\left\{\int_0^{\pi}\frac{(1 + r^2)\cos n\theta d\theta}{(1 - 2r\cos\theta + r^2)^{\frac{1}{2}}} - \int_0^{\pi}\frac{2r\cos\theta\cos n\theta d\theta}{(1 - 2r\cos\theta + r^2)^{\frac{1}{2}}}\right\}$$

Now

$$(1 - 2r\cos\theta + r^2)^{-\frac{1}{2}} = P_0 + P_1 r + P_2 r^2 + \text{etc., etc., } ad\ inf.$$

where
$$P_m = \frac{1 \cdot 3 \ldots . 2m - 1}{2 \cdot 4 \ldots . 2m}2\cos m\theta + \frac{1}{2}\cdot\frac{1 \cdot 3 \ldots . 2m - 3}{2 \cdot 4 \ldots . 2m - 2}2\cos(m-2)\theta + \frac{1 \cdot 3}{2 \cdot 4}\frac{1 \cdot 3 \ldots . 2m - 5}{2 \cdot 4 \ldots . 2m - 4}2\cos(m-4)\theta + \text{etc., etc.}$$

We thus arrive at various groups of integrals of the form

$$\int_0^{\pi} f(r)\cos m\theta\cos n\theta d\theta$$

$f(r)$ being an infinite series in ascending powers of r. All these integrals are zero except those for which m and n are equal, so the complete evaluation is less laborious than would appear at first sight. The detail of the process need not be given, as it is quite straightforward. It leads to the following general formulae for a_0 and a_n.

$$a_0 = 1 + \frac{1}{2^2}r^2 + \left(\frac{1}{2}\right)^4\frac{1}{4^2}r^4 + \left(\frac{1 \cdot 3}{2 \cdot 4}\right)^2\frac{1}{6^2}r^6 + \left(\frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6}\right)^2\frac{1}{8^2}r^8 + \text{etc., etc., } ad\ inf.$$

$$a_n = 2(-1)^n r^n\frac{1 \cdot 3 \ldots . . 2n - 1}{2 \cdot 4 \ldots . . 2n}\left[-\frac{1}{2n-1} + \frac{1}{2}\cdot\frac{1}{2n+2}r^2 + \sum_{m=2}^{m=\infty}\frac{1 \cdot 3 \ldots . (2m-3)}{2 \cdot 4 \ldots . 2m}\cdot\frac{(2n+1)(2n+3)\ldots . .(2n+2m-3)r^{2m}}{(2n+2)(2n+4)\ldots . .(2n+2m)}\right]$$

It should be noted that a_0 is a standard elliptic integral and need not be separately evaluated. Also the special case of equal amplitudes ($r = 1$) reduces as follows :—

$$(1 + 2r \cos \theta + r^2)^{\frac{1}{2}} = 2 \cos \frac{\theta}{2} \text{ when } r = 1$$

Thus the envelope of the interference pattern for equal amplitudes is given by $2 \mid \cos \theta/2 \mid$, which can be expanded in a Fourier series by the ordinary method, giving :—

$$2 \mid \cos \theta/2 \mid = \frac{4}{\pi}\left\{1 - 2 \sum_{2}^{\infty} \frac{\cos n\pi/2 \cos n\theta/2}{n^2 - 1}\right\}$$

$$= \frac{4}{\pi}\{1 + 2/3 \cos \theta - 2/15 \cos 2\theta + 2/35 \cos 3\theta - 2/63 \cos 4\theta, \text{ etc.}\}$$

NOTE.—Since the above paper was written the author has had occasion to re-examine the matter of demodulation, referred to in Section 4 (b), in the light of a paper by C. B. Aiken on "The Detection of Two Modulated Waves which Differ Slightly in Carrier Frequency," *Bell System Tech. Journ.*, 1931, Vol. 10, pp. 1-19. It appears that the demodulation effect proper, *i.e.*, the reduction of the intensity of the reproduction of the actual modulation of the interfering station, does not depend on the carrier beat frequency, and will occur whether this beat frequency is supersonic or not. The relation between the carrier beat frequency and the demodulation effect is indirect, in that for given field intensities the disparity of the rectifier voltages will be greater the greater the beat frequency. In practice, therefore, the demodulation effect will tend to be more pronounced with a supersonic frequency separation between the stations, but the beat frequency is not otherwise involved in the analysis of the effect. Briefly, for given carrier-rectifier voltages the effect depends on the ratio of these voltages and not on their frequency difference.

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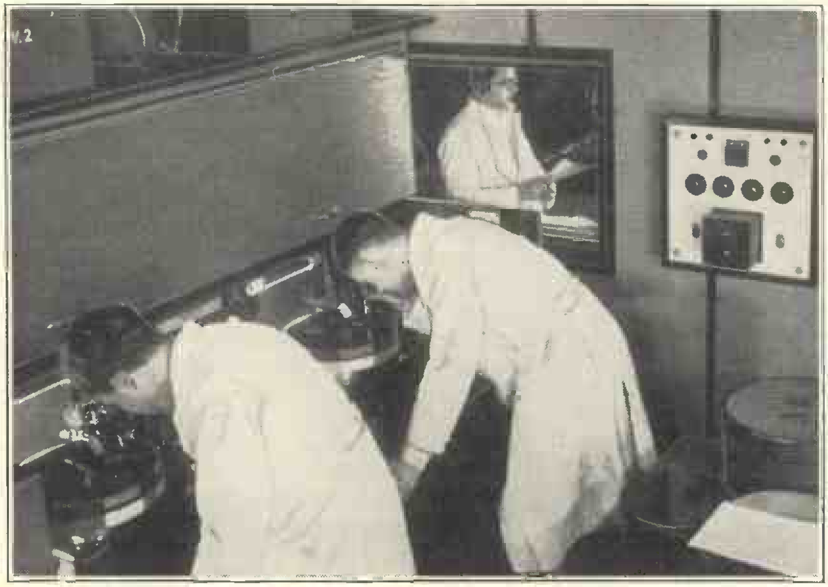
SOUND REPORTING SERVICE.

A NEW development in broadcast "running commentaries" is reported from Germany, where the Norag broadcasting organisation, covering North Germany, employs a reporting van which is sent to places of interest and current happenings are recorded for subsequent broadcasting during the evenings' programmes.



The interior of a reporting van, showing sound recording in progress. The reporter giving the running commentary can be seen through the window.

The Graphical Solution of Detector Problems.*

By G. S. C. Lucas, A.M.I.E.E.

(*B.T.H. Co., Engineering Laboratory.*)

SOME time ago the writer was engaged in experimental work using a thermionic valve as a detector and developed what he believes to be a novel graphical method for solving detector problems. The method is applicable to problems in anode bend or grid detection with diode, triode, screen grid and pentode valves, and requires very little mathematical knowledge. Once standard valve curves are available, fairly accurate results can be obtained in a few minutes. The calculated efficiencies obtained by the graphical method have been checked by actual measurement, and the results show a very close agreement.

The solution of problems in anode bend detection makes use of a curve relating plate current and $\frac{\text{plate voltage}}{\text{“}m\text{” factor}}$, hereafter referred to as the $I_p - \frac{E_p}{m}$ characteristic, which was first mentioned by Mr. L. J. Davies of the B.T.H. Engineering Laboratory in a lecture given before the Rugby Engineering Society in December, 1928.

GRAPHICAL SOLUTION APPLIED TO GRID RECTIFICATION.

The application of the graphical method to grid rectification is first explained because it is somewhat simpler than anode bend rectification.

Consider, first, a thermionic valve with the grid biased positively, so that the grid current is I_0 (see Fig. 1). If an A.C. signal is impressed on the grid, the grid current rises from I_0 to I_1. The new value of grid current, I_1, can be determined graphically in the following manner. Join the points *ab* by a straight line, and take $\frac{1}{2}$ *cd* as the increase in current when the signal $E \sin \theta$ is impressed on the grid. The new reading of grid current is $I_0 + \frac{1}{2} cd = I_1$.

The proof of the above method for determining the rectified current is given in Appendix 2, and it will be seen to be sufficiently accurate for practical purposes.

Fig. 2 shows a resistance R connected in the grid circuit with the bias voltage re-adjusted so that the potential of the grid is still 1 volt positive with respect to the filament. When an A.C. signal is impressed on the

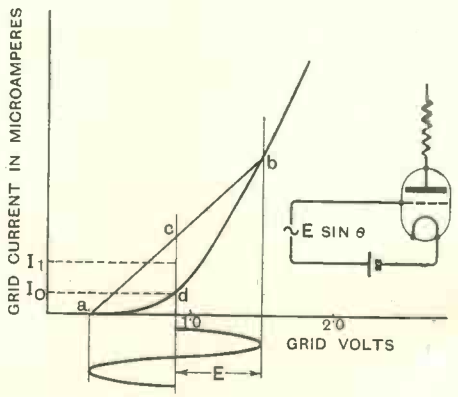


Fig. 1.—*Grid volt-grid current curve.*

grid, the grid current rises and the increased current flowing through the resistance R lowers the potential of the grid. The relation between the volts drop across the external resistance and the current flowing through it may be shown graphically by drawing the line fe_3 through the point d with a slope equal to the external resistance R. If the grid current increases from I_0 to I_1, the potential of the grid will change from e_1 to e_2 and the A.C. signal necessary to produce this change can be determined graphically in the following manner. Extend the line e_2k to c so that $kf = fc$, and through the point c draw the line acb, so that $ac = cb$. Then, the maximum amplitude of the A.C. voltage on the grid necessary to produce a change in grid current of $I_1 - I_0$ and a change in grid volts $e_1 - e_2$, is E volts.

By repeating the construction for other

* MS. received by the Editor, July, 1931.

values of grid current, greater or less than I_1, the relation between the change in amplitude of the A.C. signal and the change in grid potential can be determined.

So far no mention has been made of the condenser C shunting the resistance R. Without this condenser, the resistance R decreases the slope of the grid current curve, while with a condenser of such a value that its impedance, at the frequency of the signal on the grid, is small compared to R and the average grid resistance, the slope of the grid current curve may be assumed to be unchanged. A greater change of grid current will, therefore, result for a given change in A.C. signal if a suitable condenser is used.

If the amplitude of the A.C. signal is slowly changed, the mean D.C. grid current changes, and, therefore the potential of the grid, and if the change in amplitude of the signal is effected by modulating it with a voltage of much lower frequency, the potential of the grid will vary at the frequency of the modulating voltage. The value of the shunting condenser should be such that its reactance at the lower frequency of modulation is high compared with R and small compared with R at the higher frequency of the A.C. signal.

With grid rectification, a high frequency signal of varying amplitude, the amplitude being varied by modulating it at speech frequencies, is applied to the grid circuit of

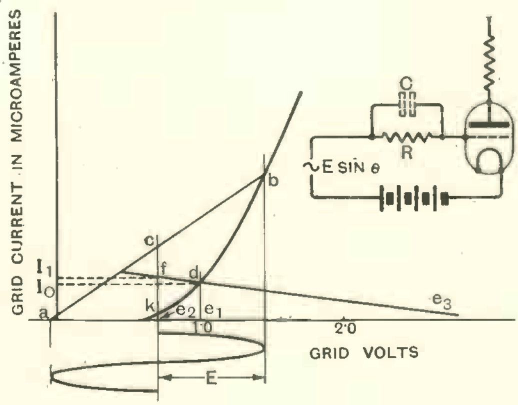


Fig. 2.—*Grid volt-grid current curve.*

the valve and the change in amplitude of the high frequency signal causes low frequency speech currents to flow through the grid leak resistance and so alter the potential of the grid at speech frequencies. The low frequency variation in grid potential is amplified by the valve as an ordinary amplifying valve. The efficiency of a grid detector can be determined by the method

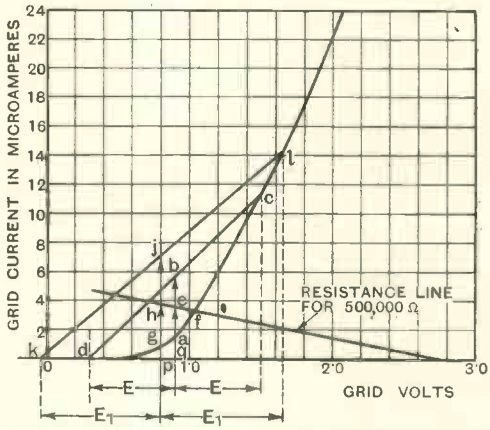


Fig. 3.—*Grid volt-grid current characteristic for G.P. 407 valve.*

described above, where the change in amplitude of the A.C. signal is determined for a given change in grid potential.

In order to make the method clear, an example is worked out below.

Example.

Using a G.P. 407 valve as a grid detector, the $I_g - E_g$ curve for which is shown in Fig. 3, and assuming :—

Frequency of carrier	$= 4 \times 10^5$ cycles/sec.
Maximum frequency of modulation	$= 5 \times 10^3$,,
Amplitude of carrier	$= 0.6$ volt max.
Grid leak resistance (R)	$= 0.5$ megohm.
Amplification factor of valve (m)	$= 14$.
Anode resistance of valve (R_a)	$= 20{,}000$ ohms.
Anode load (R_x)	$= 100{,}000$ ohms.

Find :—

(*a*) Efficiency of the detector.

(*b*) Low frequency voltage developed across anode load resistance.

(*c*) Value of shunt capacities for grid leak and anode load resistance.

The values of the shunt capacities are neglected for the moment, and it is assumed that the capacity of the grid condenser has infinite reactance at 5×10^3 cycles, and zero resistance at 4×10^5 cycles. The question of the choice of capacity is discussed in Appendix 1.

Through the point of the $I_g - E_g$ curve, where the rate of change of slope is greatest,* draw the line *ab* and step off on either side a voltage of 0.6 volt (E).

Join the points *cd* by a straight line.

Then $qe = qa + \frac{1}{2}ab$ gives the value of the grid current when the carrier signal is applied to the grid.

Through the point *e* draw the resistance line *ef*, the slope of which is equal to the grid leak resistance of 500,000 ohms.

Take another ordinate *gh*, and extend to *j* so that $gh = hj$, and draw the line *kjl* to meet the curve, so that $kj = jl$.

Then $E_1 = 0.85$ volt and the change in the potential of the grid for a change in the amplitude of the carrier from 0.6 to 0.85 is $pq = 0.1$ volt.

Expressing the efficiency of the detector as

$$\frac{\text{Change in L.F. potential of the grid}}{\text{Change in amplitude of carrier}} \times 100\,\% = \frac{pq}{E_1 - E} \times 100\,\%$$

$$= \frac{0.1 \times 100}{0.85 - 0.6} = 40\,\%$$

As already stated, the low frequency voltage developed across the anode load can be determined as for an ordinary amplifying valve, from the equation :—

$$\frac{R_x \times m \times \text{Change in potential of grid}}{R_x + R_a}$$

and assuming the carrier voltage of 0.6 volt to be modulated to 30 per cent., the peak value of the low frequency voltage drop across R is equal to

$$0.6 \times \frac{30}{100} \times \frac{40}{100} = 0.072 \text{ volts}$$

Substituting this value in the above equation, the peak value of the low frequency voltage drop across R_x is

$$0.72 \times \frac{100{,}000 \times 14}{120{,}000} = 0.84 \text{ volt}$$

* *See* Appendix 3.

The efficiency of detection will, of course, depend upon the amplitude of the carrier and the point of the grid curve over which rectification takes place.

Referring again to Fig. 3, the slope of the line *dbc* gives the mean resistance of the valve between the grid and filament, or, in other words, the average grid damping. The value of the bias volts is given by the intersection of the line *hf* on the abscissae, *i.e.*, 2.75 volts positive.

Then, collecting data obtained, assuming 30 per cent. modulation of a carrier signal of 0.6 volt :—

Efficiency of detector	= 40 per cent.
L.F. voltage drop across R	= 0.072 volt max.
L.F. voltage drop across R_x	= 0.84 volt max.
Mean grid to filament resistance	= 100,000 ohm.
Grid bias volts	= + 2.75 volts.
Grid capacity (see Appendix 1)	= 150 μμF

Care should be taken to see that the plate volts on the valve are high enough to ensure that the valve always operates over the straight part of the plate current-grid volts curve. Referring to our example, the static curve for the valve with 100,000 ohms in the plate circuit should be straight over the maximum grid swing, *i.e.*, from 0 to + 1.6 volts. Where large inputs are used, the plate voltage may require to be as high as 200 volts with a battery voltage of 300 to 400 volts, depending upon the value of the anode resistance. Very frequently the plate volts are so low that the valve acts as an anode bend detector, as well as grid detector.

The anode resistance should, in every case, be shunted with a condenser suitable for by-passing the radio frequency carrier signal. The method for determining the correct value of capacity is the same as for the grid condenser, as explained in Appendix 1.

It is assumed that the grid current-grid voltage curve for the valve is independent of plate voltage, and although this is not true for large variations of plate voltage, it is practically so over the normal operating range. It is, however, advisable to plot a grid current-grid voltage curve with the plate voltage at which it is proposed to run the valve. Also, for a given type of valve the position of the curve may change, although its shape remains approximately the same for different valves, *i.e.*, the curves move bodily along the abscissae. This difficulty can be overcome by adjusting the grid bias until the steady grid current is the same as for the standard valve.

Calculations show that when working the detector at the most efficient point, the grid damping is often very high, the equivalent resistance being of the order of 100,000 ohms, and unless the grid input circuit is carefully designed, the effect of this high damping will be to decrease the amplitude of the signal. This point should always be kept in mind, as it is often responsible for very misleading results.

APPENDIX 1.

Choice of Shunting Condenser.

In the foregoing calculations, it was assumed that the reactance of the condenser was zero at the frequency of the carrier, and infinite at the audio-frequencies. This condition can never be obtained in practice, and it is necessary to determine the value of capacity that most nearly approaches the ideal condition. Therefore, a value of C is chosen so that the percentage decrease in the highest audio-frequency signal across the grid resistance, due to the condenser reactance not being infinite, is equal to the percentage of radio-frequency voltage remaining due to the reactance at the radio-frequency not being zero.

Then if

R = Grid leak resistance
r = Average grid to filament resistance
C = Shunting capacity.
e = Voltage drop across R and C
e_1 = Voltage drop across R when $C = 0$
E = Total voltage in the grid circuit
ω_1 = 2π × frequency of the highest audio-frequency
ω_2 = 2π × frequency of the carrier
p_1 = Fraction of voltage drop at ω_1
p_2 = Fraction of voltage remaining at ω_2

Then at ω_1

$$e = \frac{ER}{\sqrt{(R+r)^2 + (\omega_1 CRr)^2}} = (1 - p_1)e_1 \quad (1)$$

and at ω_2

$$e = \frac{ER}{\sqrt{(R+r)^2 + (\omega_2 CRr)^2}} = p_2 e_1 \quad \cdots \quad (2)$$

and

$$e_1 = \frac{ER}{R+r} \quad \cdots \quad \cdots \quad (3)$$

From equations (1), (2) and (3)

$$p_1 = 1 - \frac{1}{\sqrt{1 + \frac{(\omega_1 CRr)^2}{(R+r)}}} \quad \cdots \quad (4)$$

$$p_2 = \frac{1}{\sqrt{1 + \frac{(\omega_2 CRr)^2}{(R+r)}}} \quad \cdots \quad (5)$$

From equations (4) and (5) it is necessary to find the value of C to make p_1 and p_2 equal, and since ω_1, ω_2, R and r are known, a value of C that satisfies the two equations can be found. The quickest way to solve for C is to substitute a number of different values of C in the equations, as shown in the example, rather than to try to solve mathematically.

Example.

Referring to our previous example :—

$R = 0.5 \times 10^6$ ohms.
$r = 0.1 \times 10^6$ ohms.
$\omega_1 = 2\pi \times 5 \times 10^3$
$\omega_2 = 2\pi \times 4 \times 10^5$
C = Capacity in microfarads.

$$p_1 = 1 - \frac{1}{\sqrt{1 + \frac{(\omega_1 CrR)^2}{(R+r)}}}$$

$$= 1 - \frac{1}{\sqrt{1 + 6.7 \times 10^6 C^2}}$$

$$p_2 = \frac{1}{\sqrt{1 + \frac{(\omega_1 CrR)^2}{(R+r)}}} = \frac{1}{\sqrt{1 + 4.4 \times 10^{-2} C^2}}$$

and substituting for C and tabulating :—

$C \mu\mu F$	100	150	200
p_1	0.032	0.045	0.062
p_2	0.047	0.032	0.024

The best value of C lies between 100 and 150 $\mu\mu$F. It is usual in practice to take higher values of capacity, but the values obtained by this method have been found quite satisfactory, and higher values most certainly cause an unnecessary cut-off of the higher audio-frequencies.

APPENDIX 2.

Proof of Graphical Method for Determining Change in Current.

Referring to Fig. 4, let the part of the $I_g - E_g$ curve over which it is proposed to operate be represented by the equation :—

$$y = a + bx + cx^2 + dx^3 + \text{etc.} \quad .. \quad (1)$$

Then if $x = -n$

$$y = I_0 = a - bn + cn^2 - dn^3 + \text{etc.} \quad (2)$$

and if an alternating signal of $n \sin\theta$ volts is

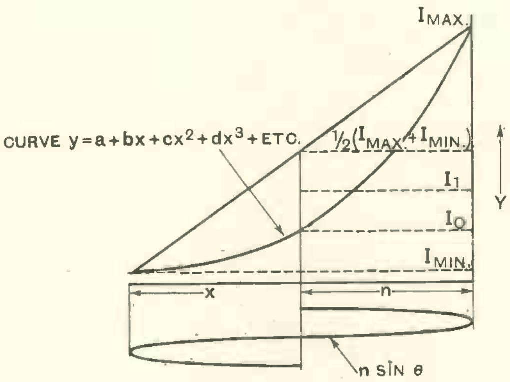


Fig. 4.

impressed on the grid from a zero position of $-n$ volts

$$x = n(\sin\theta - 1)$$

$$x^2 = n^2(\sin\theta - 1)^2 = \left(\frac{3}{2} - 2\sin\theta - \frac{1}{2}\cos 2\theta\right)n^2$$

$$x^3 = n^3(\sin\theta - 1)^3 = \frac{15}{4}\sin\theta - \frac{1}{4}\sin\theta - \frac{5}{2} + \frac{3}{2}\cos 2\theta\Big)n^3$$

$$x^4 = n^4(\sin\theta - 1)^4 = \left(\frac{35}{8} - \frac{7}{8}\cos 2\theta - \frac{1}{8}\cos 4\theta - 7\sin\theta + \sin 3\theta\right)n^4$$

and substituting in equation (1)

$$y = a + bn(\sin\theta - 1) + cn^2(\sin\theta - 1)^2 + dn^3(\sin\theta - 1)^3 + \text{etc.}$$

Rewriting and collecting terms :—

$$y = \left(a - bn + \frac{3}{2}cn^2 - \frac{5}{2}dn^3 + \frac{35}{8}en^4 + \text{etc.}\right)$$
$$+ \left(bn - 2cn^2 + \frac{15}{4}dn^3 - 7\,en^4 + \text{etc.}\right)\sin\theta$$
$$- \frac{1}{2}cn^2 - \frac{3}{2}dn^3 + \frac{7}{2}cn^4 + \text{etc.}\Big)\cos 2\theta$$
$$+ \left(-\frac{1}{4}dn^3 + en^4 + \text{etc.}\right)\sin 3\theta + \text{etc.} \ldots (3)$$

The first term in this equation gives the value of the D.C. grid current when a signal of $n \sin\theta$ volts is impressed on the grid and equation (2) gives the value of the grid current with no signal on the grid. Thus, subtracting equation (2) from the first term in equation (3) gives the change in D.C. current when an A.C. signal is impressed on the grid.

Equation (1) taken to the 6th power

$$= y = I_0 = a - bn + cn^2 - dn^3 + en^4 - fn^5 + gn^6 + \text{etc.}$$

and first term of equation (3) taken to 6th power

$$= y = a - bn + 3/2\,cn^2 - 5/2\,dn^3 + \frac{35}{8}en^4 - \frac{63}{8}fn^5 + \frac{231}{16}gn^6$$

and subtracting, change in grid current

$$= \frac{1}{2}cn^2 - \frac{3}{2}dn^3 + \frac{27}{8}en^4 - \frac{55}{8}fn^5 + \frac{215}{16}gn^6 \quad (4)$$

Then, referring to Fig. 4

when $x = 0$ $y = I_{max.}$

$x = -2n$ $y = I_{min.}$

$$I_{max.} = a$$

$$I_{min.} = a - 2bn + 4cn^2 - 8\,dn^3 + 16\,en^4 - 32fn^5 + 64gn^6 + \text{etc.}$$

$$\frac{1}{2}(I_{max.} + I_{min.}) = a - bn + 2cn^2 - 4\,dn^3 + 8en^4 - 16fn^5 + 32gn^6 \quad .. \quad (5)$$

and subtracting equation (2) from (5)

$$\frac{1}{2}(I_{max.} + I_{min.}) - I_0 = cn^2 - 3dn^3 + 7en^4 - 15fn^5 + 31gn^6 + \text{etc.}$$

and

$$\frac{\frac{1}{2}(I_{max.} + I_{min.}) - I_0}{2} = \frac{1}{2}cn^2 - \frac{3}{2}dn^3 + \frac{7}{2}en^4 - \frac{15}{2}fn^5 + \frac{31}{2}gn^6 + \text{etc.} \ldots \quad (6)$$

Equation (6) gives the change in grid current obtained by the graphical method of taking

$$\frac{\frac{1}{2}(I_{max.} + I_{min.}) - I_0}{2}$$

and equation (4) gives the true value of change in current. It will be seen that the difference is only very small until the 5th and 6th powers are reached, and in most cases the operating part of the grid curve can be represented by an equation containing terms up to the 4th power only, with reasonable accuracy, and, even if higher terms are necessary, the error in using the graphical method is not great.

APPENDIX 3.

Point of $E_g - I_g$ Curve with Greatest Change of Slope.

It can be shown that the most efficient point of the curve on which to operate is the point where the rate of change of slope is greatest, and the following simple method

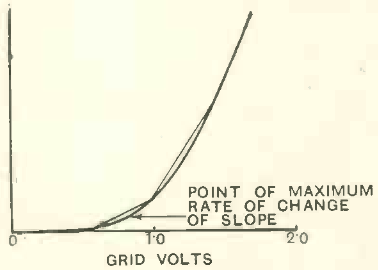


Fig. 5.—*Method of finding optimum point of curve.*

determines this point. Referring to Fig. 5, join points of equal intervals of grid volts along the curve of straight lines, then the rate of change of slope is greatest where the deviation from the straight line is grea

OBITUARY.

THE death occurred on February 18th of Dr. D. W. Dye, at the early age of 44. We met him first in 1906, as a student at the City and Guilds Engineering College in South Kensington. In 1910 he went to the National Physical Laboratory and he spent the rest of his life there. Nobody has done more to uphold the international reputation of the N.P.L. for electrical measurement of the highest attainable accuracy. He was a worthy successor of Albert Campbell and Sir Frank Smith, and only those who have been closely associated with him and know the amount and character of the work which he has done, the enthusiasm with which he attacked the most difficult experimental problems, and the grim determination with which he sought and eliminated the various sources of error, will be able to realise what a loss has been sustained by the N.P.L. and by the many other organisations with which he was associated.

In 1924 he contributed to *Experimental Wireless* a series of articles on the Intervalve Transformer.

In recent years he devoted himself specially to the study of radio frequency standards and measurements. He developed the multivibrator controlled by a tuning fork and by means of a phonic wheel obtained records on a tape side by side with records from a standard clock, thus giving a direct comparison between the radio frequency and the standard clock. He had recently devoted much attention to quartz oscillators and had developed a new type which, when maintained at a steady pressure and temperature, operated with a constancy beyond anything previously attained.

Dr. Dye was awarded the D.Sc. degree of London University in 1926, and he was made a Fellow of the Royal Society in 1928. He was a member of the Standards Committee of the Radio Research Board and honorary Secretary of the British National Committee of the Union Radio Scientifique Internationale. He acted as Chairman of the Commission on Radio Standards at Washington, Brussels and Copenhagen.

GENERAL GUSTAVE FERRIÉ, the head of the French military wireless service, died on February 16th, at the age of 63. He had been associated with radio telegraphy since the earliest days, for he was present in 1898 when Marconi made his experiments across the English Channel. He not only built up the French military wireless service, but he was a great pioneer in the application of radio telegraphy to other branches of science, especially to the accurate transmission of time signals, so enabling the longitude of any part of the earth's surface to be determined to a degree of accuracy hitherto impossible. He was President of the Union Radio Scientifique Internationale. In 1919, Oxford University conferred upon him the honorary degree of Doctor of Science. The most striking evidence of the esteem in which he was held by his own countrymen was afforded two years ago when a special law was promulgated exempting General Ferrié from the law under which he should have retired and concluding with the words " le général de division Ferrié est maintenu en activité sans limite d'âge."

Those who have met him in London or elsewhere, or who have experienced his kind hospitality in Paris, will mourn the loss of a most lovable personality. G. W. O. HOWE.

The Selectivity of Broadcast Receivers.

Discussion before the Wireless Section, I.E.E., 24th February, 1932.

A very large gathering attended the meeting organised by the Wireless Section of the Institution of Electrical Engineers, when the problem of the selectivity of broadcast receivers was discussed.

LIEUT-COL. A. S. ANGWIN (Chairman of the Wireless Section) presided, and the discussion was opened by PROFESSOR C. L. FORTESCUE, who referred to the variety of electromotive forces in the area of a broadcast receiver and the varied functions of the elements of the receiver as a whole. He described the selectivity of the receiver as the extent to which the output of sound is independent of the waves emitted from all sources other than the transmitter from which the desired programme is being received. He put a number of questions of a controversial nature to the meeting, and elaborated these questions in order to indicate the lines on which the discussion should proceed. The questions put forward were as follows:—*What range of audible frequency is desirable? Why do considerations of the audible frequency desirable determine the selectivity of a receiver? Are receivers as selective as possible? What is the best circuit arrangement for obtaining the necessary selectivity? Would the general use of selective receivers enable the difference of wavelength between transmissions to be reduced?* And finally, *Could the average purchaser of a broadcast receiver be entrusted with a sharply tuned high-frequency circuit?*

Professor Fortescue added that a problem of great importance arising out of the question of selectivity was whether the present policy with regard to the allocation of wavelengths in our broadcasting stations was a sound one. For example, if selective receivers were employed, could we work with stations having carrier waves spaced at only comparatively small intervals? The considerations he had put forward pointed to the fact that the present situation was based on sound theoretical and sound practical results.

MR. N. ASHBRIDGE (B.B.C.) said that there were really two classes of listeners. In the first place there was the man living in an area of very strong field strength, of from 20 millivolts per metre upwards, in which selectivity was not particularly necessary. Secondly, there was the man living in an area having a field strength of, say, 5 millivolts per metre, and who had to contend with peaks of signal strength from a distant station at night. He did not think the side-band frequencies caused the "grasshopper" noises from unwanted stations, which were referred to as side-band heterodyning; possibly the causes were the frequencies where the energy was the greatest—round about 1,000 to 2,000 cycles. It was questionable, therefore, whether there would be very much reduction of the "grasshopper" noises as the result of deliberately cutting off the high frequencies from the transmitter.

With regard to the feasibility of sharply tuned receivers, it seemed to him that one of the first matters for the designer of receivers to tackle was stability of tuning. He was not considering this so much from the point of view of the man working the knobs, but had in mind that in a mains receiver the tuning might be all over the place through changes in the mains. It was questionable whether many of the present-day transmitters would be good enough if we were going to achieve the extreme limits of selectivity.

The problem of the amount of the musical frequencies that ought to be included was highly controversial. Professor Fortescue had said that from 50 to 5,000 was considered to give satisfactory results, but he was in complete agreement with Professor Fortescue that sooner or later they would have to go higher.

Discussing the judgment of quality by musical people, he said it was noticed that a musician, no matter how good, was not particularly sensitive to the width of band included in the transmission, but was much more sensitive to changes in amplitude. There were people who, though not musicians, were very interested in musical reproduction, and were interested also in the electrical side and they would notice it at once. The public in general did notice the difference between 5XX and the London transmitters. 5XX was considerably down at 5,000 cycles.

As to the upper limit for loud speakers, he would have thought that 2,000 cycles was rather a pessimistic figure, to say the least. That figure was mentioned by Professor Fortescue. Many, he believed, could register well above 5,000. They might be hopelessly non-linear, but something was registered by the ear.

With regard to the suggestion that the spacing of 9 kc. was quite adequate, he drew attention to the fact that the London Regional transmitter was working at 11 kc. with its troublesome neighbour, Mühlacker, and the Northern Regional had, roughly speaking, 11 kc., with, on either side, Langenberg and Prague, so that it was not safe to say that the present spacing was quite adequate.

With regard to single-side-band working, he pointed out that there were over 12 million licensed receivers in Europe, so that if the whole of Europe decided to change over to side-band working—and one day they might—we should have to consider all those receivers.

Dealing further with the question of separation between stations, Mr. Ashbridge said that the outlook of those concerned with broadcasting was very different from our own, and that was the trouble in connection with the controversy as to whether or not the spacing should be wider. The average broadcast engineer abroad—though this did not apply to every country—was not very much interested in frequencies above 4,500 or so. Again, they did not experience much side-band heterodyning from us, whereas complaints were received on a fairly large scale in England, even with our 11 kc. separation. There were two reasons for the difference between this and other countries in that respect. One was that the people abroad seemed to use ultra-selective receivers; secondly—and this was more important—they went in for much higher modulation than we do. In this connection he added that America was considering, in putting down broadcast cables, that they must have practically linear response up to 8,000 cycles.

MR. P. K. TURNER commented on Professor Fortescue's statement that a lower frequency limit of 50 and an upper limit of 5,000 were considered to give good results. A clear cut-off at 5,000 was considered a luxury in a gramophone record or a film. Something like 4,000 was more normal, whereas broadcast transmission contained at least another octave above that.

In strict logic, Professor Fortescue was right in saying that any attempt to estimate the performance of radio receivers must include the performance of the loud speaker. Unfortunately, however, the practicability of that was very doubtful, because even if one included, in the performance curve of the receiver, the mean spherical radiation of the loud speaker, one still could not make any allowance for the acoustic circumstances under which it was being used.

He was not entirely convinced of the correctness of Professor Fortescue's statement to the effect that if a stray side-band from an unwanted transmission cut into the band one was trying to receive, the results might be the same as if it had been a side-band of the desired transmission.

A matter of interest in that connection was the demodulation effect. When one was confronted with two carriers, say 10 kc. apart, and reduced by some means the unwanted carrier to not more than one-hundredth of the wanted carrier, it had the most startling effect—he could not say that it was more than an apparent effect—of blotting out completely the modulation of the unwanted carrier. His measurements had been rudimentary. Owing to circumstances he had had to make tests by simply building receivers and trying them out, but certainly his impression was that when that sort of circuit was pushed to the limit, so that the unwanted carrier was reduced to something like one- or three- or four-hundredths of the wanted carrier, and then one proceeded to reconstitute the audio-frequencies by a differentiating circuit, there seemed to be extraordinary freedom from the annoying chirping noises due to modulation. In such a receiver the whistle had to be dealt with specially, but that was not unduly difficult.

Mr. Turner urged very strongly the retention of the frequencies above 5,000 cycles.

MR. F. S. BARTON (Royal Aircraft Establishment, Farnborough), discussing frequency range, referred to some tests carried out at the Bell Telephone Laboratories, in which a number of experienced listeners had listened to orchestral music, the high and low frequencies being cut off from time to time by means of filters. The net result of the tests was that, when there was a musical range extending from about 70 to 8,000 cycles, the listeners considered that the reproduction was 95 per cent. perfect.

Mr. Barton went on to refer to some work being carried out by the R.A.E. at Farnborough to develop frequency filters.

MR. M. G. SCROGGIE illustrated the three possible cases which might exist, his object being to clarify ideas on the relation between selectivity and the desirable band of audio-frequencies. In the first case he illustrated two stations completely separated, where the side-bands did not overlap. It was universally agreed, he said, that, in theory at any rate, it was possible to separate reception from those stations completely by using a band-pass filter. The second case was that in which the side bands overlapped—and there seemed to be a certain amount of controversy still as to whether or not it was possible to separate two such stations completely and retain the whole band of frequency at the full modulation without any heterodyne interference. The third case was that in which the side-bands overlapped with the carrier waves, and he believed it was universally agreed that it was not possible to receive the transmission from one of those stations completely without losing some of the modulation. The orthodox position was that separation was possible only in the first case, and, as Professor Fortescue had pointed out, it was generally considered desirable for receivers to cover an audio-frequency band of 10 kc., or preferably even more. Mr. Scroggie had difficulty in understanding how it was possible to reconcile those aims with the conditions as they existed—the fact that stations were separated by 9 kc. at present—and it seemed to be of no use discussing at length principles which had no application.

MR. I. J. COHEN gave a picture of the existing conditions for commercial radio-telephony, and considered first the long-wave Transatlantic telephone circuit. This operated on the single side-band suppressed carrier system, *i.e.*, only one side-band was transmitted. As the circuits were engineered from a telephone point of view, only the frequencies corresponding to the audio-frequency band, of from 250 to 2,750 cycles per second, were considered, and, therefore, the band occupied was 2,500 cycles per second. At the moment there were not many long-wave telephone circuits, so that there was no necessity to guard against interference from this source. But the ether was full of long-wave telegraph transmissions, and at 250 cycles per second from the carrier frequency on one side of the allotted telephony band, and at 500 cycles per second from the other edge, there existed strong telegraph carrier frequencies.

The conditions on the wavelengths from 14 to 40 metres had become almost as bad as on the broadcasting band. It was necessary to limit the receiving width of the short-wave telephony sets to about 8,000 or 9,000 cycles per second, and to have large attenuation outside this range. The Post Office receivers used on these services contained some two dozen valves, five high-frequency tuned circuits, intermediate frequency band-pass filters (containing many sections), audio-frequency filters and equalisers. Perhaps the broadcasting receiver of the future would be developed on these lines in order to secure sufficient selectivity. It would certainly be good for the valve manufacturers.

MR. P. W. WILLANS, said that one of the principal difficulties was that of the audio-frequency performance of loud speakers. If it differed as heard from different parts of the same room he could not see how the problem could be treated from the scientific point of view; quality was not strictly a science, but an art, and he felt that there was no satisfactory answer to Professor Fortescue's question on that point.

He believed—and he regarded it as a godsend to receiver designers—that it was possible for us to cut top at the receiving end and obtain quality unimpaired. What would happen if the B.B.C. suddenly employed microphones which had no field effect, and acted as exact translating devices, he did not know. He had a dreadful feeling that people would find their transmission lacking in top, and it was his hope that if the B.B.C. did develop that microphone—and he hoped they would —they would put in some top. In expressing the view that we ought to consider the broadcasting range as ending at 5,000 cycles rather than 10,000 cycles, Mr. Willans said that, though he was willing to compromise, we must deal with realities, and the realities were the state of the ether and the state of the public. If the public demanded to listen to foreign stations, then they were troubled with heterodyne interference; the only way of eliminating or diminishing heterodyne interference was to push up our own side-bands in competition with it.

The reference to "grasshopper" noises had interested him. He believed the cutting of side-bands and restoring the audio-frequency quality would do something for us, and for that reason he laid stress on carrier rather than side-bands. That sort of set had a great future.

With regard to Mr. Turner's point, in connection with his plea for 10,000 cycles, that it was necessary to present even skilled people with two alternatives in quick succession before they could distinguish one from the other, he said that if that were so the manufacturers would be very reluctant to go for it. He believed we were using our limited frequency range to the best advantage, and that the limited frequency range, in the present state of the ether, was the one to go for.

Dr. J. D. S. Rawlinson said that one of the most interesting points raised by Professor Fortescue was the endeavour to define a figure of merit for selectivity. Professor Fortescue's two figures of merit appeared to be related not so much to the selectivity of the receiver as to the audio-frequency response. A possible way of defining two figures of merit would be to plot the high-frequency resonance curve of the receiver for a C.W. input of constant amplitude at various frequencies, measure the actual area within a band of $\pm$ 4,500 cycles per sec. of the frequency to which the receiver was tuned, and construct a rectangle of the same area on the base of $\pm$ 4,500 per second, about the mean frequency. One could then define the two figures of merit:—

(a) One depending on the maximum departure of the actual curve from the mean height, *i.e.*, the height of the rectangle. If this were not greater than 50 per cent. it would not be noticeable in the audio-frequency output. Such a figure would pass small peaks and hollows almost unnoticed, but would penalise a receiver which had a bad peak or a steep fall away in the band.

(b) A second figure expressing the ratio of the height of the rectangle to the height of the actual resonance curve at a distance of 9,000 cycles from the mean frequency. For receivers used near London a figure of perhaps 10 might be good enough, but for receivers to be used on the south coast a figure of the order of 1,000 might be required.

The figures suggested did not give anything like the quality which Professor Fortescue was working for with the 10,000 cycle width of band, but he did not think that for anybody living at a distance from the high-powered stations there was a possibility of being able to work with such a wide band.

Mr. D. N. Corfield, dealing with the question of frequency range, said that that seemed to centre around the question of whether we were to have a range of, say, 4,500 cycles, and so get away from interference, but at the expense of having to put up with poor speech reproduction. For really lifelike speech, having the sibilants properly reproduced, it was almost essential to have a frequency range of about 8,000 cycles. How was that to be achieved? One could use a band-pass arrangement, but there one would get into difficulties through the side-bands of interfering stations coming into that band width in full strength, whereas if we used a circuit with very high selectivity we obtained a different effect. It had been pointed out by Mr. Turner that if one used a very selective circuit, and if there were a station whose carrier frequency was not receivable but whose side-band frequency was receivable, the resultant interference was very small.

The next point was that if we were to get this frequency band into the spectrum, and get a number of stations into our allotted wavelength range, the only satisfactory means of doing it, apparently, was to use a single side-band. But the question was, at which end? If at the transmitting end, we had to ask everyone to buy a new receiver. Alternatively, we could by suitable means—which were yet in an early stage of development—receive only one side-band of a double side-band transmission. That could be accomplished by means of the quartz crystal resonance circuit, giving very sharp response.

Mr. F. Murphy emphasised that selectivity could be defined only with respect to the conditions to be met. For instance, one perhaps lived within a field of strength from Brookmans Park of 300 mv. per metre, but had an ambition to receive Mühlacker, which was 1½ mv. per metre. In other words, one desired a receiver with a selectivity which would discriminate between an adjacent panel and a station several hundred times as strong. There were three forms of interference, *i.e.*, the ordinary heterodyne interference, the intelligible modulation interference, and the side-band interference, and he dealt mathematically with the problem as to whether any one form or resonance circuit would give greater freedom than any other, assuming the audio-frequency response was defined. There were three factors needed, he concluded, in the definition of selectivity. First, it could be defined in terms of the field strength it would discriminate against for the adjacent channel; coupled with that there should be a statement of the percentage audio-frequency response, say, at 4 kc. off tune; and, thirdly, at what volume level—because there was no such thing as zero interference, the old definition of zero being that it was less than any assignable quantity.

Mr. E. A. Brooke said that if one tried to define selectivity simply by the audio characteristic one omitted what happened in the detector itself, neighbouring transmissions capable of giving interference could not be overcome by limiting the audio response. Therefore, it seemed that selectivity must be defined on the high-frequency side rather than the audio side. It seemed also that, under present conditions, with total separation of 9 kc. or thereabouts, if interference were to be eliminated, or at any rate limited, the available audio high-frequencies it was possible to receive must necessarily be limited to somewhere about 5,000, otherwise there was the obvious trouble due to the neighbouring side-bands.

Mr. H. L. Kirke (B.B.C.), discussing the question of side-bands and the cut-off at 5,000 cycles, referred to some tests he had carried out recently with two transmitters separated by 9 kc. One was supposed to be the transmission required and the other the interfering transmission. In the interfering transmitter circuits there was an arrangement whereby he could cut in and out a filter circuit cutting off at 5,000. The receiving circuits were so arranged that no programme interference was audible, but strong side-band interference was audible. Frequencies above 5,000 in the neighbouring transmission created no interference whatever in the receiver in use. Curves recently published in the American journals by Harvey Fletcher showed the average energy to be expected in speech and music over the frequency range, and from these curves one could see that although the human ear appreciated the frequencies above 5,000 cycles, the intensities at which those frequencies were normally transmitted by the various instruments or people was very low indeed. Consequently, there was no argument in favour of cutting off in the transmitter at 5,000 cycles, and these higher frequencies should be left for those fortunate enough to be able to take advantage of them.

Discussing the frequency characteristics of microphones, Mr. Kirke said that perhaps this was an excellent opportunity to tell the truth. The normal Reisz microphone used had a rising frequency characteristic above 1,000, and incidentally below, rising up to 6 decibels up to 4,000 to 6,000 cycles, and cutting off very soon after 6,000. So that with normal circuits we were sending out an excess of the higher audio-frequencies at 5,000 cycles. When we used a condenser microphone the response was liable to be 15 decibels up to 4,000 or 5,000 cycles, when one was speaking in a direct line with the microphone. Mr. Kirke went on to refer to some recent experiments with a new type of condenser microphone which, he was glad to say, was a British product. It was believed that it had frequencies in it well above 10,000 cycles per second, and it had a sensibly flat frequency characteristic; there was no rise at 4,000 or 5,000 cycles.

With regard to stray side-bands, he said that he had been concerned with many tests, and one could get rid of the side-band interference by cutting off after the first detector. As to cut-off in high audio-frequencies, tests were carried out to ascertain what was tolerable in the way of cutting. Most people agreed that a cut-off at 5,000 cycles was more or less tolerable, but they liked the higher frequencies in if possible. Very few people could notice when frequencies above 7,000 were cut off.

The question of the shape of the overall characteristic was important. Should we have cut-off or tail-off? He preferred tail-off; even if a little were left above 5,000 cycles, he liked it.

Mr. Kirke stated that he had carried out tests on a receiver of the superheterodyne type in which the selectivity of the intermediate frequency circuits was very great, and the loss of higher modulation frequencies caused thereby compensated for by suitable equalisers in the audio-frequency circuits.

The pre-first detector circuits were of the so-called square peak or band-pass arrangement, and the second detector was a square law detector. The receiver was tested as it arrived from a manufacturer, and no attempts were made to trim the circuits in any way. The pre-second detector selectivity was such that there was practically no demodulation of the wanted signal at modulation frequencies below 500 cycles per second. The demodulation was considerable at higher modulation frequencies than this.

During the tests of the receiver it was noticed that the output sounded very impure when the modulation frequency applied to the carrier of the test set was 200 cycles. The analysis of the output was as follows:—Fundamental frequency, 1.6 per cent.; 2nd harmonic, 30 per cent.; 3rd harmonic, 9 per cent.; 4th harmonic, 37 per cent.; etc., up to 10th harmonic.

The causes of this very high distortion appeared to be threefold:—(1) Considerable tuning asymmetry before the second detector, probably both as regards phase and amplitude; (2) the production of considerable harmonics by the use of a square law detector, probably as the wanted signal is not appreciably demodulated at modulation frequencies below 500; (3) any harmonics caused by (1) and (2) are amplified at the expense of the fundamental frequency owing to the frequency characteristics of the low frequency amplifier.

It was not suggested that the receiver in question was either a first-rate or typical example of its kind, and Mr. Kirke thought that by the use of a linear detector and carefully arranged tuning circuits it might be possible to produce a result comparable in quality with a straightforward well-designed receiver. It was interesting to speculate as to whether such results could be achieved commercially, particularly when it was realised that special apparatus was required to carry out the necessary tests on such a receiver. Aural tests were apt to be misleading.

His remarks were not to be taken as a criticism of a principle, but were intended to point out the difficulties which might arise in manufacture on a large scale.

Mr. H. Dewhurst (of the Royal Aircraft Establishment, Farnborough) showed some curves illustrating the results obtained with filters which had been developed at Farnborough, as mentioned earlier by Mr. Barton. The first attempt was to make a three-element type, but later there was evolved an intermediate frequency filter of the four-element type—two units in the series arm and two in the parallel arm.

Dr. R. S. Smith-Rose, deputising for Mr. Colebrook—whose absence was due to illness—said that the latter had been working on certain properties of selective receivers; he had studied the theoretical problems involved and had endeavoured to carry out accurate quantitative experiments to verify the various issues at stake. He had found a satisfactory correlation between the two, and probably his results would be communicated in detail later. In the course of his work Mr. Colebrook had demonstrated a selective receiver with adjustable tone correction, and one of the things which had impressed Dr. Smith-Rose with regard to it was that one had the reproduction under one's own control to some extent; one could adjust the tone correction until the product suited one's own ears.

Mr. J. E. G. Bailey referred to some experiments he had made with a receiver of a highly selective type with subsequent audio-correction, which experiments had shown that this method had its conveniences and its limitations. The highly peaked circuit with subsequent correction was useful for eliminating interference of the first type referred to by Mr. Scroggie—where the side-bands of two stations did not overlap. The second type of interference—where the side-bands overlapped—could only be met by the demodulation effect, which was extraordinarily complicated. The third type—where the side-bands overlapped with the carrier waves—had not been eliminated in any way at all, so far as he knew.

Mr. G. Builder illustrated the serious distortion which occurred in band-pass circuits in which the response curve showed a double peak, his purpose being to emphasise that one must consider the possibilities of serious transient distortion when designing a receiver—particularly one in which the circuits were of low decrement.

Mr. T. Wadsworth said that the discussion seemed to have disclosed two schools of thought regarding the problems of selectivity and quality. The first school would regard the quality of the receiver as the essential characteristic, and it seemed that the B.B.C. was definitely out to get the best quality into the homes of the users. Those who adhered to the second school of thought regarded a receiver as being an extremely selective device, and considered its quality to be of secondary importance—or rather, they held that the quality that could be achieved was good enough for use on broadcast reception. He was of the opinion that the first school were right, and it followed as a corollary that the present wavelength separation, 9 kc., was inadequate. It was questionable whether the use of ultra-selective circuits and tone control were fundamentally correct, because there was no evidence, in his opinion, in using tone control, that one could reinstate something one had already taken away in order to get the increased selectivity.

In connection with the B.B.C. transmissions, it would be an advantage to all concerned to have the frequency characteristics given for all the stations, so that one would know what would happen when experiments were being made. He had carried out experiments recently—and the results were in conflict with what Mr. Turner had stated—in which music and speech were recorded on a film up to 7,000 or 8,000 cycles with ordinary commercial recording equipment, and there was little doubt that those records were better to listen to, for all classes of individual, than was broadcast reception.

Professor Fortescue, in a brief reply to the discussion, said it was a matter for relief that our theory seemed all right after all. It was also a relief to find that there was a great preponderance of opinion in favour of our broadcasting concentrating upon giving the best possible results, even though it might mean a wider separation between stations.

It had been mentioned, in regard to highly selective high-frequency circuits, and so on, that the fact that interference between side-bands was not so marked as it was expected to be could be explained from the fact that the energy in the very high-frequency components was small.

Professor Fortescue could not see that there was any difference whether the selectivity was effected in the high-frequency or audio-frequency side. What did it matter how much energy came from the loud speaker at a frequency of 10,000 if it did not make the slightest sound.

Finally, he said that a new language was being introduced in regard to these matters, and that apparently we had to become accustomed to the terms "tail-off" and "too toppy." He appealed, however, for the elimination of some of these awful terms, and for the use of decent English in describing technical work.

Errata.—The accompanying diagram should replace the Fig. 8, page 129, of last month's issue, the figure on that page becoming Fig. 9, and the reference in the text on that page should relate to Fig. 9.

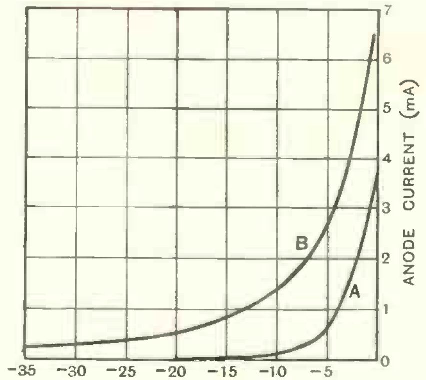


Fig. 8.—*Grid volts-anode current curves of (A) an M.S.4 valve, and (B) a V.M.S.4 valve. Both taken at — anode volts 180, screen volts 60.*

Correspondence.

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

The Dynatron Oscillator.

To the Editor, The Wireless Engineer.

SIR,—Referring to Mr. F. M. Colebrook's article dealing with the dynatron oscillator published in the November issue of your journal, I should like to suggest a simple explanation for the mechanism of his new circuit, *i.e.*, of a dynatron having a condenser connected between the plate and the control-grid, and the latter connected to the cathode through a high resistance (Fig. 1).

It seems to me that the circuit can oscillate at higher frequencies because the "static" curve $I_a - V_a$ is replaced by a "dynamic" one having a steeper slope and consequently with a lower negative resistance, which will balance an oscillatory circuit having a lower dynamic resistance. The control-grid receives a positive feed-back. Supposing that the valve is working with a zero grid-bias, the static characteristic will be AOB (Fig. 2). When the plate current has its maximum value, the control-grid receives a positive impulse, say + 1 volt, the current is therefore increased from A to A′. When the current has its minimum value, the impulse is negative and the current is decreased from B to B″. This gives rise to a "dynamic" characteristic A′OB″, which has a lower resistance.

It is to be noted that the dynamic resistance of the circuit will be lowered by the parallel path—condenser in series with the input impedance in parallel with the grid resistance. The ratio r/K must be high enough to prevent excessive damping of the oscillatory circuit. Attention must be drawn to the fact that the average grid potential becomes more negative due to the accumulation of negative charges in the control-grip, which return slowly to the cathode through the grid-leak resistor. From this result the fall in screen-grid and in anode currents referred to in the article and an increase of negative resistance. Is the instability observed in the new circuit due to this grid detection effect and to the increase of negative resistance?

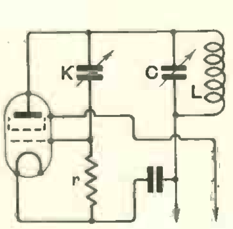


Fig. 1.

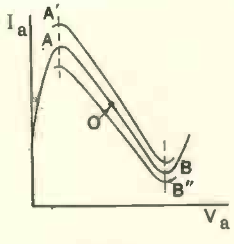


Fig. 2.

It is also to be noted that this new circuit can introduce some amount of 2nd harmonic distortion because the curve-family is narrower in the lower bends than in the upper ones, and also, because of grid rectification.

An American constructor, who employs a dynatron as heterodyne oscillator*, points out, without explaining the reason, that sometimes the insertion of a ½ megohm resistor in the grid return is necessary to make the valve oscillate. This seems quite clear; in this way, the grid becomes free and can receive a positive feed-back from the plate through the plate grid capacity and associated wires capacity.

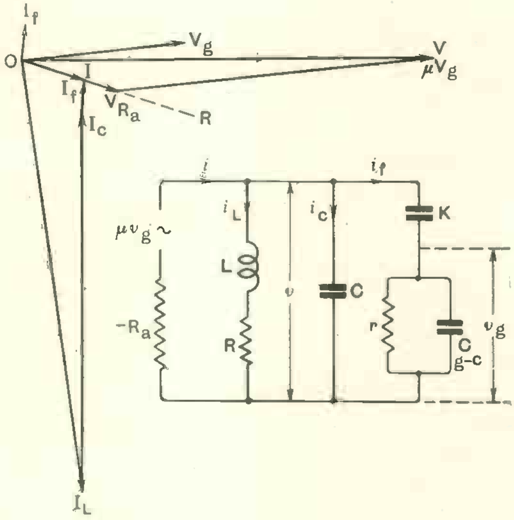


Fig. 3.

It occurs, however, that sometimes, when the grid voltage is increased above a critical point, the plate current begins to decrease. The amplification factor becomes negative and the feed-back will be also negative. It seems that above such point the electron-acceleration produced by the control-grid has the effect of increasing the secondary emission of the plate. Is this phenomenon responsible for the above mentioned instability? However, this phenomenon occurs mainly in the region of the lower bends of the characteristics where the feed-back is negative.

In the Fig. 3 is represented the equivalent circuit of the system and a vectorial diagram of the currents and voltages, assuming that the valve works on a straight region of the curves, that the amplification factor is constant and that there is no grid rectification. Starting with the voltage V, the current through the valve I is represented by the sum of the currents through the two branches of the oscillatory circuit and of the feed-back current. The voltage across the negative resistance, having the direction of I, joined with the e.m.f.

* See *Radio News*, April, 1931, p. 884, and *Radio Craft*, May, 1931, p. 667.

μV_g must be equal to the voltage V. The frequency, the negative resistance and the feed-back voltage must be so adjusted that $\bar{V} = \bar{V}_{Ra} + \mu \bar{V}_g$ and $\bar{I} = \bar{I}_L + \bar{I}_G + \bar{I}_f$. Provided that the negative resistance is low enough, the frequency and the resistance will be automatically adjusted to fulfil the above conditions. The oscillations will attain a point on the characteristic bends where the tangent will give the value of the negative resistance required.

Lisbon. FRANCISCO PINTO BASTO.

The Loud Speaker Coil of Optimum Mass.

To the Editor, The Wireless Engineer.

SIR,—I was gratified to notice Dr. McLachlan's expansion of my analysis for determining the optimum value of coil mass for a maximum drive velocity.

I showed that, for a given power W dissipated across the conductor coil of mass, m_0, the value of this mass must be made equal to the effective mass, m, of the driven part of the system to produce maximum velocity.

The analysis was therefore conditioned by assuming W to be constant; and providing this condition is strictly recognised the equation $m = m_0$ for maximum velocity is independent of frequency unless these is a departure from inertia control.

It is obvious, however, that with an increase of frequency three important changes occur:—

(1) The value of W falls due to the rising impedance of the conductor coil.

(2) The value of m changes due to:—(a) non-uniformity of velocity magnitude and phase over the surface of the diaphragm and (b) a reduction in the value of accession to inertia.

(3) Changes in the value of radiation resistance.

In an article which I submitted to this journal, without success, some few months ago, these changes were examined and certain postulations made regarding their probable effect upon the value of m_0.

I also showed that the inductance/resistance ratio of the conductor coil bore a definite proportionality to its volume, and for a given material, to its mass therefore.

The practical value to assign to m_0, therefore, was a matter for compromise.

I was forced, however, in the interests of economy in correspondence space, to limit the analysis to a simple and well defined case and feel, therefore, well justified in adopting my original attitude and procedure in setting down my findings.

Sidcup, Kent. F. R. W. STRAFFORD.

The Mutual Interference of Signals in Simultaneous Detection.

To the Editor, The Wireless Engineer.

SIR,—In your issue of last month there appeared an article on the above subject by Mr. Boohariwalla and myself in which it was shown that, if strong and weak signals ($S \cos \omega_1 t$ and $W \cos \omega_2 t$ respectively) are simultaneously received with a linear detector, the effective modulation of the weaker signal is reduced to $\frac{1}{2}\,\frac{W}{S}$ of its original value. In discussing the effect of various types of detector, use was made of a static characteristic relating mean signal current to amplitude of input voltage. I wish to add to what was said in the article that this type of characteristic can only be used in interpreting dynamic effects when certain conditions are fulfilled. For example, in cumulative grid rectification, the time constant of the grid circuit should be sufficiently low for changes of the modulation frequency of the signals to be followed. But what is of greater importance in the present instance (as Mr. M. V. Callendar first kindly pointed out to me) is that this time constant should be sufficiently small for changes of the difference frequency $\left(\frac{\omega_1 - \omega_2}{2\pi}\right)$. to be followed, in order that the ordinary theory of demodulation should be valid. Only when this is the case is the mean signal current proportional to the composite voltage

$$\left\{\sqrt{S^2 + W^2} - \tfrac{1}{4}\,\frac{S^2W^2}{(S^2 + W^2)^{\frac{3}{2}}} + \text{etc.}\right\}$$

as given in equation (8) of the paper. For cases in which the time constant of such a grid circuit is too high the mean signal current tends to be that corresponding to the signal peak voltage $(S + W)$ and there is then no interaction of signals and thus no demodulation. This means that the demodulation effect tends to be most marked when the difference of carrier frequencies is low, and it is a mistake to call such a frequency difference "supersonic" without further qualification. In our experiments the two oscillators used had exactly the same types of coils and condensers and the frequency difference was increased until no reading due to a heterodyne note was obtained on the condenser-shunted Moullin voltmeter.

E. V. APPLETON.

Wheatstone Laboratory,
King's College, London.

Effective Mass of Loud Speaker Cones.

To the Editor, The Wireless Engineer.

SIR,—In his paper on the above subject in your March issue, Dr. M. J. O. Strutt states (p. 149), "In literature, as far as I know, only cones without any air or other damping have been considered theoretically hitherto, whereas full experimental curves on the equivalent mass have not been published." This remark is rather misleading because in *The Wireless World*, August 12th, 1931, Dr. N. W. McLachlan described measurements on effective mass and gave two complete curves for loud speaker diaphragms. A full report on this work with the mathematical equations was read before the Physical Society last October. (*Proc. Phys. Soc.* 44, p. 88, 1932.)

Dr. Strutt refers to Kennelly, but the latter neither mentions *effective mass* nor gives formulae for its calculation. The term *equivalent mass* used by Dr. Strutt is associated with the Kinetic Energy. The latter is $\frac{1}{2}M'v_0^2$ where M' is the equivalent mass, including the accession to inertia, and v_0 the central velocity. When the diaphragm does not move the velocity varies at different radii and M' is less than that of a rigid diaphragm. Moreover the *equivalent mass* is always positive, whilst the *effective mass* can be positive, negative or zero. It is preferable to define the effective mass as it arises in the formula for mechanical impedance, namely, $Z = B + j\omega M_e$. This refers to the driving point, whereas the equivalent mass involves the whole surface of the diaphragm.

In making calculations on loud speakers it is desirable to know not only M_e but the mechanical resistance B, *e.g.*, in the calculation of the coil of optimum mass as given by Dr. McLachlan in your March issue. By using a Bridge method, both of these quantities can be found for a M.C. speaker without attracting anything to the diaphragm, *i.e.*, under working conditions. By the aid of a suitable table of values, or a curve, and a properly organised routine, complete curves of B and M_e can be found much more quickly than is generally realised.

London. G. A. V. SOWTER.

BOOK REVIEW.

Radio Telegraphy and Telephony.

By RUDOLPH L. DUNCAN and CHARLES E. DREW.

Pp. xi + 1046, with 527 Figures. (Second Edition). John Wiley and Sons, Inc., New York, and Chapman and Hall, Ltd., London. 1931. 45s.

There are many roads to the attainment of wireless wisdom, and there are doubtless many to whom the pleasant avenues of verbiage provided by Messrs. Duncan and Drew will have their appeal. But it is permissible to raise a doubt whether, in the long run, the easy path will be the most worth while. The authors have been at pains to eliminate mathematics as far as possible from their treatment; the result is a bulky volume of over a thousand pages of descriptive matter, copiously illustrated, and covering very completely the whole province of radio communication. The book is remarkably up to date, containing a full discussion of the technique of modern transmitting and receiving equipment, and the applications of radio to aircraft and direction-finding.

The fundamental defect of the book in the eyes of the present reviewer is that, in their zeal to avoid mathematics, they have—unintentionally no doubt—done not a little to discredit such methods in the minds of their readers. These, being presumably non-mathematicians, are not in a position to realise the very real " shorthand " aids to theory which are provided by algebraic and vector symbolism. But no indication is ever given of the benefits to be derived by the mathematical expression of scientific ideas; on the contrary, the authors seem to go out of their way to present all mathematical work in as unfavourable a light as possible. Two of the very few pieces of algebra in the book—dealing respectively with Inductance values and Ohm's Law for A.C.—are quite needlessly obscure; while the valiant attempt to explain the use of vectors (save the mark!) is marred by the absence of arrows from a relative diagram. Indeed, wherever the realm of mathematics is approached the authors seem to court trouble: for example, we might cite the needlessly repeated definition of " hypotenuse " on pp. 149, 158 and 162, the last of which contains a bad error. In addition, p. 158 has the helpful statement: " The hypotenuse, Z, is the resultant or total of all oppositions, namely, reactance X and resistance R, which, as previously stated are termed impedance." Again, a whole paragraph on p. 238 dealing with the construction of the parabola and the accompanying illustration might well serve as an " Awful Warning " of everything which the parabola is not.

As might be expected from such an attempt to popularise scientific description, the authors are apt to discount the difficulties of proving their statements, and occasionally, as on p. 163, see a proof where, in fact, there is none. Again, elementary matters such as the formula for parallel resistances are merely stated without proof at all. On the logical side they are distinctly weak, and are not averse to using a term which is only defined on a later page.

The book is, however, interesting as an honest attempt to translate the intricacies of wireless into simple language, though for the reasons stated it may be doubted whether success has been altogether achieved. In fairness it should be said that the authors deserve all credit for the detailed, painstaking manner in which the often recondite processes of wireless have been described and illustrated.

It may not, perhaps, be out of place here to point out a very common mistake which is often made in expositions of grid leak and condenser rectification, and which is given currency in this book. This concerns the manner in which the actual potential of the grid varies during the passage of a signal oscillation of varying amplitude. All the grid potential variations are shown as occurring on the negative side of the normal value; actually under usual working conditions, the positive peaks of grid potential will lie more or less on a level. The discussion of grid detection is noteworthy for its entire omission of all reference to the grid current characteristic. Instead we have a series of diagrams showing in much detail the effect on plate current of variations in the grid voltage, though, as shown above, the accuracy of these is open to question. Incidentally, what in this country is called " power grid detection " is not discussed by the authors, who use this term to mean what we call " anode-bend detection."

The book is beautifully produced, and very few typographical errors were noticed. Some idea as to its quality may be gleaned from one or two extracts, taken almost at random.

The decibel " may be defined as the difference between two amounts of sound powers when their intensities are in the ratio of $10^{0.1}$, indicating a ratio in the order of 0.0001 to 0.01." (p. 1013).

" Mutual conductance is the ratio of the amplification factor and the plate impedance. A vacuum tube rated in mutual conductance more nearly conveys the actual operating conditions of the tube where the effectiveness of the elements is brought into play " (p. 290).

" The purpose influencing the desire to study alternating currents is to be able to ascertain when the circuit constants are correct, that is, when the proper conditions exist " (p. 139). Just so.

W. A. B.

D

Abstracts and References.

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PROPAGATION OF WAVES.

PROPAGATION OF HERTZIAN WAVES IN ELECTRONIC GAS UNDER THE INFLUENCE OF A MAGNETIC FIELD.—G. Todesco. (*Nature*, 6th Feb., 1932, Vol. 129, p. 203.)

The theory of the propagation of Hertzian waves in an ionised medium under the influence of a magnetic field suggests that if the field H is of suitable direction and strength the electrons will absorb part of the energy of a wave propagated through the ionised medium. This has been directly shown by the writer, using 18 cm waves; he allowed "the wave from the oscillator to pass through the anode filament space of a diode placed inside a coil producing the magnetic field," so that the filament was along the lines of magnetic force. Lighting the diode caused a diminution in the field strength due to the arriving wave when the strength of H was about 600 gauss. Values of H slightly different from this caused the effect to disappear. This value corresponded fairly well to the value necessary to give the electrons a natural rotation frequency corresponding to $\lambda = 18$ cm.

The writer finds that "the observed effect: (*a*) is proportional to the number of the absorbing orbits produced inside the diode; (*b*) increases linearly with the energy of the incident wave; and (*c*) accompanies the incident vibration, whatever may be the plane in which this vibration is polarised with reference to the electronic orbits inside the diode."

INVESTIGATIONS OF KENNELLY-HEAVISIDE LAYER HEIGHTS FOR FREQUENCIES BETWEEN 1 600 AND 8 650 KILOCYCLES PER SECOND [THE EXISTENCE OF THE *E* AND *F* REGIONS, AND THE PART PLAYED BY REFLECTION].—T. R. Gilliland, G. W. Kenrick, and K. A. Norton. (*Bur. of Stds. Journ. of Res.*, Dec., 1931, Vol. 7, No. 6, pp. 1083–1104.)

Continuation of the work dealt with in 1931 Abstracts, pp. 88, 204 (two) and 549. Authors' summary:—"The results of observations of the height of the Kennelly-Heaviside layer carried out near Washington, D.C., during 1930 are presented. Evidence for the existence of two layers (corresponding closely in virtual height to the E and F regions discussed by Professor Appleton) is found during daylight on frequencies between three and five megacycles. The modification in the virtual height of the higher F layer produced by the existence of a low E layer is investigated theoretically, and the possibility of large changes in virtual height near the highest frequency returned by the E layer is pointed out. A number of oscillograms showing the characteristic types of records observed during the tests are presented together with a graph of average heights from January to October, 1930."

In their conclusions the writers remark that while the reflection coefficients computed are small, except quite near the critical frequency (the highest frequency for which energy is returned by refraction at normal incidence from a non-turbulent layer of the type assumed), and vary somewhat according to the law of variation assumed for the refractive index, they apparently may reach several per cent, on the basis of plausible assumptions. *Reflection* may, therefore, be involved in the explanation of some of the phenomena observed; for except very near the critical frequency *refraction* cannot explain the simultaneous appearance of rays from both layers "unless horizontal gradients, that is, electron clouds, are assumed. While such clouds are, of course, possible, it must be borne in mind that they would not be stable and hence would be expected to exist only under disturbed conditions."

ECHO SIGNALS IN TRANSATLANTIC PICTURE TELEGRAPHY [AND RESULTS IN S-N DIRECTION, CAPE TOWN TO SOMERTON].—H. M. Dowsett. (*Journ. Television Soc.*, Dec., 1931, Series 2, Vol. 1, pp. 84–97.)

T. L. Eckersley has dealt with results in an *east and west* direction (1930 Abstracts, pp. 206–207). Among other conclusions, he was led to deduce that one way of decreasing echo was to employ a shorter wavelength, since more high-angle rays would pass through the layer and would therefore be lost. Fig. 14 of the present paper, showing a comparison of facsimile echoes received at Somerton from Montreal on 33 and 16 m waves, confirms this. The writer goes on to discuss 1931 results in a *north and south* direction, giving records obtained at Somerton from Cape Town on 32 and 16 m waves. It was expected that some difference might be observed in working in this direction, and this is confirmed—the facsimile records giving "less echo, different echo times, and other effects which are still under analysis to determine why they differ from the Canadian results." It is pointed out that in addition to being north and south instead of east and west, the signals from Cape Town travel almost twice as far as those from Montreal, and mostly overland instead of mainly over sea, "so that without more evidence one hesitates to give all the credit for the improved results to the direction of transmission."

Fig. 17*a* gives an example of good normal conditions on the 16 m day wave, which is suitable for facsimile and probably for television. Fig. 17*b* illustrates one of the "puzzle effects on the S. African service"—unexplained high-angle wipe-out just when echo effects should have been at a maximum. Fig. 18 shows echoes from scattered signals—echoes of period round 0.01 sec., which have no definite direction or time relation with the main signal, and against whose effects it is difficult to make provision. Figs. 19 and 20 show the effects of the same magnetic storm on the Cape Town and Montreal circuits respectively. In the former case, the disturbance first caused all the high-angle rays to be absorbed, weakening signals and removing echoes; it then (95 minutes later) caused very strong echo and scattering effects.

In the latter case, only the record of the first effect is shown.

RECEPTION AND WEATHER CONDITIONS [GERMAN AMATEURS' OBSERVATIONS].—(*See* under "Reception.")

MEASUREMENTS IN THE NEAR FIELD OF A BROADCASTING STATION [AND THE EFFECTS OF HOUSES, AERIALS, ETC.].—Zickendraht. (*See* under "Stations, Design and Operation.")

DIE IONISATION DER ATMOSPHÄRE UND DIE AUSBREITUNG DER KURZEN ELEKTRISCHEN WELLEN (10–100 M) ÜBER DIE ERDE. III. SCHLUSS (The Ionisation of the Atmosphere and the Propagation of Short Electric Waves—10 to 100 m—over the Earth. III. Conclusion).—K. Försterling and H. Lassen. (*Zeitschr. f. tech. Phys.*, 1931, Vol. 12, No. 11, pp. 502–527.)

This paper concludes the summarising report on our knowledge of the propagation of short waves, of which parts I and II were dealt with in Feb. Abstracts, p. 87. The daylight range of waves of lengths down to 10 m is worked out for a spherical earth on the lines of geometrical optics by successive approximations, assuming a parabolic distribution of ionisation in the upper ionised layer, with maximum density of electrons 1.3×10^6 per cc; curves are given for the daylight range as a function of the angle of emission, for various wavelengths, and for the true and apparent height of the upper layer as a function of the range for $\lambda = 70$ m and various times of day. The frequency-change method of layer height measurement and the results obtained by it are discussed. Curves are also given for the electric field strength to be expected at various daytime ranges from a 1 kw emitter radiating uniformly in all directions for various wavelengths, whereby the ray is assumed to have undergone one reflection.

The reflection coefficient of the earth and the case of multiple reflection between the earth and the ionised layer are considered. Curves are drawn for the electric field strength for $\lambda = 20$ m as a function of the range for the cases of one, two and three reflections at the ionised layer. Damping and reflection at the lower layer also receive consideration. It is concluded that short-wave communication to a distance is chiefly due to multiple reflection, as waves propagated within the ionised layer would undergo too much attenuation to give noticeable signals. The known results on multiple signals and their dependence on wavelength and time of day are dealt with and a list of literature references is appended.

ÜBER DIE AUSBREITUNG DES LICHTES IN INHOMOGENEN MEDIEN (On the Propagation of Light in Inhomogeneous Media).—K. Försterling. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 1, pp. 1–39.)

This theoretical investigation is based on the use of Maxwell's equations for continuous media, without consideration of discrete scattering centres. A plane wave is supposed normally incident from an infinite homogeneous medium on a layer whose dielectric constant is a function of its depth. The layer is of finite thickness and bounded on the side away from the incident wave by another infinite medium of constant dielectric constant. The expression for the dielectric constant is assumed to vanish at the boundary of the medium and to be represented in the neighbourhood of the origin by a series in positive integral powers of the depth. The wave is found to be totally reflected when no absorption is present but not when a small amount of absorption is assumed (*i.e.*, when the dielectric constant is assumed complex).

It is then assumed that the departure of the dielectric constant of the inhomogeneous layer from a constant value is small, and some special types of variation are considered, including that of a sudden change, in which it is shown that Fresnel's formulae hold. If the thickness of the layer is sufficiently small, no reflection takes place. A rigid solution of Maxwell's equations is given for the case when the dielectric constant $\epsilon(z) = (\epsilon_1 z + \epsilon_0)^k$, where k is a whole number. The reflection is found not to be total and the reflected amplitude is calculated for special cases.

ÜBER DIE VERTEILUNG DES ENERGIESTROMS BEI DER TOTALREFLEXION (On the Distribution of the Energy Stream in Total Reflection).—F. Noether. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 2, pp. 141–146.)

A simple physical explanation is given for the "puckering" and other phenomena known to occur in the transmission of electromagnetic energy from a diverging beam of light across a totally reflecting surface.

ÉTUDE DU MOUVEMENT D'UNE SPHÈRE PESANTE DANS UN CHAMP ÉLECTRIQUE IONISÉ (Study of the Motion of a Heavy Sphere in an Ionised Electric Field).—M. Pauthenier and M. Moreau-Hanot. (*Comptes Rendus*, 18th Jan., 1932, Vol. 194, pp. 260–263.)

Continuation of the work referred to in Abstracts, 1931, pp. 398–399, and February, p. 88.

EXPERIMENTAL CONTROL OF THE MOTION OF SMALL METALLIC SPHERES IN AN IONISED ELECTRICAL FIELD.—M. Pauthenier and M. Moreau-Hanot. (*Comptes Rendus*, 8th Feb., 1932, Vol. 194, pp. 544–546.)

Experimental confirmation of the theory dealt with above. With spherical particles of radius between 60 and 120 μ, the descents, plotted as functions of the radii, lie very nearly on the straight line given by the theory: in the case of spheres of radius less than 20 μ the descents, as anticipated, decrease more quickly than the radii. The field was one of 8 c.g.s. units; the spheres were of a metallic alloy, but the fundamental laws as to limiting charges and duration of charge have a more general application, holding good certainly for conducting spheres of all densities and probably for particles departing considerably from the spherical form.

SUR LA DÉCHARGE EN HAUTE FRÉQUENCE (The H.F. Discharge [Study of the Effect of the Distance between the Electrodes]).—C. Gutton and G. Beauvais. (*Comptes Rendus*, 25th Jan., 1932, Vol. 194, pp. 338–341.)

H. Gutton's results at low pressures, and those of

Gill and Donaldson at higher pressures (Abstracts, 1930, p. 267: 1931, p. 607), show that very small variations in pressure can produce sudden jumps in the effective p.d. at which the discharge sets in or breaks off. The pressures at which these jumps occur depend on the frequency of the oscillations and on the distance between the electrodes. The present writers have examined the variation, with this distance, of the starting and stopping p.ds., working on wavelengths between 22 and 5.25 metres, and using the surface of an adjustable mercury column as one electrode. As the electrode distance is increased, the p.d. necessary to maintain the discharge decreases, from the high value required for a short gap, to a minimum; increases again, and then decreases to a still lower minimum (only 42 v for an 11-m wave). These results are interpreted as effects of the régime of stationary oscillations described by Mlle. Chenot (1931 Abstracts, p. 261).

DIE MESSUNG DER PONDEROMOTORISCHEN STRAHLUNGSKRAFT AUF RESONATOREN IM ELEKTROMAGNETISCHEN FELD (Measurement of the Ponderomotive Force Exerted on Resonators in the Electromagnetic Field).—K. Fritz. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 8, pp. 987–1016.)

Author's summary:—The force exerted by electromagnetic radiation on a resonator in the form of a straight wire of length $l = \frac{\lambda}{2}$ has been measured for the first time with damped and undamped waves. Forces were found varying from 10^{-5} to 10^{-3} dyne ($\lambda = 112$; 180; 204; 245 cm.).

This radiation force was calculated, using the formula $k = \frac{W}{c}$ [k = translatory radiation force, c = velocity of e.m. waves in vacuo], from the power intake W calculated from the heat developed at the centre of the antenna. The difference of this calculated value from those found by direct measurement could be kept to less than 6 % in favourable conditions.

Greater differences, so far as they occurred, could be shown experimentally to be due to impure sinusoidal current distribution along the [receiving] antenna. A special exact measurement was made of the current distribution along l for $\lambda = 204$ cm ($l = 102$ cm).

WANDERWELLEN IN STETIG VERÄNDERLICHEN KABELN (Surges in Continuously Variable Cables).—A. Gemant. (*Archiv f. Elektrot.*, 12th Jan., 1932, Vol. 26, No. 1, pp. 11–18.)

"The Heaviside operational method is used to calculate the course of rectangular surges in cables whose capacity varies from place to place."

BROADCASTING WITH ULTRA-SHORT WAVES.—G.W.O.H. (*Wireless Engineer*, Feb., 1932, Vol. 9, pp. 59–60.)

An Editorial prompted chiefly by Schröter's paper dealt with in Jan. Abstracts, p. 30. The writer suggests the use of a reflecting surface above the aerial, so that energy which would otherwise be radiated above the horizontal, and lost, may be usefully employed. He also points out the importance of research to develop a highly sensitive receiver for these waves which shall be free from troublesome sensitivity to random disturbances such as ignition noises.

EXPERIMENTAL RESEARCHES ON THE PROPAGATION OF AIR WAVES IN A LONG CYLINDRICAL TUBE.—Th. Vautier. (*Ann. de Physique*, Nov., 1931, Vol. 16, pp. 311–410 and plates.)

Continuation of the work referred to in 1931 Abstracts, p. 146.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

I RADIOATMOSFERICI: ANALISI DEI DATI RACCOLTI NEL 1928 A MONTECASSINO DAL SERVIZIO RADIOATMOSFERICO ITALIANO (Atmospherics: Analysis of Data obtained in 1928 at Monte Cassino by the Italian Atmospherics Service).—B. Paoloni and P. Ilardi. (Reprint from *Dati e Memorie sulle Radiocomunicazioni*, 1931, 16 pp.)

For analysis of the 1927 data, *see* Abstracts, 1929, p. 504, and 1930, p. 269. The same wavelength (2 600 m) and hours (9, 15 and 21) hold for the 1928 results. The graphs show:—the monthly density of each of the eight "grades" (Figs. 2 and 3); the annual percentages of the various "grades" (Fig. 4); the monthly overall densities of atmospherics at the three hours of observation (Fig. 5); and finally the directional effects, Figs. 6 and 7 giving the angular distributions for the three specified hours, for a normal day with a high pressure régime, and for a day of overcast sky with storm clouds in some sectors, respectively.

SUR LA THÉORIE DE L'AURORE POLAIRE (On the Theory of the Polar Aurora).—A. Dauvillier. (*Comptes Rendus*, 11th Jan., 1932, Vol. 194, pp. 192–194.)

Report on the writer's observations during the polar night. "They fully confirm the mechanism indicated [March Abstracts, p. 159]: the aurora is the secondary effect of an initial cosmic phenomenon at a great distance from the earth . . . The various concentric and co-planar arcs of different intensities represent *the rays of the terrestrial magnetic spectrum of the solar electrons*. The polar aurora thus acquires a capital importance, in giving us the qualitative and quantitative measure of the solar electronic emission.

"The phenomenon presents two phases: the first corresponds to the initial cosmic effect, sometimes lasting only a very short time. The second is a *phosphorescence*, spreading slowly, due to the excitation, ionisation and polymerisation (ozone) produced by the secondary electrons. This form gives rise to post-auroral luminous clouds whose movements are remarkable. We have observed a case in which these clouds ['whirlwinds of ions'], directly they were formed, were carried along at a speed of several tens of kilometres per second. This colossal 'wind,' reigning at a height of 200 km, is probably of electromagnetic origin. It is linked with a large increase in intensity."

The simple theoretical aspect only obtains when the intensity is slight. When it increases, complicating secondary effects occur which are no longer of a cosmic nature. These are discussed on page 193, and the Note ends with figures of atmospheric potential gradient showing that "the field is reduced to half its normal value by the presence of an aurora, in accordance with the theory," and with cosmic ray measurements showing variations "five times as great as the error of measurement and not attributable to variations of atmospheric pressure or to magnetic activity."

SPECTROHELIOGRAPHIC STUDY OF THE SOLAR CORONA APART FROM ECLIPSE TIMES.—B. Lyot. (*Comptes Rendus*, 1st Feb., 1932, Vol. 194, pp. 443–446.)

AN ATTEMPT TO DETECT THE SPONTANEOUS TRANSFORMATION OF HELIUM INTO PENETRATING RADIATION.—G. T. P. Tarrant and L. H. Gray. (*Proc. Camb. Phil. Soc.*, Jan., 1932, Vol. 28, Part 1, pp. 124–127.)

From the results of their experiments the authors calculate that 1 gm. of helium emits not more than 8.6×10^{-4} quanta per sec., and on the hypothesis that each quantum represents one disintegration, derive the decay constant $\lambda < 5.66 \times 10^{-27}$ sec^{-1} and the half value period $T > 3.88 \times 10^{18}$ years.

ON THE RANGE OF FAST ELECTRONS AND NEUTRONS [Are Cosmic Rays Neutrons ?].—J. F. Carlson and J. R. Oppenheimer: W. H. Watson and F. R. Terroux. (*Phys. Review*, 1st Nov., 1931, Series 2, Vol. 38, No. 9, pp. 1787–1788: 15th Dec., No. 12, pp. 2291–2292.)

FIRST COSMIC-RAY TELESCOPE BUILT AT [BARTOL] RESEARCH LABORATORY.—W. F. G. Swann. (*Sci. News Letter*, 23rd Jan., 1932, p. 53.)

To determine whether cosmic radiation is received equally from all directions, or whether there is a directive effect. Two steel spheres 7 feet apart containing nitrogen at 100 atmospheres pressure are separated by a lead cylinder. The whole apparatus is mounted as an equatorial telescope. The difference in ionisation in the two spheres is measured and represents the amount of radiation coming from a definite direction and absorbed by the lead.

NEUTRONS AND COSMIC RAYS.—L. D. Huff. (*Phys. Review*, 15th Dec., 1931, Series 2, Vol.38, No. 12, p. 2292.)

The author concludes from a theoretical argument that "it is impossible to distinguish between neutrons and photons by magnetic effects if the energies are of cosmic-ray magnitudes. It is doubtful if neutrons with energy small enough to be appreciably deflected in a magnetic field would produce enough ionisation to be observed at all."

ÜBERGANGSEFFEKTE BEI DER ULTRASTRAHLUNG (The Effects on Cosmic Radiation of Passage through Different Materials).—H. Schindler. (*Zeitschr. f. Phys.*, 1931, Vol. 72, No. 9/10, pp. 625–657.)

This paper describes an investigation of the absorbing effect of different materials (Hg, Pb, Fe, Al, H_2O, paraffin) on the cosmic radiation incident in a solid angle of $\pm 30°$.

ABSORPTIONSMESSUNGEN DER DURCHDRINGENDEN KORPUSKULARSTRAHLUNG IN EINEM METER BLEI (Absorption Measurements of the Penetrating Corpuscular Radiation in a Metre of Lead).—B. Rossi. (*Naturwiss.*, 22nd Jan., 1932, Vol. 20, No. 4, p. 65.)

COMPARISON OF COSMIC RAYS IN THE ALPS AND THE ROCKIES.—A. H. Compton. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, p. 190.)

Abstract only. "The ionisation due to the cosmic rays is found to be the same, within a probable experimental error of 2 or 3 per cent" at the Jungfraujoch and at the same altitude on Mt. Evans. "The absolute value of the ionisation is in close agreement with that reported by Millikan for similar altitudes."

FURTHER INVESTIGATION OF COSMIC RAYS.—A. H. Compton. (*Science*, 8th Jan., 1932, Vol. 75, No. 1932, pp. 40–41.)

Details of a concerted effort to be made in the spring and summer of 1932 to determine the source and nature of cosmic rays. Intensity measurements will be made at varying altitudes on mountains (7 000 to 26 000 ft. in height) in many different parts of the world.

THE RESIDUAL IONIZATION [DUE TO COSMIC RADIATION] IN NITROGEN AT HIGH PRESSURES.—J. W. Broxon. (*Phys. Review*, 1st Nov., 1931, Series 2, Vol. 38, No. 9, pp. 1704–1708.)

ÜBER DIE IONISATION IN DRUCKKAMMERN (On the Ionisation in Pressure Chambers [including those used in Cosmic Ray Experiments]).—E. G. Steinke and H. Schindler. (*Naturwiss.*, 1st Jan., 1932, Vol. 20, No. 1, pp. 15–16.)

The cause of the pressure dependence of ionisation is ascribed to unsaturation.

CHARACTER OF ATMOSPHERIC IONISATION.—P. A. Sheppard. (*Nature*, 30th Jan., 1932, Vol. 129, p. 169.)

A letter noting the results of recent experiments at Kew Observatory on the ionisation currents to the central electrodes of three cylindrical condensers, through which air is aspirated. The voltages on the outer cylinders are automatically reversed every five minutes and the ionisation currents are recorded photographically.

The ionisation current is found to consist of a succession of pulses which occur simultaneously on all three current records. The results are interpreted "as evidence that the ionisation in the bottom layer of the atmosphere is by no means uniformly diffused" but that "parcels of relatively highly ionised air are present," distributed more or less regularly through the atmosphere.

DISTRIBUTION OF MOBILITIES OF IONS IN AIR.—J. Zeleny. (*Phys. Review*, 15th Dec., 1931, Series 2, Vol. 38, No. 12, p. 2293.)

An answer to Loeb and Bradbury's criticism of former work of the writer (1930 Abstracts, p. 175.)

THE EFFECT OF ELECTRON ATTACHMENT ON THE ION MOBILITY CURVES IN THE ZELENY AIR BLAST METHOD OF ION MOBILITY MEASUREMENT.—L. B. Loeb and N. E. Bradbury. (*Journ. Franklin Inst.*, Feb., 1932, Vol. 213, No. 2, pp. 181–194.)

On the basis of this point of view further much-needed investigations are indicated.

ELEMENTARE BESCHREIBUNG DES STATISCHEN GEWITTERFELDES (Elementary Description of the Statical Field of a Thunder Cloud).—F. Ollendorff. (*Archiv f. Elektrot.*, 18th Dec., 1931, Vol. 25, No. 12, pp. 789–795.)

Author's summary :—This paper gives an elementary calculation for the electrostatic field of a thundercloud. The system of charges in the cloud is treated as a double layer with a circular boundary, in contrast to the double layer of infinite extent formerly used as a simple assumption. It appears that, with this assumption, the solution for the field of a very extensive double layer with a circular hole in its mechanical or electrical structure is simultaneously obtained ; both arrangements give rise to identical field distributions. The field can be represented, using Stokes's theorem, by an electric vector potential which can be calculated on elementary lines and which is the same in form as the magnetic vector potential of a circular current. The curl of the electric vector potential determines the electric field, while the time derivative of this potential gives in essence the quasi-stationary magnetic field. The field of the induced terrestrial charges is taken into account by the method of images. The electric field at the earth's surface, which determines the danger of being struck by lightning, is calculated from the resultant vector potential. The result is made available for practical calculation by means of a diagram which is valid for all ratios of the distances involved. In particular, it is shown how to find some data about the thundercloud from measurements of the field at the earth's surface. A numerical example shows that the fundamental assumptions of the calculations lead to results which agree satisfactorily with experimental determinations.

SPARKING POTENTIAL AND ELECTRODE MATERIAL.—L. B. Loeb. (*Phys. Review*, 15th Nov., 1931, Series 2, Vol. 38, No. 10, pp. 1891–1897.)

Author's abstract :—A consideration of the character of the normal spark breakdown in air with external ionisation and involving time lags of greater than 10^{-4} second indicates that with the assumption of space charges the original Townsend theory of sparking can be maintained and that the spark mechanism, as is experimentally found, will be independent of electrode material. It is shown that the results of Duffendack, Wolfe and Randolph, in which they find a dependence of sparking potential on the work function of the electrodes are due to their special experimental arrangement and in no sense contradict the Townsend theory, as asserted by them. It is shown that short time (less than 10^{-5} second) surge impulse breakdown in gaps of small area with insufficient ionisation necessitates a new breakdown mechanism involving probable impact ionisation at the cathode by positive ions to replace the deficient ionisation.

VARIATION OF THE SURFACE TENSION OF THE "FULMINANT MATERIAL" AS A FUNCTION OF TEMPERATURE AND MOLECULAR WEIGHT.—E. Mathias. (*Comptes Rendus*, 1st Feb., 1932, Vol. 194, pp. 413–416.)

UNTERSUCHUNG VON OBERFLÄCHENENTLADUNG BEI STOSSSPANNUNG (Investigation of Surface Discharge with Impulse Voltage).—P. Rosenlöcher. (*Archiv f. Elektrot.*, 12th Jan., 1932, Vol. 26, No. 1, pp. 19–24.)

Author's summary :—The paper contains an investigation of surface discharges on a photographic plate between various electrode arrangements with impulse voltages of very short duration. Typical discharge figures occur only in an inhomogeneous field. In the case when the point electrode is positive they take the form of single threads passing from the points to the cathode ; when the point is negative the discharge appears as a glow surrounding it. In a vacuum the figures are broader and smudged in appearance. The laws of their occurrence are similar to those of discharge through air, so that they may be used to elucidate this also. The occurrence of the figures is not noticeable in oscillograms. The velocity with which the positive threads are formed is extraordinarily high. They are probably electron paths in which weak excitation of light takes place.

METEOROGRAPH WITH AUTOMATIC SHORT WAVE TRANSMISSION (FOR BALLOON WORK).—H. Kirsten : Moltchanoff. (*Zeitschr. V.D.I.*, 30th Jan., 1932, Vol. 76, p. 104.)

A short description of the Moltchanoff time-impulse device used on the *Graf Zeppelin* Arctic trip, where the meteorological balloons reached heights of 16–17 km., and showed that the temperature fell steadily up to about 10.5 km. and then remained constant or increased slightly. The 25–100 m transmitter is quartz-controlled. The total weight, including batteries, is about 1.4 kg. A list of important papers is given.

PROPERTIES OF CIRCUITS.

ÜBER DIE RESONANZENTZERRUNG BEI WIDERSTANDS-VERSTÄRKERN (On Distortion Correction by Resonance Methods, in Resistance-Coupled Amplifiers).—H. Bartels. (*E.N.T.*, Jan., 1932, Vol. 9, pp. 26–30.)

From the Siemens and Halske laboratories. "Circuits are given with the help of which resistance-coupled amplifiers can be corrected for distortion, or have distortion introduced. Since these circuits make use of resonance between the separate circuit components and the intervalve capacities, the original height of amplification is maintained in the corrected zone." Fig. 1 shows the introduction of a tuned inductance L_1 between two stages for increasing the amplification towards the upper frequency limit ; Fig. 2 gives the resulting amplification curves with L_1 as parameter. Fig. 3 gives a circuit for increasing the amplification at the lower frequencies, the inductance L_2 here lying parallel to the grid of the second valve. The coupling condenser C_2 is also involved in the resonance. The value of L_2 is limited by that of C_1, the total dynamic capacity of the valve : the resonance between L_2 and C_1 must be sufficiently above the selected resonance frequency, *i.e.*, C_2 must be greater than C_1. Fig. 4 shows the amplification curves, C_2 and L_2 being varied so that the selected resonance frequency remains constant.

Section 3 deals with some practical applications : thus the circuit of Fig. 1 is useful where audio-frequency sources with low entrance resistance (*e.g.*, microphones) are used and it is desired to employ an input transformer with as high a ratio as possible, in order to increase the signal/noise ratio. The method may also be usefully employed with loud speakers, microphones and pick-ups for correction at the ends of the frequency band without decreasing the all-round level of amplification—as occurs with the more usual methods. Another use is in connection with photoelectric cell cables, to correct for the effect of the cable capacity. Other uses lie in sound-film and in broadcasting control room work ; in broadcast receivers for obtaining a sharp cut-off at the upper frequency limit ; and in multi-stage amplifiers fed from a common supply, to prevent back-coupling effects by a sharply falling amplification curve. Finally, Fig. 5 gives an application to measuring purposes, namely the measurement of the dynamic capacity of valves with an error of under 1 $\mu\mu$F. *See* also below.

THE RESISTANCE-COUPLED AMPLIFIER AS OSCILLATORY CIRCUIT : CORRESPONDENCE.—H. G. Baerwald : Schlesinger. (*E.N.T.*, Jan., 1932, Vol. 9, p. 38.)

Referring to Schlesinger's paper dealt with in January Abstracts, pp. 32–33, Baerwald mentions his establishment of the same results (1929 Abstracts, pp. 446–447 and 570) and his consequent development of the method of " phase compensation " for correcting the decrease of amplification at the upper frequency limit. Schlesinger replies : the extension of the upper frequency limit by the use of inductive coupling was employed by him in the von Ardenne laboratory in 1929 for television amplifiers and for an amplifier for h.f. measuring purposes. For this, and for his treatment of the building-up processes, *see* Abstracts, 1931, p. 106 (von Ardenne), and January, p. 33.

DER GELTUNGSBEREICH DER STRECKER-FELDTKELLERSCHEN MATRIZENGLEICHUNGEN VON VIERPOLSYSTEMEN (The Range of Validity of the Strecker-Feldtkeller Matrix Equations for Quadripole Systems).—H. G. Baerwald. (*E.N.T.*, Jan., 1932, Vol. 9, pp. 31–38.)

For the successful use of these equations for the calculation of complex transmission systems, *see* Abstracts, 1930, p. 271, and 1931, pp. 92–93 and 377–378.

SUR UN POINT DE STABILITÉ DU POTENTIEL D'UNE ÉLECTRODE ISOLÉE D'UNE LAMPE TRIODE (A Point of Stable Potential of an Insulated Electrode in a Triode).—G. A. Beauvais. (*Comptes Rendus*, 25th Jan., 1932, Vol. 194, pp. 358–360.)

" If one insulates one of the electrodes of a triode and charges the other to a potential higher than that of the filament (for example, several hundred volts in the case of the type *Télégraphie Militaire* valve) the insulated electrode can take up two different potentials for which a stable equilibrium exists. One of these is close to that of the filament, the other is fairly near to that of the h.t. electrode but is always lower than the latter. . . . To study the phenomenon, the valve characteristics are traced, extended to the region of high potentials. The I_g/E_g characteristic is seen to begin by rising at small grid potentials ; it then falls again, cutting through the horizontal axis, passes through a minimum and remounts rapidly, crossing the axis again when the grid potential approaches that of the plate. It is at this [second] point [of intersection] that the potential of the insulated grid will fix itself in a stable manner ; since an increase or a decrease of potential from that point will bring with it, from the shape of the characteristics, a change in the charge on the grid which will tend to diminish or increase the potential of the latter.

" By similar reasoning it is seen that the *first* intersection of curve and axis corresponds to an *unstable* equilibrium. The I_p/E_p curve, also, has an analogous form, cutting the axis before and after passing through a minimum ; the first point correponds to an unstable, the second to a stable, equilibrium of potential for the insulated plate brought to these points. In both cases it is round these points of unstable equilibrium that one must work to obtain oscillations from the valve in a dynatron circuit."

The results may be explained either by secondary emission or by ionisation of the residual gas and the creation of positive charges. The Note ends with numerical examples.

ÜBER DIE RECHNERISCHE BEHANDLUNG MECHANISCHER SCHWINGUNGSFÄHIGER GEBILDE UNTER BENUTZUNG ÄQUIVALENTER ELEKTRISCHER ERSATZSCHEMEN (On the Calculation of Mechanical Vibratory Systems by the Use of the Equivalent Electrical Circuits).—A. Forstmann. (*Hochf : tech. u. Elek : akus.*, late *Zeitschr. f. Hochf : tech.*, Jan., 1932, Vol. 39, pp. 11–18.)

Author's summary :—After deriving the relations of fundamental importance in the quantitative treatment of vibratory mechanical systems, various practical cases [moving-coil cone loud speakers, electromagnetic pick-ups, and modern types of electromagnetic cone loud speakers] are thus treated with the help of their equivalent circuits, and conditions derived for the frequency- and amplitude-independence of their action. Independence of amplitude demands above all things the absence of subsidiary external directive forces, which produce a non-linear variation of the elasticity with amplitude and a consequent formation of combination notes. Frequency independence, in equivalent networks, demands as high a natural frequency as possible and a sufficiently high damping ; in particular, the latter is also needed for the avoidance of building-up and decay distortions.

Relations are also given for the effective electrical resistance of the mechanical moving parts, together with the conditions for frequency-independence of the applied electrical energy and of the electric potential at the output.

Equivalent Electrical Networks.—O. Brune. (*Phys. Review*, 1st Nov., 1931, Series 2, Vol. 38, No. 9, p. 1783.)

Some remarks on a recent article on the above subject by N. Howitt (1931 Abstracts, p. 553).

Resistance, Self Inductance and Capacity.—W. Holzer. (*Bull. Assoc. suisse d. Élec.* No. 24, Vol. 22, 1931, pp. 599–601.)

The writer develops, for a medium of dielectric constant ϵ and specific resistance ρ, three linear relations between resistance, self inductance and capacity, namely

$$R \,.\, C = \rho \times \epsilon \times 8.842 \times 10^{-14},\ L \,.\, C = \epsilon \times \frac{10^{-10}}{9}$$

and $\frac{L}{R} = \frac{1}{\rho} \times 40\pi$. Except the $R.C$ relation, these are applicable (with certain restrictions) provided the magnetic fields in the interior of the conductors are neglected—that is, provided the phenomena are at high frequency (*e.g.*, surges). If one quantity is known, the other two can thus be derived.

Mathematical Analysis of Non-Linear Circuits.—Part II. Other Circuits involving Saturation, and Arc and Vacuum-Tube Circuits.—A. Boyajian. (*Gen. Elec. Review*, Dec., 1931, Vol. 34, pp. 745–751.)

Conclusion of the paper referred to in Jan. Abstracts, p. 34.

The Question of Non-Linear Distortion.—Hofer. (*See* under "Transmission.")

The Design of the Band Pass Filter.—Bligh. (*See* under "Reception.")

Designing Detector Circuits.—Turner. (*See* under "Reception.")

TRANSMISSION.

Electron-Coupled Oscillator Circuits [for Short Waves]: Combining the Features of Oscillator and Buffer Amplifier.—J. B. Dow. (*QST*, Jan., 1932, Vol. 16, pp. 23–25.)

"Latest developments in the family of oscillator circuits" dealt with in February Abstracts, p. 93. Two electron-coupled versions of the Hartley circuit are first discussed. In the first, "the screen grid serves both as the anode of the oscillator circuit and as a shield, being at 'ground' r.f. potential. This requires operation of the filament at r.f. above ground, accomplished by supplying filament power through the tank [oscillatory circuit] inductance from the low-potential end, one side of the circuit being the tank coil tubing and the other an insulated lead inside." In the second, the filament is supplied through two parallel wires wound so as to form part of the inductance. The next circuit is a tuned plate modification, in which the filament supply is through the whole tank coil tubing and an insulated lead contained therein. The last circuit is a Colpitts circuit as an electron-coupled oscillator. All these circuits are recommended as master oscillators in preference to those covered by the *Proc. I.R.E.* paper (*loc. cit.*) for the reason that no neutralising adjustments are necessary, and because any ordinary design of tetrode appears to fit their requirements.

Harmonic Generation by Grid Circuit Distortion.—F. E. Terman, D. E. Chambers and E. H. Fisher. (*Elec. Engineering*, Dec., 1931, Vol. 50, pp. 966–967.)

Summary of a paper on the possibilities of using the non-linear grid voltage/current characteristic to produce harmonics, instead of the usual plate voltage/current characteristic. From the subsequent discussion :—"The grid distortion harmonic generator using tuned grid impedance is characterised by a harmonic output that decreases very slowly as the order of the harmonic is increased. The result is that while the method has little, if any, advantage over the usual arrangement on the second and third harmonic, it is much superior on higher harmonics." Using valves with ratings up to 250 watts, the method was workable on fundamental frequencies even above 3 megacycles, and although "adjustments were . . . critical with un-neutralised circuits . . . a reasonable amount of power has been obtained on 8 metres with a generator drive by an 80-metre crystal."

Generation of Ultra-Short Waves by Grid Distortion Harmonic Generator.—Terman, Chambers and Fisher. (*See* preceding abstract.)

The Dynatron Oscillator.—K. C. Black: W. T. Percival: Colebrook. (*Wireless Engineer*, Feb., 1932, Vol. 9, p. 77.)

Analyses of the results obtained by Colebrook with his new circuit, for very high frequencies, dealt with in Jan. and March Abstracts, pp. 34 and 164.

A Point of Stable Equilibrium of an Insulated Electrode in a Triode [and the Formation of Oscillations in a Dynatron Circuit].—Beauvais. (*See* under "Properties of Circuits.")

Sopra uno Schema a due Triodi per la Produzione di Onde ultracorte (A Two-Triode Circuit for the Generation of Ultra-Short Waves).—N. Carrara. (*L'Elettrotec.*, 5th December, 1931, Vol. 18, pp. 874–876.)

The writer describes experiments in which two cylindrically symmetrical triodes, Philips' A 410, were connected in parallel with their grids positive and their plates at filament potential. Abnormally strong plate currents were observed, which are ascribed to inter-electrode ultra-short-wave oscillations: the effect is dependent on the coupling between the plate and filament leads.

When a single A 410 was used in B.-K. connection, no oscillations were produced; but the introduction of a small variable capacity across the ends of the Lecher wires set them up, the wavelength depending on the value of the capacity. For a constant capacity, λ varied with V_g, but the Barkhausen condition $\lambda^2 V_g$ = const. was not satisfied. The wavelengths were of the order of 80 cm.

ZUR FRAGE DER ERZEUGUNG VON ELEKTRONENSCHWINGUNGEN NACH BARKHAUSEN-KURZ (On the Question of the Generation of Barkhausen-Kurz Electron Oscillations).—W. J. Kalinin. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 1, pp. 113–128.)

Author's summary:—The paper contains a comparative investigation of the behaviour in a Barkhausen-Kurz circuit of a high-vacuum valve and one containing gas; their characteristic surfaces are given. Attention is called to peculiarities in the oscillation regions and the wavelength distribution of the soft valve. It appears that in each oscillation region a formula holds which is not that of Barkhausen but the alternative relation $\lambda^2 V_g = aV_g + b$, which may be regarded as a generalisation of Barkhausen's condition. This gives the condition $a = 0$ for Barkausen-Kurz oscillations and also Gill-Morrell oscillations for $b = 0$.

Three types of oscillation regions exist: (a) those in which $a > 0$ and $b \neq 0$ (given by the 10-watt Russian valve investigated by the author in a previous paper—1930 Abstracts, pp. 41–42); (b) those in which $a > 0$ and $b = 0$ (regions with constant λ); (c) those in which $a < 0$ and $b \neq 0$ ("dwarf regions"). The first type was found only in the high vacuum valve, the two others only in soft valves. Points of interest for future work are:—(1) Test of the above formula for different types of valve. (2) Investigation of the origin of different types of oscillation regions under different pressure conditions and with various gases in the valve. (3) The values of the coefficients a and b in the above formula and possible theoretical explanations. (4) Test of the connection between distribution of oscillation regions and the degree of vacuum in the valve.

GILL-MORRELL AND BARKHAUSEN-KURZ OSCILLATIONS.—R. Cockburn. (*Nature*, 6th Feb., 1932, Vol. 129, p. 202.)

A preliminary notice of investigations on a triode which gives Gill-Morrell or Barkhausen-Kurz oscillations according to the value of the emission current.

SCHEMA DI UNA POSSIBILE INTERPRETAZIONE DELLE OSCILLAZIONI ELETTRONICHE DI BARKHAUSEN E KURZ: PER L'INTERPRETAZIONE DELLE OSCILLAZIONI ELETTRONICHE (A Possible Interpretation of the Electronic B.-K. Oscillations: The Interpretation of Electronic Oscillations).—A. Rostagni. (Summaries in *L'Elettrotec.*, 25th Nov., 1931, Vol. 18, pp. 848–849.)

See also February Abstracts, pp. 92–93.

ELECTRIC OSCILLATIONS IN IONISED GASES—SOME REMARKS ON THEIR PRESENT THEORIES.—J. Kunz. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, pp. 183–184.)

Abstract only of remarks on the generation of Barkhausen-Kurz oscillations.

DIRECT PIEZOELECTRIC [TOURMALIN] CONTROL FOR ULTRA-SHORT WAVES.—Straubel. (*See* under "Measurements and Standards.")

THE CALCULATION OF LEAKAGE IN AUTO-TRANSFORMERS [AND THEIR USE IN HEISING-MODULATED TRANSMITTER CIRCUITS].—Gürtler. (*See* under "Subsidiary Apparatus and Materials.")

ZUR FRAGE DER NICHTLINEAREN VERZERRUNGEN (The Question of Non-Linear Distortion).—R. Hofer. (*Telefunken-Zeit.*, Nov., 1931, Vol. 12, No. 59, pp. 45–50.)

In a previous paper (1931 Abstracts, p. 613) the writer derived a formula for the calculation of the decrease in distortion obtained by the connection of a constant ohmic resistance in series with a resistance which varied with the current. It was not pointed out that this formula is not exact, but only gives sufficiently accurate results in practice if the slope of the current/voltage function shows only slight variation. "Since the question to what degree form-distortions are suppressed by increase of the constant resistances has a considerable importance in amplifier technique, these relations are here investigated with the necessary strictness, the treatment being limited to the case of ohmic resistances." One conclusion arrived at is that the correcting effect of the constant resistance decreases with the steepness of slope of the modulation curve; so that, for example, if a valve is controlled right into the saturation zone, the correction is only slight.

A DIRECT READING MODULATION METER.—F. E. Nancarrow: Cooper and Smith. (*Wireless Engineer*, Feb., 1932, Vol. 9, p. 79.)

Another letter on the paper dealt with in March Abstracts, pp. 162–163.

MODULATION METERS AND INDICATORS FOR BROADCASTING CONTROL ROOMS.—Lubszynski and Weigt. (*See* under "Stations, Design and Operation.")

SHORT AND MEDIUM WAVE TRANSMITTER ON S.S. SANTA MARIA.—C. J. Pannill. (*Rad. Engineering*, Nov., 1931, Vol. 11, p. 20.)

The same valves, and for the most part the same components, are used for short and medium waves. The difficulty of keeping the connections short (for the sake of the short waves), and yet providing proper spring suspension, is overcome by floating the whole transmitter panel on four semi-elliptical motor-car springs.

RECEPTION.

RECEPTION AND WEATHER CONDITIONS.—German Amateurs. (*World Radio*, 12th Feb., 1932, Vol. 14, No. 342, p. 247.)

Dealing with observations on broadcast reception as affected by weather conditions, recently made by German amateurs. Reports state that reception depends to a certain extent on the air pressure at about 3 000 metres above ground, being good from regions where it is low and poor from regions where it is high. A still better guide to reception conditions is stated to be the temperature at the receiving station: "receivers where reception is 90 % excellent are usually situated in regions where cold air currents predominate. Varying air currents, or a strip of warm air between two cold currents in the region separating transmitter from receiver, have the same all-round effect as warm air. Increase in signal strength on warm days is gradual, whereas on cool or cold days it is—if conditions are otherwise favourable—much more rapid, attaining its maximum at 9 p.m. Sudden changes from warm to cold, or *vice versa*, may therefore explain many "freak" receptions. Instabilities affecting reception usually come from E or NE, attaining their maximum over Western Europe. Whereas listeners in Western Germany have poor reception from stations such as Budapest, Vienna, Rome, Trieste, Milan, Bucharest and Wilno, listeners in Eastern Germany invariably get good reception from these stations.

Reception was also good from distant stations when the sky above the receiving station was overcast by alto-stratus clouds. Good reception was also often obtained when the sky was clear, provided the condition was caused by retarded air motion within the region of an extensive anticyclone. In Germany, good long-distance reception from an easterly direction is associated with a low barometric pressure at high altitudes over Eastern Europe, producing northerly winds and cool, rainy weather; while good reception from stations west of Germany is accompanied by southerly winds and fine weather.

SELECTIVITY IN RADIOTELEGRAPH RECEPTION: AUDIO AND RADIO FREQUENCY SELECTIVITY: THE APPLICATION OF BAND-PASS AND LOW-PASS FILTERS: THE SIMPLIFICATION OF THEIR DESIGN AND CONSTRUCTION.—R. A. Hull. (*QST*, Jan., 1932, Vol. 16, pp. 8–15.)

"In receiving good quality c.w. signals only about one per cent of the available audio frequencies are necessary or even useful. The rest of them serve chiefly to hinder the ear in its work of selecting the signal desired from those undesired."

RADIO RECEPTION FROM DISTANT STATIONS, WITH RECEIVER LOCATED CLOSE TO POWERFUL TRANSMITTER.—C. H. W. Nason: Eckert. (*Rad. Engineering.*, Nov., 1931, Vol. 11, p. 35.)

A description of the Eckert "selectivity increasing" device dealt with in 1931 Abstracts, p. 323 (G.W.O.H.: Eckert.).

THE DESIGN OF THE BAND PASS FILTER.—N. R. Bligh. (*Wireless Engineer*, Feb., 1932, Vol. 9, pp. 61–66.)

The performance of ordinary band pass filters varies greatly with the wavelength to which they are tuned, and it is essential to have some means for rapidly estimating it. In his treatment of the subject the writer pays particular attention to the special type of filter dealt with in 1931 Abstracts, p. 323 (in which the variation in band breadth over the frequency range covered is greatly reduced) and to an alternative type (Fig. 3b). The former gives a rather suddenly narrowing band breadth at the higher frequencies, the latter tends to increase the breadth at those frequencies, so that a combination of the two types could be used to obtain further constancy of band breadth. Such an elaboration, however, is seldom needed in practice.

RADIO INTERFERENCE FROM INSULATOR CORONA.—F. O. McMillan. (*Elec. Engineering*, Jan., 1932, Vol. 51, pp. 3–9.)

From the summary of results: 1.—Standard multi-shell pin-type insulators of conventional design are susceptible to corona formation at three different points. 2.—Radio interference and visible corona formation for clean insulators start at the same voltage. 3.—Radio interference from insulator corona may be reduced by (a) designing the insulator so as to eliminate regions of overstressed air; (b) providing conducting coatings on different parts to act as dielectric flux distributors; and (c) displacing the overstressed air with an insulating compound. 4.—The radio-interference radiation from an insulator having a definite critical corona voltage shows a decided polarity effect for all corona voltages up to approximately twice the critical disruptive value. *See* also Herweg and Ulbricht, March Abstracts, p. 166.

THE REDUCTION OF ATMOSPHERIC AND MAN-MADE INTERFERENCE IN RECEPTION.—E. Nesper. (*Funkmagazin*, Nov., 1931, pp. 887–892.)

THE DIODE.—H. L. Kirke. (*Wireless World*, 3rd February, 1932, Vol. 30, pp. 115–118.)

In this article it is suggested that many shortcomings of the diode rectifier may be overcome by using two valves in such a manner as to separate the functions of rectification and amplification into two distinct stages. "The disadvantage of heavy damping due to Miller effect is eliminated; the a.f. amplifier has no r.f. voltages superimposed upon the a.f. voltages, and consequently the length of the straight portion of the characteristic is practically doubled, and yet the input circuit to the detector may have one pole earthed, which facilitates design and construction."

DESIGNING DETECTOR CIRCUITS.—P. K. Turner. (*Wireless World*, 10th February, 1932, Vol. 30, pp. 132–134.)

The use of anode volts/anode current curves in the case of a power valve for ascertaining such data as maximum undistorted output, optimum external load impedance, etc., is commonplace. The author claims to have found a way of ascertaining equally essential data in the case of detectors by means of a special set of anode volts/anode current curves in which each individual curve corresponds to a fixed value of r.m.s. carrier volts input. Such things as the optimum value of input for minimum distortion and the resulting output voltage for a 100% modulation are easily found by these curves—which, it is suggested, valve makers might supply. It is pointed out that the measurements necessary for drawing these curves are considerably more involved than those requisite for preparing ordinary curves.

GRID CIRCUIT LINEAR DETECTION [USING A SCREEN-GRID VALVE].—J. R. Nelson. (*Rad. Engineering*, Nov., 1931, Vol. 11, pp. 32–34.)

"This type of detector will be compared with several types of detectors in common use in order to show its marked superiority as regards sensitivity under practical operating conditions." The large input voltage required to obtain fairly linear rectification with a grid-bias detector imposes rather severe shielding and filtering problems on the amplifier design, so that if the same results could be obtained by less r.f. voltage a cheaper r.f. amplifier could be used. The necessary conditions for satisfactory working are derived. Practical results with a Type ER 224 valve show that the screen-grid detector using grid-current rectification would not quite work the new 6.3 volt pentode output valve ER 236 with resistance coupling, but that there was ample output voltage if the correct choke coupling was used. But the plate circuit impedance must not be too high, or bad distortion will be introduced : a resistance in parallel with the choke or transformer is the best way of ensuring that the impedance is not too high.

On Distortion Correction, by Resonance Methods, in Resistance-Coupled Amplifiers.—Bartels. (*See* under " Properties of Circuits.")

The Resistance-Coupled Amplifier as Oscillatory Circuit.—Baerwald : Schlesinger. (*Ibid.*)

Counteracting Acoustic Feedback through the Tuning Condenser [particularly in Midget Receivers].—Z. Bouck. (*Rad. Engineering*, November, 1931, Vol. 51, pp. 21–22.)

Showing first how the reduced condenser dimensions, with decreased number of plates and decreased air gaps, increases the feed-back difficulty, the writer then demonstrates that—apart from improvement due to the use of heavier plates of an acoustically sluggish material (" it is reasonably certain that an alloy can be developed which will be more satisfactory for condenser plates than the metals used to-day ")—the trouble can be reduced by more perfect paralleling of the plates and by centering them by mechanical rather than visual spacing. For if the plates are not properly centered, a movement in one direction will cause a greater capacity increase than a movement in the opposite direction, with the result of modulation at the fundamental frequency, and consequent regeneration. He also suggests that additional staking of the rotor plates along the unmeshing edges, and less staking of the stators, might produce a more uniform vibratory period in both sections.

Microphonic Feed-Back Phenomena in Radio Receivers [particularly Self-Contained Receivers].—H. A. Brooke. (*Journ. I.E.E.*, Feb., 1932, Vol. 70, No. 422, p. 268.)

(i) Plain a.f. feed-back between detector and loud speaker. (ii) Amplitude modulation, in the receiver itself, of the r.f. signal ; due to periodic variations in the amplification factor of (usually) the first valve caused by vibration of grid or cathode system, or both ; sprung valve-holders eliminate only the mechanical vibrations, not the acoustic, and are therefore of little assistance here. The only true remedy lies in suitable design of the valve electrode supports. (iii) Frequency modulation of the oscillator in superheterodynes, very pronounced if the receiver is properly designed for high adjacent-channel selectivity ; caused by mechanical vibrations of the variable condenser—either " reed " or " diaphragm " vibrations of the rotor and/or stator end-vanes, or transverse vibration of the rotor gang-structure. The first type is usually avoidable by bracing the vanes where possible, the second is generally more troublesome. If the length of spindle is more than about ten times its diameter, it should be supported in more than two bearings, or definite means for damping out transverse vibrations should be provided at points along its length. Otherwise the amount of feed-back must be reduced, *e.g.*, by mounting the receiver chassis on soft rubber blocks.

Recording Characteristics of Radio Signals and Static [at the Bureau of Standards Laboratory].—S. R. Winters : Parkinson. (*Rad. Engineering.*, Nov., 1931, Vol. 11, pp. 36–38.)

Including Parkinson's list of advantages of the superheterodyne circuit for a measuring and recording system such as his " three-in-one " apparatus for recording static and fading and for measuring the strength of broadcast signals.

" Ganging " the Tuning Controls of a Superheterodyne Receiver.—A. L. M. Sowerby. (*Wireless Engineer*, Feb., 1932, Vol. 9, pp. 70–75.)

After enumerating three possible methods of ganging this particular type of receiver, where the oscillator circuit has to be tuned throughout to a frequency a fixed number of kilocycles away from that to which the signal-frequency circuits are tuned, the writer deals at length with the method in which all the tuning condensers are alike, but the one for the oscillator has its law modified by a combination of series and parallel fixed condensers. Although, unlike the other methods, " this can at best provide only approximate accuracy of ganging, it has the very real advantage of convenience and ready applicability."

The Stenode Radiostat.—J. Robinson. (*Wireless Engineer*, Jan. and Feb., 1932, Vol. 9, pp. 24 and 78–79.)

Continuation of the discussion referred to in March Abstracts, p. 165.

Modern Fabrication of Radio Receivers and Other Like Assemblies [particularly the use of Self-Tapping Screws].—A. C. Lescarboura. (*Rad. Engineering*, Nov., 1931, Vol. 11, pp. 39–42 and 45.)

Fuses and Scale Illumination in Receivers.—(*Die Sendung*, 22nd January, 1932, Vol. 9, p. 72.)

A New Circuit for the Production of High Negative Grid Bias.—L. Medina. (*Funkmagazin*, Nov., 1931, pp. 856–857.)

Half the secondary of the mains transformer feeding the full-wave rectifier anodes is used to supply the anode potential of a small half-wave rectifier which provides the grid bias.

Amplifier Tone-Control Circuits.—Scroggie. (*See* under " Acoustics and Audio-frequencies.")

AERIALS AND AERIAL SYSTEMS.

MESSUNG DER STRAHLUNGSKENNLINIEN VON KURZWELLEN-RICHTANTENNEN IM FLUGZEUG (Aeroplane Measurement of the Radiation Characteristics of Short Wave Beam Aerials).—K. Krüger and H. Plendl. (*Telefunken-Zeit.*, Nov., 1931, Vol. 12, No. 59, pp. 7–25.)

The measurements here described are those dealt with in 1931 Abstracts, p. 385 (two). The present paper combines these previous papers and amplifies them in regard to the actual conditions of measurement and the apparatus used.

DIE STRAHLUNGSCHARAKTERISTIKEN VON GEERDETEN SCHIRM–, L– UND T–ANTENNEN (The Radiation Characteristics of Earthed Umbrella, L and T Aerials).—L. Hochgraf. (Summary in *E.T.Z.*, 21st Jan., 1932, Vol. 53, pp. 64–65.)

Calculations of the vector potential of the aerial current, and from this of the distant field, first for a perfectly conducting earth and then for four different conductivities, on the assumption of a sinusoidal current distribution in the aerial and of a wave velocity in the wires equal to that of light. In connection with the earth conductivity, the limitations of the Reciprocity theorem are discussed. The strengths of the direct and reflected fields are calculated, the latter being first reduced by a constant absorption factor and then added to the former. The writer's attempts at experimental confirmation of his various results have so far had little success.

VERSUCHE ÜBER DIE ABSTIMMUNG VON RICHTANTENNEN BEI KURZEN WELLEN (Experiments on the Tuning of Directional [Lecher Wire Type] Short Wave Aerials).—F. Kiebitz. (*Hochf: tech. u. Elek: akus.*, late *Zeitschr. f. Hochf: tech.*, Jan., 1932, Vol. 39, pp. 8–10.) *See* 1931 Abstracts, p. 617.

A CONTINUOUSLY LOADED CABLE FOR USE AT HIGH FREQUENCIES [at Receiving Stations of Long-Wave Transatlantic Telephony Circuit].—F. E. Nancarrow and H. Stanesby. (*P.O. Elec. Eng. Journ.*, Jan., 1932, Vol. 24, Part 4, pp. 296–298.)

Description and results of tests of a cable designed to match the impedance of the open wire transmission lines for the various parts of the widely spaced antenna system, and used for the final termination within the receiver building.

ÜBER NEUE DÄMPFUNGSMESSUNGEN AN HOCHFREQUENZENERGIELEITUNGEN (New Damping Measurements on High-Frequency Feeders).—K. Baumann and H. O. Roosenstein : Gothe. (*Telefunken-Zeit.*, Nov., 1931, Vol. 12, No. 59, pp. 50–55.)

From the paper dealt with in 1931 Abstracts, p. 616.

AERIAL LEAD-IN IN AN AREA OF HIGH NOISE LEVEL.—H. J. Loftis and H. C. Forbes. (*Proc. Inst. Rad. Eng.*, January, 1932, Vol. 20, p. 13.)

Note on a recent paper. A system was outlined for cases where the actual aerial is in a comparatively quiet zone while the lead-in is in an area of high noise level. A double lead, with an aerial and counterpoise, may be so connected that the induced noise in the down-lead balances itself out. Practical results are shown by curves: an 80 : 1 improvement in signal-to-noise ratio is said to be obtained.

ERFAHRUNGEN MIT EMPFANGSANTENNEN (Tests with Receiving Aerials).—E. Neckenbürger. (*AEG-Mitteil.*, No. 8, 1931, pp. 461–463.)

Modern receivers require the aerial to be matched to them. Two- and three-valve single-circuit receivers without r.f. stages are best served by 30 to 50 metre outdoor aerials. Indoor aerials are only good for a few strong distant stations after the onset of darkness. For multi-circuit receivers with screen-grid r.f. stages, 10 to 20 metre indoor aerials are best, and also give greater selectivity. Details of individual aerials of various kinds, and the results obtained with them, are given, together with a discussion of interfering noises and their prevention.

VALVES AND THERMIONICS.

ÜBER DEN ZUSAMMENHANG ZWISCHEN DURCHGRIFF UND ENTLADUNGSGESETZ BEI RÖHREN MIT VERÄNDERLICHEN DURCHGRIFF (On the Connection between "Durchgriff" [Penetration Coefficient] and Emission Law in "Variable Mu" Valves).—G. Jobst. (*Telefunken-Zeit.*, Nov., 1931, Vol. 12, No. 59, pp. 29–44.)

Three definitions of a variable-mu valve are possible: as a valve in which (1) the value of "durchgriff" ($1/\mu$) is a function of the distance x along the cathode axis, measured from one end; *i.e.*, $D_1 = f(x)$: (2) the "durchgriff" is a function of grid and anode potentials, and therefore of the current; *i.e.*, $D_2 = \dfrac{\partial J}{\partial E_a} : \dfrac{\partial J}{\partial E_g}$: and (3) the emission law departs in a definite manner from the $V^{3/2}$ law. The writer shows that any one of the three definitions specifies the valve, and that *all three can be derived in turn, one from the other, in the order named.* His analytical treatment shows that in variable-mu valves, as in constant-mu valves, the current I_a can be represented by $I_a = E_a^{3/2} . F(v)$, where $v = \dfrac{E_g}{E_a}$. Also that D_2 (the "durchgriff" according to definition 2) *is not dependent on E_g or E_a separately*, but only on their ratio v; *i.e.*, $D_2 = \phi(v)$. This result is confirmed experimentally, for a screen-grid valve, in Section D1, p. 40, Figs. 46 and 47.

The above-stated relations $D_1 = f(x)$, $D_2 = \phi(v)$, and $I_a = E_a^{3/2} . F(v)$, are shown to be connected mathematically, and the variation of I_a according to the last formula enables the necessary variation of D_1, along the cathode, to be calculated. A general formulation of the connecting law is not given here, but the table on p. 40 gives the results of the graphical discussion, on pp. 35–38, and the calculations, on pp. 38–40, of the behaviour of D_1

and D_2 when $F(v)$ is assumed to be equal in turn to $(v + D_{max.})^{5/2}$, e^{pv}, and $(v + D_{max.})^2$.

Section D2 deals with the use of the cathode-ray oscillograph in connection with the design of variable-mu valves. Thus by suitable choice of anode or screen-grid potential the required shape of characteristic can be obtained in the oscillograph, and the "durchgriff" easily calculated from the values of the applied potentials.

BEMERKUNGEN ZUM RÖHRENDREIECK (Remarks on the Triangular Valve Diagram).—H. Klingelhöffer and A. Walther. (*Telefunken-Zeit.*, Nov., 1931, Vol. 12, No. 59, pp. 59–61.)

Referring to Meyer's use of the triangular diagram connecting mutual conductance, amplification factor, and internal resistance (1931 Abstracts, p. 441), the writer suggests a different method (already described by Miura—1931 Abstracts, pp. 557–558) using an *equilateral* triangle logarithmically scaled.

THE HEPTODE—A NOVEL THERMIONIC VALVE [PUSH-PULL H.F. AMPLIFYING VALVE FOR SHORT WAVE CONTROL].—E. J. C. Dixon. (*P. O. Elec. Eng. Journ.*, Jan., 1932, Vol. 24, Part 4, pp. 299–302.)

A paper on the special valve referred to in February Abstracts, pp. 103–104 and 112 (Angwin). A simple push-pull valve would consist of a single cathode, a control grid on either side of this and an anode outside each grid. The reaction potential on the first grid from its anode would be in opposite phase to that anode potential, and in order to balance the reaction potential an equal and opposite potential can conveniently be derived from the second anode, which is 180° out of phase with the first. This can be effected by means of a stabilising grid on the remote side of the second anode, and a short cross-connection to the first grid. The capacity of the stabilising grid to the second anode can be arranged to be equal to that between the first anode and the grid, and the cross-connection may be duplicated to reduce its inductance. The complete double-acting balanced valve therefore includes *seven* electrodes. The valve illustrated and described is the V.T. No. 63, of 250 watts dissipation per anode, suitable for frequencies up to 18 megacycles/sec. and capable of providing sufficient output to excite two triodes, each of 3 kw dissipation, connected in push-pull.

Possibilities of development to larger sizes are briefly discussed: already heptodes in silica envelopes, with about 1 kw dissipation per anode, have been made. Possible application of the heptode to the *generation* of constant frequency oscillations, and to receiving purposes, is mentioned: a comparison is made with the screen-grid valve, the development of which in large transmitting sizes is still under development. Such valves, however, have the inherent disadvantage of necessarily very high anode impedance, whereas the heptode can be made with relatively low impedance—which should be of particular service for short-wave work.

THE DIODE.—Kirke. (*See* under "Reception.")

STEUERUNG DER GLIMMENTLADUNG AN EINER NETZKATHODE MITTELS EINER DRITTEN ELEKTRODE HINTER DER KATHODE (Control of the Glow Discharge on a Grid Cathode by means of a Third Electrode behind the Cathode).—A. Güntherschulze and F. Keller. (*Zeitschr. f. Phys.*, 1931, Vol. 72, No. 3/4, pp. 133–142.)

PHENOMENA IN OXIDE COATED FILAMENTS. II. ORIGIN OF ENHANCED EMISSION.—J. A. Becker and R. W. Sears. (*Phys. Review*, 15th Dec., 1931, Series 2, Vol. 38, No. 12, pp. 2193–2213.)

A continuation of work referred to in 1930 Abstracts, p. 103. The present article discusses the question of the place of origin of the thermionic electrons. From their experimental results the authors conclude that: "(1) The active layer is at the outer oxide surface [*cf.* Huxford, 1931 Abstracts, p. 622]. The activity depends upon the concentration of barium and oxygen on this surface and also upon the amount of metallic barium dispersed through the oxide. The core material does not directly affect the emission but it does greatly affect the ease with which free barium is produced by heat treatment or electrolysis. (2) The thermionic electrons originate in the oxide just underneath the adsorbed barium. (3) Most of the current through the oxide is conducted by electrons, a small portion being carried by barium and oxygen ions."

KONEL—A SUBSTITUTE FOR PLATINUM [AND THE USE OF NICKEL FOR FILAMENTS].—E. F. Lowry. (*Elec. Engineering*, Aug., 1931, Vol. 50, pp. 659–660.)

A description of Lowry's work leading to the development of the alloy dealt with in 1929 Abstracts, p. 635. Previously he showed that pure nickel would give a life of more than 1 500 hours.

ON THE THEORY OF THERMIONIC EMISSION.—N. H. Frank. (*Phys. Review*, 15th Nov., 1931, Series 2, Vol. 38, No. 10, pp. 1918–1919.)

Abstract only:—"A theory of thermionic emission between plane parallel electrodes including space charge effects is developed to include the modifications introduced by quantum mechanics."

THE DEVELOPMENT OF AN ELECTRON-EMITTING ALLOY.—O. S. Duffendack, R. A. Wolfe and D. W. Randolph. (*Electrochem. Soc.*, Preprint 59–17, 1931, p. 157: summary in *Elektrot. u. Masch:bau*, 13th Dec., 1931, Vol. 49, p. 921.)

Experiments in connection with finding the best material for sparking-plug electrodes showed a complete connection between sparking voltage and the work function of the cathode, and led to the development of a nickel alloy with a barium admixture which gave particularly constant action. The barium admixture gave an emission which remained constant over more than 200 hours at 1 100° C. The amount of evaporation of the barium at this temperature hardly exceeded that of the wire itself, the barium forming a true alloy with the nickel. A nickel alloy with 0.09 % barium content gave 200 μA electron current at 1 100° C and 2 mA at 1 150° C. The emission increases very rapidly with increasing barium percentage: thus wires with a 0.1 % barium content are very suitable as a core for oxide-coated valve filaments.

A NEW METHOD OF DETERMINING THERMIONIC WORK FUNCTION BY PHOTOELECTRIC CELL. —Harris. (*See* under "Phototelegraphy and Television.")

TRANSMISSION OF ELECTRONS THROUGH POTENTIAL BARRIER OF THORIATED FILAMENT.—W. B. Nottingham. (*Phys. Review*, 15th Nov., 1931, Series 2, Vol. 38, No. 10, p. 1918.)

Abstract only :—"Thermionic measurements on a thoriated filament showed the electron velocity distribution to be accurately Maxwellian at the temperature of the filament for values of applied potential negative of V_0. At V_0 thus determined, the work function was 3.2 to 3.5 volts. With small accelerating potentials, referred to V_0, the current increased rapidly and reached a fair saturation value at 1.5 to 2.0 volts. Electron velocity distributions from a *deactivated* or pure tungsten filament were Maxwellian at the temperature of the filament. Comparing curves for activated and deactivated filaments heated to give the same "saturation" emission, showed that the velocity distribution from the pure tungsten was accurately reproduced with the activated filament over the range of accelerating potential mentioned above. This result can be ascribed to the transmission of electrons *through* a potential barrier ($B - C =$ 1.4 volts), 4.5×10^{-8} cm wide at one volt under the top. The transmission coefficient $D(W)$ of the Nordheim-Fowler theory must be a function of the energy of the impinging electrons. Therefore the emerging electrons will certainly not have a Maxwellian distribution at the temperature of the filament. Experimentally the barrier transmits the faster electrons easily, as would be expected, with the result that those transmitted happen to have practically a Maxwellian distribution with a temperature 48 % $\pm$ 3 higher than the filament."

DIFFUSION OF ELECTRONS BACK TO AN EMITTING ELECTRODE IN A GAS.—I. Langmuir. (*Phys. Review*, 1st Nov., 1931, Series 2, Vol. 38, No. 9, pp. 1656–1663.)

Author's abstract :—An expression is derived for the current i between two electrodes, one of which emits (with uniform current density I_0) electrons with an initial volt velocity V_0 when the electrodes are placed in a gas at such a pressure that the electrons suffer only elastic collisions. If V is the voltage between the electrodes, λ the mean free path of an electron, the current is given by $i = (16\ \pi/3)\ I_0\lambda\ C\phi$ where C is the electrostatic capacitance between the electrodes and $\phi =$ $(V/V_0)\ ln\ (1 + V/V_0)$. If the emitted electrons have a Maxwellian velocity distribution, this equation is applicable with slightly modified values of ϕ, V_0 now being replaced by T/11600 volts.

THERMIONIC EMISSION IN CAESIUM-OXIDE PHOTO-CELLS AT ROOM TEMPERATURES.—E. F. Kingsbury. (*Phys. Review*, 15th Nov., 1931, Series 2, Vol. 38, No. 10, p. 1918.)

Abstract only :—"The measurements on these cells recently reported (Kingsbury and Stilwell, 1931 Abstracts, p. 508) have been extended to a number of cells of a wide variety of treatment during construction. A relation between the thermionic constants, log A and b_0, has been obtained which approximates in slope the relation obtained by Richardson and Young for potassium cells sensitised with oxygen. The caesium cells, however, give from 100 to 1 000 more emission at corresponding temperatures. The variation in overall photo-sensitivity to tungsten light seems to be independent of the thermionic constants. In general the photo-response decreases with increasing temperature but the behaviour is complex, some cells increasing with rise of temperature and some showing an erratic superposition of the two effects.''

THE EMISSION OF POSITIVE IONS FROM METALS.—H. B. Wahlin. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, p. 183.)

SPURIOUS CONTACT POTENTIALS AND "TRAPPED" ELECTRONS.—W. B. Nottingham. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, p. 183.)

EFFECT OF THE TARGET ON BREAKDOWN IN COLD EMISSION.—W. H. Bennett. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, p. 182.)

PHOTOELECTRIC AND THERMIONIC PROPERTIES OF PALLADIUM.—L. A. Du Bridge and W. W. Roehr. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, pp. 99–107.)

PHOTOELECTRIC AND THERMIONIC EMISSION FROM COBALT.—Cardwell. (*See* under "Phototelegraphy and Television.")

ÜBER DIE WIRKUNG DER SEKUNDÄRELEKTRONEN AUF DEN STATISCHEN ARBEITSZUSTAND DER EINGITTERÖHRE (On the Effect of Secondary Electrons on the Statical Working Condition of the Single Grid Valve).—S. A. Obolensky. (*Archiv f. Elektrot.*, 18th Dec., 1931, Vol. 25, No. 12, pp. 834–846.)

L'INFLUENCE DE LA CAPACITÉ DE GRILLE ET PLAQUE DE LA LAMPE DÉTECTRICE DANS LES POSTES DE RÉCEPTION DE RADIO-COMMUNICATIONS SANS RÉACTION (The Influence of the Grid/Plate Capacity of the Detector Valve in Radio Receivers without Retroaction).—A. van Sluiters. (*Rev. Gén. de l'Élec.*, 16th Jan., 1932, Vol. 31, pp. 91–93.)

An examination of the equivalent circuits shows how the capacity in question effects both selectivity and amplification.

VARIATION OF THE RESISTANCES AND INTER-ELECTRODE CAPACITIES OF THERMIONIC VALVES WITH FREQUENCY.—L. Hartshorn: W. E. Benham. (*Wireless Engineer*, Jan, Feb. and March, 1932, Vol. 9, pp. 24, 79 and 151–152.)

Continuation of the discussion dealt with in March Abstracts, p. 168.

DISTORTION IN VALVE CHARACTERISTICS.—Lucas : Turner. (*Wireless Engineer*, Feb., 1932, Vol. 9, p. 75.)

A reply to Turner's letter, on the paper by Lucas dealt with in March Abstracts, p. 168.

ACOUSTICS AND AUDIO-FREQUENCIES.

UNTERSUCHUNGEN ÜBER DEN HEULSUMMER (Investigations on the "Howl" Generator).—W. L. Barrow. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 2, pp. 147–176.)

Author's summary :—The paper is concerned with the so-called "howler," *i.e.*, a source of sound whose frequency varies periodically, while the amplitude remains approximately constant. A low-frequency howler is described, in addition to the known form with two high-frequency circuits. It consists of a valve generator in which the coils in the oscillating circuit have iron cores. The inductance of the coils and thence the frequency is varied periodically by periodic magnetisation of the iron cores.

The analysis of the spectrum of the emitted tone by Carson's method is given and extended. An experimental method is then described for an oscillographic analysis of compound oscillations, in particular of the beat oscillations of the howler.

The effect of an e.m.f. of the type given by the howler on an oscillatory circuit is investigated experimentally.

The application of the beat oscillator to the investigation of space acoustics is discussed.

A NEON TUBE AUDIO-FREQUENCY OSCILLATOR.—D. Pollack. (*Rad. Engineering*, Nov., 1931, Vol. 11, pp. 24–25.)

Cf. Geffcken and Richter, March Abstracts, p. 175.

REVERBERATION TIME MEASUREMENTS IN COUPLED ROOMS.—C. F. Eyring. (*Journ. Acous. Soc. Am.*, Oct., 1931, Vol. 3, pp. 181–206.)

"Some data on acoustically coupled rooms with formulae applicable to their study."

LA CORRECTION DE L'ACOUSTIQUE DANS LES HABITATIONS (Correction of the Acoustics of Buildings [Some New Sound-Insulating Materials]).—(*Génie Civil*, 6th Feb., 1932, Vol. 100, No. 6, pp. 144–145.)

Including mention of "banroc"—a light and porous "rock-wool," "acoustic felt" made from selected hair and asbestos fibre, and "sanacoustic tiles" consisting of "banroc" enclosed in envelopes of perforated sheet steel or aluminium.

TRANSMISSION OF SOUND THROUGH PARTITIONS [Measurements at the National Physical Laboratory].—A. H. Davis. (*Engineering*, 5th Feb., 1932, Vol. 133, pp. 147–148.)

A NEW METHOD FOR MEASURING THE VELOCITY OF SOUND IN VARIOUS MATERIALS [DEPENDING ON STEREO-ACOUSTIC OBSERVATIONS].—G. Veenekamp and H. Schmidt. (*Schalltechnik*, Vol. 4, 1931, p. 21 : summary in *Elektrot. u. Masch:bau*, 3rd Jan., 1932, Vol. 50, p. 23.)

Two microphones deliver the sound to two telephones, each affecting one of the observer's ears, with a time difference caused by the paths to the two microphones being different. The effect is to give an impression that the sound is arriving from one side (von Hornbostel and Wertheimer having shown that we unconsciously interpret time differences between 3×10^{-5} and 1.2×10^{-3} sec. as direction indications). By adjusting the distances of the telephones from the two ears, a "straight-ahead" effect can be produced, and from the knowledge of the respective distances the velocity of sound in the material can be found.

VELOCITY OF LONGITUDINAL VIBRATION IN SOLID RODS (ULTRASONIC METHOD) WITH SPECIAL REFERENCE TO THE ELASTICITY OF ICE.—R. W. Boyle and D. O. Sproule. (*Canadian Journ. of Res.*, December, 1931, Vol. 5, No. 6, pp. 601–618.)

VELOCITY OF SOUND IN CYLINDRICAL RODS.—G. S. Field. (*Ibid.*, pp. 619–624.)

A NOTE ON THE SOUND GENERATED BY A ROTATING AIRSCREW.—E. T. Paris. (*Phil. Mag.*, Jan., 1932, Series 7, Vol. 13, No. 82, pp. 99–111.)

ZUR DISPERSIONSTHEORIE DES SCHALLES (On Acoustic Dispersion Theory).—H. O. Kneser. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 6, pp. 761–776.)

Author's summary :—A dispersion equation is derived for the propagation of sound in gases on the basis of simple assumptions concerning the exchange of quantised excitation energy in collisions between molecules. Only one quantity is involved which cannot be determined thermodynamically : the lifetime of the excitation energy.

DIE DISPERSION HOCHFREQUENTER SCHALLWELLEN IN KOHLENSÄURE (The Dispersion of High Frequency Sound Waves in Carbon Dioxide Gas).—H. O. Kneser. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 7, pp. 777–801.)

Experimental tests of the theory referred to above gave good agreement if oscillation energy alone, not rotational energy, is considered as the excitation energy.

MESSUNG DER PHASEN- UND AMPLITUDENKURVEN VON ELEKTRODYNAMISCHEN LAUTSPRECHERN (Measurement of the Phase and Amplitude Curves of Electrodynamic Loud Speakers).—W. Binder. (*Physik. Zeitschr.*, 15th Jan., 1932, Vol. 33, No. 2, pp. 85–87.)

A NEW METHOD OF SOUND FREQUENCY ANALYSIS [HOT-WIRE RESISTANCE METHOD USING A VALVE FILAMENT].—T. Theodorsen. (*Nat. Advisory Comm. Aeronautics, U.S.A.*, Rep. No. 395, 1931.)

See 1931 Abstracts, p. 563. The principle and a full specification of the apparatus are given, together with specimen diagrams showing the distribution of energy in the different frequencies, a commercial beat-frequency oscillator being used as generator. Attention is drawn to the equal sharpness of the records at all the frequencies examined.

RADIO LOUD SPEAKERS.—N. W. McLachlan. (*Elec. Review*, 22nd Jan., 1932, Vol. 110, pp. 115–116.)

Deals with the problem of obtaining faithful and realistic reproduction. Efficiencies of hornless and exponential horn types of moving coil loud-speakers are compared. For same input, reproduction by latter is louder and better than by former. With hornless type although bass register is more powerful, resonances are more marked and higher frequencies often weak. Suggests that an exponential horn structure might be incorporated within the walls of a house when being built, the opening occupying an appreciable portion of one of the walls.

AIR COLUMN RESONANCES AND SYMMETRICAL MODES OF TRUNCATED CONICAL SHELLS (LOUD SPEAKER DIAPHRAGMS).—N. W. McLachlan. (*Nature*, 6th Feb., 1932, Vol. 129, pp. 202–203.)

The results given in this letter indicate "that the 900-cycle resonances described in a recent paper [Jan. Abstracts, p. 41] are mainly due to the air column, whilst those around 2 300 cycles pertain to the symmetrical modes."

ON THE CALCULATION OF MECHANICAL VIBRATING SYSTEMS BY THE USE OF THE EQUIVALENT ELECTRICAL CIRCUITS.—Forstmann. (*See* under "Properties of Circuits.")

TRANSIENTS AND TELEPHONY.—T. S. E. Thomas. (*Wireless Engineer*, Jan., 1932, Vol. 9, p. 23.)

Continuation of the discussion referred to in Jan. Abstracts, p. 42.

AMPLIFIER TONE-CONTROL CIRCUITS.—M. G Scroggie. (*Wireless Engineer*, Jan., 1932, Vol. 9, pp. 3–10.)

"The object of the present article is to provide data for rapidly arriving at suitable circuit constants for compensating or modifying an audio-frequency characteristic by means of a 'tone circuit' in parallel with an intervalve resistance coupling. The advantage of this system is that it lends itself to easy and accurate predetermination of characteristics. It is shown how the impedance of such a circuit can be conveniently studied by means of a circle diagram, and from this sets of representative frequency characteristic curves are derived which are applicable to the majority of practically useful conditions, and which enable circuit constants, giving approximately the desired performance, to be seen by inspection. . . . Finally, some practical points in the design of tone-controls are dealt with."

PERCENTAGE HARMONIC DISTORTION.—Greenwood: Bedford: Callendar: Scroggie. (*Wireless Engineer*, Jan., 1932, Vol. 9, p. 23.)

Continuation of the discussion dealt with in Feb. Abstracts, p. 100. Scroggie winds up by the statement that for practical purposes anything like an accurate estimate is out of the question; this being so, perhaps the conventional "9 : 11 scale" is as good a system as any, so long as this is admitted to be what it is, a useful arbitrary basis of comparison of valves and not a measure of actual working conditions.

PAPERS ON L. F. FEED-BACK IN RADIO RECEIVERS.—Bouck: Brooke. (*See* under "Reception.")

OPTICAL SYSTEM FOR SOUND-ON-FILM REPRODUCTION, COMPRISING A STRAIGHT-FILAMENT LAMP, A CYLINDRICAL OBJECTIVE, AND AN ORDINARY OBJECTIVE.—(French Pat. No. 709 366, Bussard, pub. 6th Aug., 1931; long summary in *Rev. Gén. de l'Élec.*, 26th Dec., 1931, Vol. 30, p. 218 D.)

DIFFERENTIAL PITCH SENSITIVITY OF THE EAR.—E. G. Shower and R. Biddulph. (*Journ. Acous. Soc. Am.*, Oct., 1931, Vol. 3, pp. 275–287.)

"Data on the differential pitch sensitivity of the normal ear and description of the apparatus and technique employed."

PHOTOTELEGRAPHY AND TELEVISION.

HALBTONÜBERTRAGUNG MIT KURZEN WELLEN (Half-Tone Picture Telegraphy on Short Waves [Telefunken "Channel-Change" System]).—F. Schröter: Schriever: Ilberg. (*Telefunken-Zeit.*, Nov., 1931, Vol. 12, No. 59, pp. 25–28.)

Newspaper requirements demand half-tone work, and a fine enough screen for block reproduction. The writer begins by expounding various objections to the "time-modulation" method (Ranger system) and then outlines the new Telefunken method in which the *amplitude* modulation from the photo-electric scanning is transformed into *frequency* modulation. His original suggestion was to use a loop oscillograph whose mirror was deflected proportionally to the rectified scanning currents and thus directed a light ray on to one or other of a series of *n* photoelectric cells each controlling one frequency channel.

This idea has been modified by Schriever to employ *one* cell only, inside a rotating drum-shaped screen carrying *n* circles of perforations. Thus photoelectric currents of *n* different frequencies are obtained, according to the circle of perforations on to which the light ray is directed by the oscillograph mirror. The diagram shows 4 circles, giving frequencies of 1 000, 2 500, 4 000 and 5 500 c/s. Each frequency governs one of four crystal-controlled transmitters; the spacing of the carrier waves of these corresponds to the above audio-frequencies. At the receiver these frequencies are regained by two heterodyne stages and then separated by filters. By means of a potentiometer circuit patented by Ilberg they then control the recording light relay. The above plan gives a series of five tones (including the black "spacing" tone). By using the Ranger double-modulation principle this series is doubled, and excellent results are obtained.

NOTE SULLA TRASMISSIONE DELLE IMMAGINI DAGLI AEREI ALLA TERRA E VICEVERSA (Note on Facsimile Transmission from the Air to Earth and *vice versa*).—U. Guerra. (*L'Aerotecnica*, May, 1931, p. 532.)

ECHO SIGNALS IN TRANSATLANTIC PICTURE TELEGRAPHY [AND RESULTS IN S–N DIRECTION, CAPE TOWN TO SOMERTON].—Dowsett. (*See* under "Propagation of Waves.")

SOME NOTES ON TELEVISION IN THE U.S.A. [WITH COMPARATIVE DATA OF JENKINS, WESTINGHOUSE (KDKA), BELL TELEPHONE LABORATORIES, AND BAIRD (ENGLISH) SYSTEMS].—J. H. O. Harries. (*Journ. Television Soc.*, Dec., 1931, Series 2, Vol. 1, pp. 98–99.)

"The different systems are best compared primarily by noting their respective abilities to transmit

(i) breadthways details in the picture, which ability is proportional to the value of A_0 [area of maximum definition, *i.e.*, the angular area of the picture when viewed at the optimum distance—so that the strips just blend into a whole].

(ii) lengthways details in the picture, which ability is proportional to $f_{max.}\ t$, *i.e.* to the bandwidth transmitted per picture" [t being the reciprocal of the picture rate per sec., f_{max} the top frequency of transmission]. The comparative table gives all these factors, together with values for A, the size of the picture in angular units; R_x, the scanning ratio or cycles per unit area of picture transmitted per sec., for the value of A in use; n, the number of strips per sec.; H_B, the measure of departure of the picture, as viewed, from the standard of breadthways clearness, *i.e.*, the ratio $\frac{A}{A_0} - 1$; H_L, the measure of departure from the standard of lengthways clearness, *i.e.*, the ratio $\frac{R_x}{R_0} - 1$. Throughout the tables, β — the angular width of a strip at which it just blends to the eye—is taken as 0.0007 radian, and R_0—the "standard scanning ratio" or number of cycles per sec. needed to transmit a unit area in unit time with the standard degree of even definition—as 1.76×10^6 cycles. As regards H_B and H_L, it is pointed out that these tolerances refer to the efficiency of the system as compared to a common standard, *and for the picture size actually used in that one system*: therefore it means nothing by itself to compare the values of H_B or H_L for two different systems.

TELEVISION AT THE 1931 BERLIN RADIO EXHIBITION [WITH COMPARATIVE DATA OF GERMAN P.O., FERNSEH A.G., TEKADE (TELEHOR) AND LOEWE (VON ARDENNE) SYSTEMS].—E. H. Traub. (*Journ. Television Soc.*, Dec., 1931, Series 2, Vol. 1, pp. 100–103.)

Including a description of the Fernseh A.G. new form of scanning disc construction using a continuous double spiral: the disc is run at twice the correct speed, and one spiral at a time is covered up by a second disc, containing a broad spiral slit, geared to the main disc. Hexagonal holes are used, by which the images are "entirely devoid of any streakiness." The "positive column" light source of the same company shows "absolutely no lag" although the maximum frequencies reach 135 000 c/s; two super-power valves in parallel are sufficient to supply the 10 watts feed required for its 60 candle power—this figure will probably be improved upon before the lamp is finally placed on the market.

THE "POSITIVE COLUMN" LIGHT SOURCE.—Fernseh A.G. (*See* end of foregoing abstract.)

THE GERMAN POST OFFICE CATHODE RAY TELEVISION SYSTEM.—E. H. Traub: Hudec and Perchermeier. (*Journ. Television Soc.*, Dec., 1931, Series 2, Vol. 1, pp. 75–81.)

Receiver only, the transmitter being of the Nipkow disc type. The paper is based largely on the German paper referred to in Jan. Abstracts, p. 45.

MULTI-CHANNEL TELEVISION.—C. O. Browne. (*Wireless Engineer*, Feb., 1932, Vol. 9, pp. 84–86.)

Long summary of the paper referred to in March Abstracts, p. 172.

A NEW TELEVISION SYSTEM [INCLUDING AN IMPROVED MIRROR DRUM SCANNER THROWING PICTURE DIRECTLY ON TO SCREEN].—R. W. Tanner. (*Rad. Engineering*, Nov., 1931, Vol. 11, pp. 27–28.)

"Mirrors, one for each pictorial line, are placed around the periphery of a hard rubber drum approximately 1 inch thick. Each mirror is placed at a slightly different angle with respect to the axis of rotation, to give the vertical scanning . . The individual mirrors, instead of being plane mirrors, are slightly curved in order to provide a wider angle of reflection." The scanner is about 9½ inches in diameter and throws a picture about 15 × 18 inches without the interposition of any lens. The light from a mercury arc (a new mercury-argon tube is under development to replace this) is concentrated on the drum by means of a solid cone, preferably of quartz, painted with an opaque coating except at the two ends. The large end presents a concave surface to the source of light.

NEW TYPES OF MIRROR WHEEL FOR TELEVISION RECEPTION.—R. Schadow. (*Funkmagazin*, Nov., 1931, pp. 913–916.)

Including a wheel which allows pictures of differing format to be received, and a combination of two wheels (with axes at right angles) which allows the picture-element number to be varied: it also allows the format to be changed.

A VACUUM PHOTO-CELL TYPE OF [TELEVISION] TRANSMITTER.—C. E. C. Roberts. (*Journ. Television Soc.*, Dec., 1931, Series 2, Vol. 1, pp. 82–83.) *Cf.* 1930 Abstracts, p. 402.

ÜBER EIN PHYSIKALISCHES MODELL DER SPERRSCHICHT-PHOTOZELLEN (A Physical Model of Attenuating Layer Photoelectric Cells).—F. v. Körösy and P. Selényi. (*Physik. Zeitschr.*, 1st Nov., 1931, Vol. 32, No. 21, pp. 847–850.)

The writers begin by describing the electrical processes in such cells, on lines based on the work of Lange, Schottky, and v. Auwers and Kerschbaum. They then depart from these lines by introducing the idea of retarding (brake) potential, supposing that the primary photoelectric current is decreased (as in a vacuum photoelectric cell) by a retarding potential V at the blocking layer, so that it disappears when $V = V_0$. Development of this idea leads to the construction of a physical model made up of a vacuum photoelectric cell, a selenium rectifier, and a condenser, all in parallel, in series with a 10 000 ohm resistance representing the path resistance.

Experimental comparisions between this model and a Tungsram selenium photoelectric cell are illustrated by curves. Qualitative agreement is found throughout; quantitative differences are explained as due to the resistance decrease in the layer on illumination. Contrary to previous results, the short-circuit current is proportional to the light intensity only up to 2 000 lux ($\lambda < 600\ \mu\mu$). Other results are discussed, and the writers conclude that their work, and in particular the E_0/I_0 curves for different wavelengths, proves that the primary electron movements in an attenuating layer cell are governed by the same laws as in a vacuum photoelectric cell.

Über die Stromspannungsabhängigkeit bei der lichtelektrischen Leitung in Kristallen (The Current/Voltage Relation in the Photoelectric Conductivity in Crystals).—W. Flechsig. (*Physik. Zeitschr.*, 1st Nov., 1931, Vol. 32, No. 21, pp. 843–847.)

Über eine Kristallphotozelle (A Crystal Photoelectric Cell [using Cuprite, Proustite and other Crystals]).—H. Dember. (*Physik. Zeitschr.*, 1st Nov., 1931, Vol. 32, No. 21, pp. 856–858.)

Further development of the work dealt with in 1931 Abstracts, p. 565.

Leitungs- und Photoeffekte an Sperrschichten (Conductivity and Photoelectric Effects at Attenuating Layers).—W. Schottky. (*Physik. Zeitschr.*, 1st Nov., 1931, Vol. 32, No. 21, pp. 833–842.)

A survey of the work of the writer and others up to the very latest times. The unpublished researches of Waibel on the quantum output of the attenuating layers are discussed (p. 841 onwards): maximum values of 50%, or almost one coulomb per gramme-calorie, have been obtained: on account of the absorption of the metallic layer, the *effective* selective output is only about one third of this. From these researches and the work of Gudden (March Abstracts, p. 173) the writer deduces the probability that between the internal photoelectric-effect electrons and the attenuating-layer electrons there exists not merely a connection but a complete identity; and that the attenuating layer photoelectric effect, broadly speaking, is a diffusion effect depending on the finite life of the internally liberated photoelectrons.

Über die Temperaturabhängigkeit des Sperrschicht-Photoeffektes (The Variation with Temperature of the Attenuating-Layer Photoelectric Effect).—B. Lange. (*Physik. Zeitschr.*, 1st Nov., 1931, Vol. 32, No. 21, pp. 850–856.)

A long account, illustrated by numerous curves, of experiments on the accurate determination of this variation, between + 100 and − 185° C, for a number of different types of cell.

Neue Resultate über Sperrschicht-Photozellen (New Results with Attenuating-Layer Photoelectric Cells).—E. Perucca. (*Physik. Zeitschr.*, 15th Nov., 1931, Vol. 32, No. 22, p. 890.)

Among the numerous new results summarised here are the following:—Auwers and Kerschbaum's interpretation is not quite satisfactory; a new explanation, attributing attenuating-layer photoelectricity simply to the Hallwachs effect, is in better accord with experimental results. A micrographic investigation shows that each cuprous oxide single crystal extends the whole thickness of the cuprous oxide layer, but the orientation of the crystals is not regular. No successive layers of cupric and cuprous oxides were found, so that Pélabon's theory (1930 Abstracts, p. 641) receives no support. *See* also next abstract.

Ist der Sperrschichtphotoeffekt ein Hallwachseffekt? (Is the Attenuating Layer Photoelectric Effect a Hallwachs Effect?)—E. Perucca and R. Deaglio. (*Zeitschr. f. Phys.*, 1931, Vol. 72, No. 1/2, pp. 102–115.)

See also preceding abstract. In summarising their results, the authors state that they have succeeded, under suitable conditions, in proving the existence of saturation in the open-circuit voltage of attenuating layer photocells. They traced the phenomena in these cells to a true Hallwachs effect. Metallic rectifying contacts gave them no photoelectric current.

Über einen neuartigen lichtelektrischen Effekt (On a New Photoelectric Effect).—L. Bergmann. (*Naturwiss.*, 1st. Jan., 1932, Vol. 20, No. 1, p. 15.)

A preliminary note of experiments on a new photoelectric effect produced when light falls on an iron plate painted with metallic selenium or a copper plate covered with cuprous oxide. A description is given of a cell constructed for the experimental investigation of the effect, which has also been found with other materials. To explain the phenomenon, the photoelectrons are regarded as moving in the direction of the incident light. A further account of the effect is promised.

Strukturanalyse von Photokathoden mittels Elektroneninterferenzen (The Structure Analysis of Photoelectric Cathodes by Means of Electron Interference).—W. Kluge and E. Rupp. (*Physik. Zeitschr.*, 15th November, 1931, Vol. 32, No. 22, pp. 890–891.)

For each alkali metal a series of more or less intensive diffraction maxima were found. The voltage position of these maxima is displaced, as the crystal lattice constant of the metal increases, towards the slower electrons. Parallel with the diffraction measurements, the photoelectric sensitivities of the surfaces were investigated. "With an exhaustive out-gassing of the metals, only a small absolute output was measured. Thus the feeble selective maximum of potassium around 407 mμ forms a known criterion for a good out-gassing. The relative red limits are strongly displaced towards the region of blue. The measured work function of the photoelectrons, for the pure alkali metal, follows the same course as the inner potential determined by the measurements of diffraction: to verify this, experiments with other reflection angles are being carried out." This new method of research should lead to a determination of special properties of photoelectric cathodes, hitherto impossible by purely photoelectric technique.

NEUE BEOBACHTUNGEN ÜBER FELD- UND PHOTO-EFFEKTE AN ÄUSSEREN GRENZFLÄCHEN (New Observations on Field- and Photoelectric-Effects at Outer Border Surfaces [" Mono-Layers "]).—R. Suhrmann. (*Physik. Zeitschr.*, 1st Dec., 1931, Vol. 32, No. 23, pp. 929–937.)

THERMIONIC EMISSION IN CAESIUM-OXIDE PHOTO-CELLS AT ROOM TEMPERATURES.—Kingsbury. (*See* under " Valves and Thermionics.")

CORRELATING THE SELECTIVE PHOTOELECTRIC EFFECT WITH THE SELECTIVE TRANSMISSION OF ELECTRONS THROUGH CRYSTALLINE SURFACE STRUCTURES.—A. R. Olpin. (*Phys. Review*, 15th Nov., 1931, Series 2, Vol. 38, No. 10, pp. 1917–1918.)

Abstract only.

AN INTERPRETATION OF THE SELECTIVE PHOTO-ELECTRIC EFFECT FROM TWO-COMPONENT CATHODES.—A. R. Olpin : W. H. Zachariasen. (*Phys. Review*, 1st November, 1931, Series 2, Vol. 38, No. 9, pp. 1745–1757 : 15th Dec., No. 12, p. 2290.)

Zachariasen writes that the agreements found by Olpin in this paper are purely accidental, being based on lattice constants of alkali compounds which do not agree with those determined experimentally.

INTENSITY MEASUREMENTS IN THE ULTRA-VIOLET BY PHOTOELECTRIC CELLS SENSITISED BY SODIUM SALICYLATE.—A. Chevallier and P. Dubouloz. (*Comptes Rendus*, 1st Feb., 1932, Vol. 194, pp. 452–454.)

PHOTOELECTRIC EFFICIENCIES IN THE EXTREME ULTRAVIOLET.—F. H. Spedding. (*Phys. Review*, 1st Dec., 1931, Series 2, Vol. 38, No. 11, pp. 2079–2080.)

A letter stating that " measurements of the photoelectric efficiencies of the extreme ultra-violet radiations of NE and A have been carried out which confirm earlier results (*cf.* Kenty, 1931 Abstracts, p. 622) that these efficiencies are considerably higher than the known efficiencies in the nearer ultraviolet."

ÉTUDE DU TRAÎNAGE DANS LES CELLULES PHOTO-ÉLECTRIQUES À GAZ (A Study of Sluggish Response in Gas-Filled Photoelectric Cells). —P. Fourmarier. (*Comptes Rendus*, 4th Jan., 1932, Vol. 194, pp. 86–89.)

Gas-filled cells worked at high potentials, where ionisation by collision is important, present an effect of sluggish response which shows itself in a decrease of the a.c. component when the frequency of illumination is increased. Of four possible explanations of such an effect, two are rejected because they would suggest that the frequency effect is less marked at high potentials; to decide between the remaining two, the writer has carried out tests with a cell with auxiliary anode. His conclusions are:—i. In the action of gas-filled cells it is not justifiable to neglect the ionisation by positive ions, even at potentials quite far from the glow point. ii. The slowness of this ionisation is probably the predominant cause of the sluggish response. This is confirmed by Campbell's results that argon-filled cells (β/α small) show less sluggishness than cells filled with other gases, notably helium (β/α large).

VERSTÄRKUNG DES STROMES IN PHOTOZELLEN DURCH GASENTLADUNG (Current Increase in Photocells due to Gas Discharge).—P. W. Timofeev and N. S. Chlebnikow. (*Zeitschr. f. Phys.*, 1931, Vol. 72, No. 9/10, pp. 658–668.)

A NEW METHOD OF DETERMINING THERMIONIC WORK FUNCTION BY PHOTOELECTRIC CELL. —R. E. Harris. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, pp. 182–183.)

Abstract only:—" A method of determining thermionic work function has been developed which uses a photoelectric cell to identify sameness of temperature. Change of filament wattage upon emission was measured with potentiometer accuracy while the filament was maintained at a constant brightness temperature as indicated by the photoelectric cell. Simultaneous data were obtained for determining the work function from saturation currents, and compared with this latent heat method. The sensitivity was such that one mil change in emission current caused up to 50 mm deflection upon a galvanometer. This method gave consistent values somewhat higher than those obtained by saturation current method, the latter values being similar to those usually accepted. Calculation of the resistance of the filament indicates an increase of resistance upon emission without change in temperature. The assumption of constant resistance may account for different values obtained by others with the latent heat method. Recent statistical theories indicate that the usually accepted values of the work function may be too small. The working equation used in this method seems to be independent of the statistical theory employed."

THE SMALL-SHOT EFFECT IN PHOTOELECTRIC CURRENTS.—B. A. Kingsbury. (*Phys. Review*, 15th November, 1931, Series 2, Vol. 38, No. 10, p. 1922.)

Abstract only:—" The small-shot effect, as it occurs in a photoelectric current, has been used to secure an evaluation of the electron charge. A new and original method of amplifier calibration, which involved the use of a modulated light beam, simplified the measurements and the computation of the result. In the absence of space charge, the experimental value of the electron charge was 1.61×10^{-19} coulomb for a thermionic current, and about 25 per cent greater for a photoelectric current. It was found that the small-shot effect is enormously increased in photoelectric currents which are amplified by collision ionisation. Statistical variations which might be expected to occur in a beam of radiant energy could not be detected, since, within the limits of experimental accuracy, the small-shot effect in photoelectric currents was found to be independent of the frequency of the light producing electron emission."

WELLENMECHANISCHE DISKUSSION DER LEITUNGS- UND PHOTOEFFEKTE (Discussion, on the Lines of Wave Mechanics, of the Conductivity and Photelectric Effects).—F. Bloch. (*Physik. Zeitschr.*, 15th Nov., 1931, Vol. 32, No. 22, pp. 881–886.)

ÜBER DEN ATOMAREN PHOTOEFFEKT IN DER K-SCHALE NACH DER RELATIVISTISCHEN WELLENMECHANIK DIRACS (On the Atomic Photoelectric Effect in the K-Ring on Dirac's Relativistic Wave Mechanics).—F. Sauter. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 4, pp. 454–488.)

PHOTOELECTRONS AND NEGATIVE IONS.—V. A. Bailey. (*Nature*, 30th Jan., 1932, Vol. 129, pp. 166–167.)

A letter giving evidence from recent experiments that, " for air pressures up to 59 mm, the formation of negative ions by attachment of electrons to molecules in the gas is no less notable a process than the formation of negative ions near the cathode." This conclusion is not in agreement with that of Wellish (Feb. and March Abstracts, pp. 102 and 173).

LATERAL SPACE DISTRIBUTION OF X-RAY PHOTOELECTRONS.—P. Kirkpatrick. (*Phys. Review*, 1st Dec., 1931, Series 2, Vol. 38, No. 11, pp. 1938–1942.)

THE DETERMINATION OF THE PHOTOELECTRIC THRESHOLD FOR TUNGSTEN BY FOWLER'S METHOD.—A. H. Warner. (*Phys. Review*, 15th Nov., 1931, Series 2, Vol. 38, No. 10, pp. 1871–1875.)

" The threshold for the evaporated surface of tungsten at 0° K calculated by Fowler's method agrees extemely well with the value to be expected from the thermionic work function at the same temperature as determined by Dushman. This value is 4.54 volts, or 2 720 A."

PHOTOELECTRIC AND THERMIONIC PROPERTIES OF PALLADIUM.—L. A. Du Bridge and W. W. Roehr. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, pp. 99–107.)

PHOTOELECTRIC AND THERMIONIC EMISSION FROM COBALT.—A. B. Cardwell. (*Phys. Review*, 1st Dec., 1931, Series 2, Vol. 38, No. 11, pp. 2033–2040.)

THE PHOTOELECTRIC PROPERTIES OF TANTALUM.—Cardwell. (*Ibid.*, pp. 2041–2050.)

UNTERSUCHUNG DER VERTEILUNG STARKER ELEKTRISCHER WECHSELFELDER IN DER NITROBENZOLKERRZELLE (Investigation of the Distribution of Strong Alternating Electric Fields in the Nitrobenzene Kerr Cell).—F. Hehlgans. (*Physik. Zeitschr.*, 1st. Dec., 1931, Vol. 32, No. 23, pp. 951–957.)

Continuing the work dealt with in Jan. and Feb. Abstracts, pp. 47 and 103, the writer describes tests, with 50 c.p.s. fields up to instantaneous values round 1.5×10^5 v/cm, showing that if the nitrobenzene is cleaned according to the latest technique the field distribution is always homogeneous. Artificial contamination produces distortion of the field, increasing as the instantaneous value of the field increases.

ÜBER DIE GÜLTIGKEIT DES GESETZES VON KERR FÜR NITROBENZOL BEI STARKEN ELEKTRISCHEN WECHSELFELDERN (The Validity of Kerr's Law for Nitrobenzene under Strong A.C. Electric Fields).—F. Hehlgans. (*Ibid.*, 15th Dec., 1931, Vol. 32, No. 24, pp. 971–974.)

Continuation of the above work. For the properly cleaned liquid the law holds good to within about ± 1% on the average.

MEASUREMENTS AND STANDARDS.

EIN OBJEKTIVES VERFAHREN ZUR EICHUNG DER WECHSELSTROMFREQUENZEN (An Objective Method of Calibrating [High] Alternating Frequencies).—A. Wainberg and L. Segebart. (*E.N.T.*, Jan., 1932, Vol. 9, pp. 1–4.)

From the Russian Posts and Telegraphs' Research Institute in Moscow. The frequency to be measured, reduced if necessary by multivibrator circuits, is impressed after suitable amplification on the grid of a triode. In the anode circuit of this is a circuit containing the following elements in parallel: (a) the pole-piece windings of a Wien " siren " (toothed iron wheel rotating between the poles of an electromagnet driven by a shunt-wound 80-volt motor); (b) a condenser; (c) a neon tube. By adjusting the speed of the motor, the " siren " frequency is made to synchronise with the frequency under measurement; when this point is reached the potential across the condenser drops suddenly —to zero if the e.m.f. induced by the toothed wheel is equal to that from the valve, but in any case to a value below the discharge potential of the neon tube, which therefore stops glowing. The spindle of the motor carries contacts connected to one side of a double chronograph, on whose strip are also recorded time signals in seconds.

If the synchronised speed of the motor is a whole number of turns per second, the chronograph record gives the required frequency directly. If the revolutions per second do *not* form a whole number, the additional fraction is measured by a stroboscopic device forming part of the apparatus. This involves a small spark gap, fed from an induction coil through whose primary a 140 μF condenser, charged at 300 v, discharges under the control of seconds signals from an astronomical clock; these signals discharge the condenser by means of a special carbon relay. The light of the spark is directed on to a blackened glass disc carried on the motor spindle; the blackening is cleared away to form a circle of equidistant numerals up to 30 (the number of the siren teeth) and the images of these numbers are focused on to a moving film. This record gives the fraction of a revolution which must be added to the chronograph strip number. With this equipment, a record lasting 100 seconds is enough to measure the frequency with an accuracy up to 10^{-3} per cent of the whole frequency.

Die Notwendigkeit eines Normalmasses der Zeit und meine bisherigen Erfolge beim Schaffen einer Zeitnormale (The Necessity for a Standard Time Measurement, and My Results up to the present in Creating a Standard of Time).—M. Schüler. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 12, 1931, pp. 678–684.)

The writer's standard time clock, dealt with in 1930 Abstracts, pp. 52 and 167, has now been in action for two years, and the present paper describes comparisons with the Nauen time signals, by which the errors of the latter are made evident. The sensitivity of the pendulum is indicated by a record showing the amplitude change produced in Göttingen by the June, 1931, earthquake in England.

The Time Services of the U.S. Naval Observatory: Time Services of the Telegraph Companies: Synchronous Electric Time Service.—Hellweg: Janson: Warren. (*Elec. Engineering*, Jan., 1932, Vol. 51, pp. 47–48.)

Direkte Kristallsteuerung für ultrakurze Wellen (Direct Piezoelectric [Tourmalin] Control for Ultra-Short Waves).—H. Straubel. (*Physik. Zeitschr.*, 1st Dec., 1931, Vol. 32, No. 23, pp. 937–941.)

Straubel's success in obtaining tourmalin oscillators for the direct control of ultra-short waves down to 1.2 metres has already been referred to—March Abstracts, p. 179, Harnisch. The present paper gives an account of his work. The temperature coefficient of such an oscillator is about 10 % greater than the average value for quartz, but the frequency variation is a steady change, so that a simple transmitter can dispense with thermostatic control without the receiving station " losing " its signals as it would in the case of the suddenly varying quartz. The amplitude of vibration is very small; the material of the electrodes should therefore be chosen for its small natural damping, to reduce as much as possible the energy wasted in the exchange between crystal and electrodes. Steel or 2.5 % copper-beryllium alloy is suitable.

An Interferometer Method of Studying the Vibrations of an Oscillating Quartz Plate.—H. Osterberg. (*Journ. Opt. Soc. Am.*, Jan., 1932, Vol. 22, pp. 19–35.)

Author's abstract :—" An expression involving the fringe brightness as a function of the amplitude of vibration is obtained for the case of a Michelson or a similar interferometer in which one of the returning mirrors executes S.H.M. in a direction perpendicular to its plane. A detailed discussion of the application of this expression to the measurement of the amplitude of vibration of a quartz plate is given, together with the observations upon four such plates. The superposition of either the first or second overtone upon the fundamental is also considered. The observed vibrations are predominantly flexural. The experimental results of Doerffler relating to the frequency dependence of the velocity of flexural waves are confirmed and found to apply to X-waves in a Y-cut. There is evidence of low frequency flexural waves propagated diagonally across a quartz plate. An interferometer method is suggested for distinguishing between flexural and longitudinal vibrations." *See* also 1930 Abstracts, p. 233.

A Method of High-Frequency Stroboscopy [for Observance of Density Changes within a Vibrating Quartz Crystal].—J. A. Strong. (*Nature*, 6th Feb., 1932, Vol. 129, pp. 203–204.)

The Elastic Displacement, Normal to the Surface, of Thin Rectangular Plates Subjected to Variable Forces.—Sonier. (*Comptes Rendus*, 1st Feb., 1932, Vol. 194, pp. 436–439.)

Constant Frequency by Electronic Coupling.—Dow. (*See* abstract under " Transmission.")

I Triodi e la Determinazione degli Integrali istantanei di una Grandezza alternativa periodica (The Triode and the Determination of the Instantaneous Integrals of a Periodic Alternating Quantity).—F. Vecchiacchi. (*L'Elettrotec.*, 25th Nov., 1931, Vol. 18, pp. 834–835.)

Showing that with the aid of a triode and a phase changer it is possible to determine statically the integral of a periodic alternating potential at any instant, and thus to plot the complete diagram of variation with respect to time.

I Triodi ed il Rilievo dei Cicli d'Isteresi del Ferro (The Triode and the Tracing of the Hysteresis Cycle of Iron).—F. Vecchiacchi. (*L'Elettrotec.*, 25th Nov., 1931, Vol. 18, pp. 835–836.)

Using the triode circuit referred to above. A circuit (Fig. 5) is also given in which two diodes (triodes used as such) are used for the direct reading of the mean and maximum values of an a.c. potential.

The Direct Measurement by Diodes of the Mean and Maximum Values of an Alternating Quantity.—Vecchiacchi. (*See* above.)

Das Elektronenröhren-Mikrovoltmeter (The Thermionic Valve Microvoltmeter).—E. Wöhlisch. (*Zeitschr. f. Instr : kde*, Vol. 51, 1931, p. 312.)

The writer has succeeded in measuring rapidly varying d.c. potentials from thermo-couples, of the order of 10^{-7} v, by converting (by means of an interrupter) the varying direct currents into a.c. of constant frequency (100 c/s), which is then applied through a special 1/1000 transformer to the grid of an amplifier valve. A string galvanometer in the anode circuit of this valve gives vibrations whose amplitude is a measure of the thermo-electric current. The high transformer ratio is made possible by thus limiting the amplification to one single frequency.

A HIGH SENSITIVITY POWER FACTOR BRIDGE [MODIFIED SCHERING BRIDGE: WITH ANALYTICAL THEORY].—W. B. Kouwenhoven and A. Banos, Jr. (Summary in *Elec. Engineering*, Jan., 1932, Vol. 51, pp. 40–41.)

Power factors of specimens of cable material have been measured, ranging from 0.00007 to 0.16, with a maximum variation of ± 0.000005.

POWER FACTOR MEASUREMENT BY THE CAPACITANCE BRIDGE.—R. P. Siskind. (*Ibid.*, p. 41.)

LEITFÄHIGKEITSMESSUNGEN AN PULVERN (Conductivity Measurements on Powders [of Semi-Conductors]).—P. Guillery. (*Physik. Zeitschr.*, 15th Nov., 1931, Vol. 32, No. 22, pp. 891–892.)

Conductivity measurements on semi-conductors are difficult if the substance is in the form of microcrystalline powder, the artifice of making the powder up into compressed pastilles often leading to erroneous results. The writer, with Völkl, has developed a method suggested by Gudden, in which the powder is embedded in a homogeneous dielectric and subjected to a high-frequency field of adjustable frequency. By finding the particular frequency at which the maximum damping is produced, and from a knowledge of the dielectric constants, the conductivity of the powder can be calculated. Specimen results are given and certain conclusions drawn as to the constancy of such conductivities, and the effect of grain size.

[PHOTOMETRIC] DOSIMETER FOR DETERMINING THE POWER IN H.F. CIRCUITS OF FREQUENCY 1 MEGACYCLE AND OVER.—K. Heinrich. (*Elektrot. u. Masch: bau*, 8th Nov., 1931, Vol. 49, pp. 831–833.)

Combination of an incandescent lamp coupled to the oscillating circuit, a selenium cell, and a highly sensitive meter. The writer describes the calibration of the apparatus and the results obtained in investigating the behaviour of different liquids in high frequency fields.

PIEZOELECTRIC WATTMETER FOR RAPIDLY VARYING POWERS.—(French Pat. No. 712 111, Oerlikon, pub. 25th Sept., 1931; long summary in *Rev. Gén. de l'Élec.*, 26th Dec., 1931, Vol. 30, p. 220 D.)

ATTENUATION MEASUREMENTS ON TELEPHONE AND TELEGRAPH LINES.—J. W. Horton. (*Rad. Engineering*, Nov., 1931, Vol. 11, pp. 25–26.)

SUBSIDIARY APPARATUS AND MATERIALS.

DIE BERECHNUNG DER STREUUNG BEIM SPARTRANSFORMATOR (The Calculation of Leakage in Auto-Transformers).—R. Gürtler. (*Telefunken-Zeit.*, Nov., 1931, Vol. 12, No. 59, pp. 55–59.)

The nearer the transformation ratio is to unity, the smaller are the losses in an auto-transformer compared with those in the corresponding separate-winding transformer. The writer begins by describing the construction and method of employment of an auto-transformer in the anode circuit of a Heising-modulated transmitter. To avoid non-linear distortion, the grid of the modulating valve must be prevented from becoming positive, so that the maximum amplitude of the anode a.c. potential must lie well below the d.c. value. For the oscillator valves, on the other hand, a higher voltage is required, and a transformer with a ratio between 1 : 1 and 1 : 2 is therefore needed. But at the higher audio-frequencies the transformer leakage produces a potential drop, so that to keep this leakage as low as possible the use of an auto-transformer is very desirable.

The rest of the paper deals with the calculation of the leakage: expressed in words, the procedure arrived at is as follows:—If n_1, n_2 represent the number of common turns and of total turns respectively, so that the non-common turns of the secondary are $(n_2 - n_1)$, then this last winding is treated as separated from the common winding, and the leakage calculated as for a separate-winding transformer with windings of n_1 and $(n_2 - n_1)$ turns, according to equations 6 and 7. A worked-out example (the Heising-modulation transformer) comes to 0.071 henry, while actual measurement of the leakage gave 0.067 henry.

BEITRAG ZUR KENNTNIS DER WECHSELSTROMMAGNETISIERUNG VON EISEN (Contribution to our Knowledge of Magnetisation of Iron by Alternating Currents [chiefly Theoretical Investigation]).—H. S. Hallo and R. H. Borkent. (*Archiv f. Elektrot.*, 18th Dec., 1931, Vol. 25, No. 12, pp. 796–812.)

GLEICHSTROMBELASTETE EISENKERN-INDUKTIVITÄTEN MIT LUFTSPALT (Iron-Cored Inductances, with Air Gap, carrying a Direct Current Component).—R. Gürtler. (*Hochf: tech. u. Elek: akus.*, late *Zeitschr. f. Hochf: tech.*, Jan., 1932, Vol. 39, pp. 2–7.)

In this first instalment, the writer arrives at the formula $L = 0.4\pi\, 10^{-8} n^2 \frac{q}{l} \mu_s$ henry, where n is the number of turns, l the mean path length, and q the effective cross section of the iron; and where μ_s, the so-called *apparent* (a.c.) permeability, stands for $\frac{1}{\frac{1}{\mu_{ac}} + a}$. Here μ_{ac} is the dynamic (a.c.) permeability and a is the "ideal ratio" of air-gap to l, giving equal (d.c.) induction in gap and in iron. a can be determined from the static magnetisation curve (Fig. 12), μ_{ac} from curve sheets. The inductance formula can then be applied.

The second and final instalment will deal with the construction of curve sheets for μ_s and for determining the optimum air-gap. In this way the smallest number of turns for a given core, or the smallest core for a given number of turns, may be obtained.

NON-LINEAR CIRCUITS FOR RELAY APPLICATIONS [PARTICULARLY SATURABLE CORE REACTOR CIRCUITS].—C. G. Suits. (*Elec. Engineering*, Dec., 1931, Vol. 50, pp. 963–965.)

VACUUM SWITCHES [BREAKING IN VACUA OF 10^{-4} TO 10^{-6} MM HG].—K. A. Wiedamann. (*Bull. Assoc. suisse d. Élec.*, 11th Dec., 1931, Vol. 22, No. 25, pp. 622–625.)

VORLÄUFIGE MITTEILUNG ÜBER METALLKONTAKTE MIT SEHR DÜNNER FREMDSCHICHT (Preliminary Communication on Metallic Contacts with an Interposed Very Thin Film of Foreign Material).—R. Holm: Meissner. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 12, 1931, pp. 663–665.)

With special reference to the hair-trigger vacuum switch dealt with in 1931 Abstracts, p. 628.

THE GULSTAD VIBRATING RELAY CIRCUIT AS AN APPLICATION OF THE "MITNAHME" (PULL-IN) EFFECT.—H. Salinger and A. F. Schönau. (*E.N.T.*, Dec., 1931, Vol. 8, pp. 527–533.)

INVESTIGATIONS INTO THE RESPONSE TIMES OF RELAYS.—J. Rybner. (Summary in *Physik. Ber.*, 1st Nov., 1931, Vol. 12, p. 2434.)

UNTERSUCHUNGEN AN BRAUNSCHEN RÖHREN MIT GASFÜLLUNG (Experiments on Cathode Ray Tubes containing Gas).—M. von Ardenne. (*Hochf: tech. u. Elek: akus.*, late *Zeitschr. f. Hochf: tech.*, Jan., 1932, Vol. 39, pp. 18–24.)

"Pre-concentration" of a cathode beam (preliminary concentration, close to the cathode, of the divergent rays) is accomplished sometimes by screening, sometimes by a Wehnelt cylinder. The former method has the disadvantage of high current loss, and for tubes working with slow electrons (up to 4 000 v) the Wehnelt cylinder is essential. Figs. 1, 2 and 3 show the action of this device. As regards the equally necessary "ray concentration" (farther along the path) called for by the dispersive action of the negative space charge, the magnetic fields effective in high-tension tubes are useless for low-tension tubes. Their action can only be explained by assuming a certain self-concentration of electrodynamic nature, and this is negligible in a low-tension tube. Electric fields can hardly be used, owing to their retarding effect. "Self-concentration" (by the electrodynamic attraction of the convection currents) can occur with very high velocity rays, the beam remaining uniform at pressures below 10^{-5} mm; but below 4 000 v this effect is no longer sufficient. At these velocities the mutual repulsion of the ray electrons preponderates, and a means of removing the space charge is essential. This means exists in the use of a gas residue of about 10^{-3} mm pressure. The rest of the paper is devoted, therefore, to the employment of "gas-concentration."

The action is illustrated by Fig. 4, showing a 200-volt beam in a rare gas at the pressure named. The differing explanations of Johnson and Brüche are mentioned: various effects are enumerated which can be explained by either hypothesis. The use of gas-concentration without any external fields is limited to low-tension tubes: for hydrogen the limit is round 8 000 v, for argon round 5 000 v. Section B2 deals with certain anomalies found, in the writer's laboratories, during tests on tubes using this form of concentration. Fig. 6 shows the appearance, in a line grid (as used in television) where the speed along the lines is about 100 m/sec., of parasitic oscillations of a well-defined frequency round 50 kc/sec., in directions radial from the middle point of the screen. This phenomenon occurs as soon as the anode potential exceeds about 3 000 v, and is traced to *ion oscillations* in the plane perpendicular to the ray, caused by collision with fast electrons and depending for their frequency on the kinetic temperature-velocity of the ions and the dimensions of the tube. This explanation led Schlesinger to a method of preventing these oscillations, by an external earthed metal coating (Fig. 7). A second anomaly is illustrated in Fig. 9. The sharp fluorescent line shown in *a* was given by a 50 c/s oscillation, while a 1 mc/s oscillation of the same amplitude gave only the blurred line shown in *b*—especially blurred in the middle where the speed was highest. It was found that this blurring could be partly cured by increasing the emission; this led to the effect being traced to the impoverishment in ions near the screen, due to the great recording speed being higher than the molecular velocity of the ions. Consequently, experiments were carried out with gases of smaller molecular weight than the previously used argon, and it was found that the use of hydrogen about quadrupled the high frequency "blurring limit": a sharp 5 cm line could be obtained at 3 mc/s. Oxide-coated cathodes were found to work excellently in the hydrogen atmosphere—a result which fits in with present ideas as to their mode of action.

Section C deals briefly with the processes occurring along the gaseous path—the most important practical point being the secondary ("neben") glow on the screen, a glow all over the screen of about one-hundredth the intensity of the spot and obviously due to diffused electrons of much lower speed. Fig. 10 is a long-exposure record showing this secondary glow and the effect of a small magnet pole held in front of the screen: the black spot indicates that the electrons causing the secondary glow are repelled as well as the ray electrons, and that they follow a path not very different from that of the ray. Theoretical and experimental results show that the ratio of the brightness of secondary and spot glows *is least with heavy gases*. The use of such gases, combined with a screen with an absorbent coating which reduces the effect of the slow electrons, practically suppresses the secondary glow.

Section D deals with the screen itself, its special requirements and the way in which these have been met. One great difficulty is to make it withstand the heat evolved without discoloration (due, when water-glass is employed as binding material, to the separation of sodium). By using another method (not specified) screens have been made which will stand a steady exposure to a 3 000 v 10^{-4} A ray without discoloration and—thanks to better heat-conduction from the crystals—without serious fatigue effects. Fig. 11 shows how the charges formed on the screen may have such a retarding effect on slow electrons (300 v) that the ray can no longer reach the screen with sufficient energy. Nevertheless the use of a conducting layer is not justified in low-tension tubes, the small increase in brightness thus produced being more than counteracted by the increased optical opacity.

Section E concerns itself with the fact that while the control input required to deflect a cathode ray is always very small, it is not constant for different positions of the ray; this point must be taken into account when the c.-r. tube is used as a measuring instrument in conjunction with generators of high internal resistance. It is concluded that a gas-filled tube presents a negligible load to generators of resistance not exceeding 10^5 ohms, and that *provided the plates are negatively biased with respect to the anode* no appreciable curve distortion need be feared. If these conditions are not observed, the oscillograms may not give a true record.

On the Concentration of Cathode Rays by means of Gas Particles.—W. Ende. (*Physik. Zeitschr.*, 1st Dec., 1931, Vol. 32, No. 23, pp. 942–945.)

An account of researches led up to by the production of the "visible filiform electron beams" dealt with in 1931 Abstracts, p. 167. The mechanism propounded in 1922 by J. B. Johnson is found to apply.

Improvements in Discharge Tubes with Hot Cathodes: Reduction of Power Consumed in Heating, by Thermal Insulation of Cathode.—(French Pat. No. 708 670, Claude, pub. 27th July, 1931; summary in *Rev. Gén. de l'Élec.*, 26th Dec., 1931, Vol. 30, p. 217 D.)

A Neon-Tube Oscilloscope.—Guerbilsky. (*See* abstract under "Miscellaneous.")

Über Wanderwellensteuerung, Strahlsperrung bei Kathodenoszillographen und Erzeugung sehr kurzer Lichtstösse (On Control by Surges, Beam Locking in Cathode-Ray Oscillographs, and the Production of Very Short Light Impulses).—W. Fucks. (*Archiv f. Elektrot.*, 18th Dec., 1931, Vol. 25, No. 12, pp. 847–852.)

Ondes mobiles et l'Oscillographe cathodique (Surges and the Cathode-Ray Oscillograph). —S. Teszner. (*Rev. Gén. de l'Élec.*, 12th Dec., 1931, Vol. 30, pp. 957–966.)

A full paper on the writer's modifications (1931 Abstracts, p. 511) to the Dufour type oscillograph. Special attention is given to the method of obtaining the time base, and to the means adopted for ensuring synchronism with the phenomenon to be recorded.

Surges in Continuously Variable Cables.—Gemant. (*See* under "Propagation of Waves.")

The Variation with Temperature of Photographic Processes [for Light, X- and Alpha-Rays].—J. Eggert and F. Luft. (*Veröffentl. Wiss. Zentral-Lab. Agfa*, Vol. 2, 1931, pp. 9–18.)

Investigation of various emulsions. Only with light is there an important temperature effect, with a maximum blackening at low temperatures and a minimum round 50° c. Alpha ray effects are independent of temperature: with x-rays the blackening increases steadily, but only slightly, with temperature. A ripening effect appearing at the higher temperatures occurs only with light.

Photographic Plates for Use in Spectroscopy and Astronomy.—C. E. K. Mees: Eastman Kodak Company. (*Journ. Opt. Soc. Am.*, Dec., 1931, Vol. 21, pp. 753–775.)

Giving specific information as to the characteristics of the plates made by the Eastman Kodak Company which are specially suitable for scientific work.

A New High Vacuum System.—J. A. Becker and E. K. Jaycox. (*Review Scient. Instr.*, Dec., 1931, Vol. 2, pp. 773–784.)

An oil diffusion pump used with a charcoal trap and backed by a fore pressure of 10^{-4} mm Hg is capable of producing a pressure of 2×10^{-8} mm Hg without the use of liquid air or any other cooling agent. With two in series, the system can maintain a pressure of less than 10^{-7} mm Hg for several days without any attention.

Theory of Thermal Micromanometers.—M. Matricon. (*Journ. de Phys. et le Rad.*, Dec., 1931, Vol. 2, Series 7, pp. 137 s–139 s.)

Über die Hochspannungsanlage des Kathodenoszillographen (On the High Voltage Plant of the Cathode Ray Oscillograph).—K. Beyerle. (*Archiv f. Elektrot.*, 12th Oct., 1931, Vol. 25, No. 10, pp. 708–710.)

Gasgefüllte Verstärker- und Ionensteuerröhren (Gas-Filled Discharge Tubes with Control Grid—Schottky "Wall Current" Relay Tube and Hull "Thyratron").—E. Lübcke. (*E.T.Z.*, 10th Dec. 1931, Vol. 52, pp. 1513–1517.)

Capabilities of Mercury Arc Rectifiers and Mercury Arc Valves with Controlled Grids.—Brown Boveri Company. (*Electrician*, 18th Dec., 1931, Vol. 107, pp. 837–838.)

Glass Bulb Rectifiers: Their Life, Efficiency and Special Advantages.—A. M. Browne. (*Ibid.*, p. 839.)

Die Pulsation bei Ventilgleichrichteranlagen (Pulsation in Valve Rectifiers [Investigation of Simple Theoretical Formula]).—H. Boekels. (*Archiv f. Elektrot.*, 12th Oct., 1931, Vol. 25, No. 10, pp. 705–708.)

Die Elektronenleitfähigkeit der Kupferoxyde (The Electronic Conductivity of the Copper Oxides).—M. Le Blanc and H. Sachse. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 6, pp. 727–735.)

Conductivity and Photoelectric Effects at Attenuating Layers.—Schottky. (*See* under "Phototelegraphy and Television.")

PAPERS ON ATTENUATING LAYER PHOTOELECTRIC CELLS.—Körösy and Selényi: B. Lange: Perucca. (*Ibid.*, and Gudden, March Abstracts, p. 173.)

THE TREND IN DIELECTRIC RESEARCH [INCLUDING A BIBLIOGRAPHY].—J. B. Whitehead. (*Elec. Engineering*, Dec., 1931, Vol. 50, pp. 967–970.)

See also "A Brief Review of Contemporary Dielectric Research," *ibid.*, Jan., 1932, Vol. 51, pp. 30–35.

DIELECTRIC LOSSES IN MICANITE INSULATION OF H.T. GENERATOR COILS: SURVEY.—W. Boller and M. Wellauer. (*Bull. Assoc. suisse d. Élec.*, No. 24, Vol. 22, 1931, pp. 589–598.

POWER LOSSES IN ELECTROLYTIC CONDENSERS: FILM CHARACTERISTICS OF ELECTROLYTIC CONDENSERS.—F. W. Godsey, Jr. (Summaries in *Elec. Engineering*, Jan., 1932, Vol. 51, pp. 45–46.)

A STABLE LABORATORY AMPLIFIER [FOR BRIDGE, PHOTOELECTRIC CELL, AND OTHER WORK].—C. T. Burke. (*Gen. Rad. Exper.*, Oct., 1931, Vol. 6, pp. 4–5.)

A short description of a commercially available amplifier with a gain of 250, a power output of 7 mw., and a flat frequency characteristic between 20 and 100 000 c/s. Input impedance 1 megohm, optimum load impedance 20 000 ohms.

OSCILLOGRAPHIC INVESTIGATION OF INTERMITTENT GLOW DISCHARGES.—R. Rinkel. (*Verh. d. Phys. Ges.*, No. 1, Vol. 12, Series 3, 1931, p. 20.)

Using a c.-r. oscillograph so connected to a flashing circuit that the abscissae represent the valve currents and the ordinates the condenser charging current. Loops are observed in the resulting oscillogram, indicating changes in conductivity dependent on the discharge tube potential.

ANODE SUPPLY FOR AUTOMOBILE RECEIVERS FROM CAR STORAGE BATTERY.—A. B. Bedrossyan. (*Proc. Inst. Rad. Eng.*, January, 1932, Vol. 20, p. 15.)

A paragraph on a recently exhibited device. At present a consumption of 12 watts is taken from the accumulator, but a higher efficiency is expected with improved design. No details are given.

THERMOSTAT HEATING CURRENT STABILISED AGAINST MAINS FLUCTUATIONS.—H. Abraham. (*Comptes Rendus*, 28th Dec., 1931, Vol. 193, p. 1403.)

In a Note on the possibility of maintaining a room at a constant temperature, the writer describes a current stabiliser consisting of a series inductance with an iron core suspended by a float which is in neutral equilibrium owing to an appropriate design of the portion not immersed. A current constancy of ½% is obtained.

A SIMPLE CLAMP FOR FINE WIRES [LOW-CURRENT FUSES, ETC.; USING PRESS FASTENERS].—L. Bainbridge-Bell. (*Journ. Scient. Instr.*, Dec., 1931, Vol. 8, pp. 391–392.)

TELLURIUM THERMO-ELEMENTS.—B. Lange and W. Heller: M. A. Lewitsky and M. A. Lukomsky. (Summaries in *E.T.Z.*, 10th Dec., 1931, Vol. 52, p. 1529.)

AN IMPROVED PERMEAMETER FOR TESTING MAGNET STEEL.—B. J. Babbitt. (*Bell. Tel. Reprint*, Monograph B. 618.)

EINE ERSCHÜTTERUNGSFREIE AUFSTELLUNG MITTELS LUFTPOLSTERS (A Shock-proof Mounting using Air Cushioning.)—E. Gehrke and B. Voigt. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 12, 1931, pp. 684–686.)

CONDUCTIVITY MEASUREMENTS ON [SEMI-CONDUCTING] POWDERS.—Guillery. (*See* under "Measurements and Standards.")

A METHOD OF HIGH-FREQUENCY STROBOSCOPY FOR OBSERVANCE OF DENSITY CHANGES WITHIN A VIBRATING QUARTZ CRYSTAL.—J. A. Strong. (*Nature*, 6th Feb., 1932, Vol. 129, pp. 203–204.)

STATIONS, DESIGN AND OPERATION.

MESSUNGEN IM NAHEFELD EINES RUNDSPRUCHSENDERS (Measurements in the Near Field of a Broadcasting Station [at Basle: and the Effects of Houses, Aerials, etc.]).—H. Zickendraht. (*Helvet. Phys. Acta, Fasc.* 1, Vol. 5, pp. 3–25.)

On 318.8 and 244.1 metre wavelengths, and an aerial power of about 550 watts. The paper begins with a discussion of the application of the Biot-Savart and Coulomb laws and their formulae to the distant, intermediate and near fields. The rest of the paper deals with actual measurements of the magnetic fields at distances up to (in one case) 120 metres from the transmitting aerial. Fig. 7 gives the results for the shorter of the two wavelengths, in a direction free from obstacles; it shows that from 20 to 70 metres the measured magnetic field agrees excellently with the theoretical formula (22) for the intermediate zone. The measurements were corrected for antenna effect of the receiving frame aerial, and for the weakening of field due to the frame current. The discrepancies at shorter distances are attributed to the complex nature of the transmitting aerial compared with the simple vertical wire assumed in the calculations.

The rest of the paper deals with the effects of neighbouring aerials, lightning conductors, and buildings. Fig. 9 shows the field distortion due to an aerial A_2, tuned to the transmitted wavelength, about 52 metres from the transmitting aerial, and behind a building (*see* Fig. 8). In Fig. 10 the secondary aerial is successively tuned to wavelengths between 199 and 391 m, thus passing through the transmitted wavelength of 244.1 m. Figs. 11 and 12 show the effects of an aerial tower and buildings.

BROADCAST STATION COVERAGE SURVEYS.—V. V. Gunsolley. (*Rad. Engineering*, Nov., 1931, Vol. 11, pp. 29–31 and 38.) *Cf.* Westinghouse Company, January Abstracts, p. 52.

On the Use of Field Intensity Measurements for the Determination of Broadcast Station Coverage.—C. M. Jansky, Jr., and S. L. Bailey. (*Proc. Inst. Rad. Eng.*, Jan., 1932, Vol. 20, pp. 62–76.)

Authors' summary :—This paper discusses the importance of adopting uniform standards designed to express the coverage obtained by broadcast transmitters in terms of the field intensities produced, and discusses the methods used by the authors. Illustrations are given of the methods used to determine coverage, to predict the effect of changes where transmission constants are known, and to determine interference conditions on the basis of given receiving set characteristics. The importance in the field of radio regulation of the establishment of certain fundamental principles defining the area throughout which a broadcast station is entitled to protection against interference from other stations and the conditions under which a listener is entitled to interference-free reception is particularly stressed.

Zehn Jahre Transradio: Ein Rückblick (Ten Years of Transradio—A Retrospect).—E. Quäck. (*Telefunken-Zeit.*, No. 57, Vol. 12, pp. 7–20.)

Ten Years of Transradio—A Retrospect. E. Quäck. (*Proc. Inst. Rad. Eng.*, Jan., 1932, Vol. 20, pp. 40–61.)

English version of the above paper. Author's summary :—This review of the development of the "Transradio" system includes a description of the transition from the manual operation of a single Berlin–New York radiotelegraph circuit to the operation of a system involving transoceanic radiotelegraph operation between Germany and fourteen other countries and localities. The development of the use of short waves is described and a tabulation is given of the frequencies and antennas employed with various transmitters for the several circuits. Figures are given showing the growth in traffic and the decrease in the time required for handling a telegram. References are given to papers which have been published covering the studies made of the propagation characteristics of short waves.

Broadcasting in Russia: Organisation and the Five Year Plan.—G. E. Roth. (*Die Sendung*, 27th November, 1931, Vol. 8, pp. 973–974.)

Field Strength Charts of the Budapest High-Power Broadcasting Station.—S. Baczynski. (*Telefunken-Zeit.*, No. 57, Vol. 12, 1931, pp. 32–37.)

Broadcasting with Ultra-Short Waves.—G.W.O.H. (*See* under "Propagation of Waves.")

Seven-Metre Broadcasting.—W. F. Floyd. (*Wireless World*, 17th February, 1932, Vol. 30, pp. 172–173.)

In view of the impending experimental transmissions by the B.B.C. on a wavelength of approximately 7 metres, the advantages associated with such a short wavelength are briefly discussed. It is suggested that the supersonic heterodyne and the super-regenerative types of receiver will be found to offer the greatest advantages on wavelengths of this order.

Neue Möglichkeiten des Rundspruchempfangs (New Possibilities in Broadcast Reception [Distribution over Telephone Network or Special Lines, in Switzerland]).—(*Bull. Assoc. suisse d. Élec.*, No. 24, Vol. 22, 1931, pp. 602–604.)

A short account of the systems in preparation by the Swiss P.O., the Radibus and the Rediffusion Companies.

Cannot Refuse Wired Music [Decision against Refusal of New York Telephone Company to furnish Leased Lines].—(*Rad. Engineering*, Nov., 1931, Vol. 11, p. 34.)

Aussteuerungsgeräte im Rundfunkbetrieb (Modulation Meters and Indicators for Broadcasting Control Rooms).—G. Lubszynski and H. Weigt. (*E.N.T.*, Jan., 1932, Vol. 9, pp. 4–10.)

Section 1 deals with the behaviour of pointer instruments towards short-time impulses, and shows the importance of suitable damping and natural frequency; practical values for these are given as $\omega_0/2\pi = 3$ per sec. and $\delta = 9$ per sec. An instrument with these values "will give a deflection, for an impulse time of 50 milliseconds, 20% less than the deflection from rest; steady excitation gives a maximum deflection 20% higher." Section 2 deals with mean value indicators, particularly valve voltmeters with negative bias. The dependence of the deflection on wave form and detection characteristic is discussed.

Section 3 deals with peak value indicators, discussing the valve peak voltmeter and the audion circuit device, as regards accuracy and its dependence on potential, impulse period and wave form. Other peak value indicators are the cathode-ray tube, the glow discharge tube, circuits which work on the setting-in and stoppage of high-frequency oscillations, and particularly the gaseous conduction lamp. The last appears to be very promising as a limit or margin indicator—for which purpose the audion circuit may also be used, either for the peak limit or as a "minimum indicator." In Section 4, which deals with actual practice, the writer recommends the use of two limit indicators and one quantitative instrument; the latter may be an audion circuit or (since it need not be very accurate) a mean value indicator—which class may include a.c. instruments with dry-plate rectification, dynamometers, and static, magnetic and thermal meters. By watching such a meter it can be seen when one of the limits is being approached.

GENERAL PHYSICAL ARTICLES.

On High Frequency Permeability. Some Remarks on the Papers of R. Michels and M. Wien.—W. Arkadiew. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 4, pp. 406–422.)

Remarks on the papers referred to in 1931 Abstracts, p. 630. Wien replies on pp. 423–428, and makes a correction in the same journal, No. 6, p. 736.

FERROMAGNETISM AND ELECTRICAL PROPERTIES. 3RD COMMUNICATION. THE CONNECTION BETWEEN RESISTANCE INCREASE AND MAGNETISATION.—K. Schneiderhan. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 4, pp. 385–405.)

THE DISPERSION OF X-RAYS BY WATER.—E. Amaldi. (*Physik. Zeitschr.*, 15th Nov., 1931, Vol. 32, No. 22, pp. 914–919.)

THE DISPERSION OF CONDUCTIVITY OF SOME AQUEOUS AND NON-AQUEOUS SOLUTIONS OF ELECTROLYTES.—H. Gaertner. (*Ibid.*, pp. 919–926.)

ON THE CONDUCTIVITY AND DIELECTRIC CONSTANT OF ELECTROLYTIC SOLUTIONS AT HIGH FREQUENCY.—M. Wien. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 4, pp. 429–453.)

THE KERR EFFECT IN ROCHELLE SALT.—H. Müller. (*Phys. Review*, 15th Nov., 1931, Series 2, Vol. 38, No. 10, p. 1922.)

THE EMISSION OF SECONDARY ELECTRONS FROM TUNGSTEN.—A. J. Ahearn. (*Phys. Review*, 15th Nov., 1931, Series 2, Vol. 38, No. 10, pp. 1858–1870.)

CONTROL OF THE GLOW DISCHARGE ON A GRID CATHODE BY MEANS OF A THIRD ELECTRODE BEHIND THE CATHODE.—Güntherschulze and Keller. (*Zeitschr. f. Phys.*, 1931, Vol. 72, No. 3/4, pp. 133–142.)

THE HIGH FREQUENCY DISCHARGE [STUDY OF THE EFFECT OF THE DISTANCE BETWEEN THE ELECTRODES].—Gutton and Beauvais. (*See* under "Propagation of Waves.")

THE ANGULAR DISTRIBUTION IN THE SCATTERING OF SLOW ELECTRONS BY GAS MOLECULES.—C. Ramsauer and R. Kollath. (*Physik. Zeitschr.*, 1st Nov., 1931, Vol. 32, No. 21, pp. 867–870.)

DIE ZÜNDUNG BEIM DURCHSCHLAG EINER FUNKENSTRECKE (The Breakdown Process in the Discharge across a Spark Gap).—W. Rogowski. (*Elektrot. u. Masch : bau*, 3rd Jan., 1932, Vol. 50, pp. 7–15.)

INVESTIGATION OF SURFACE DISCHARGE WITH IMPULSE VOLTAGE.—Rosenlöcher. (*See* under "Atmospherics and Atmospheric Electricity.")

SPARKING POTENTIAL AND ELECTRODE MATERIAL.—Loeb. (*Ibid.*)

PAPERS ON THE MOTION OF A HEAVY SPHERE IN AN IONISED ELECTRIC FIELD.—Pauthenier and Moreau-Hanot. (*See* abstracts under "Propagation of Waves.")

MISCELLANEOUS.

RECORDING THE DEFORMATIONS AND VIBRATIONS OF THE WING OF AN AEROPLANE IN FLIGHT [USING THE VARIATIONS OF RESISTANCE OF A THIN GRAPHITE LAYER].—A. Guerbilsky. (*Comptes Rendus*, 18th Jan., 1932, Vol. 194, pp. 249–251.)

The varying resistance of the graphite layer, produced by bending, was made to affect the grid potential of a triode controlling another triode oscillating at 1.5 megacycles/sec. In a circuit inductively coupled to the oscillating circuit was a neon-tube oscillograph, consisting of a long tube with two external electrodes, a ring near one end and a cylinder (at a short distance from the ring) extending over nearly the whole of the rest of the tube. The varying length of the luminous column starting from the ring electrode could be observed through a slit extending the whole length of the cylindrical electrode.

DETERMINATION OF THE MOISTURE CONTENT OF WOOD BY ELECTRICAL MEANS.—C. G. Suits and M. E. Dunlap. (*Gen. Elec. Review*, Dec., 1931, Vol. 34, pp. 706–713.)

On the neon-tube "moisture meter" referred to in Jan. Abstracts, p. 54.

PHOTOELECTRIC AND THYRATRON DEVICES IN INDUSTRY.—B. S. Havens. (*Gen. Elec. Review*, Dec., 1931, Vol. 34, pp. 714–721.)

Thyratron control of intermittent line and spot welding machine: moving core reactor and thyratron for controlling re-reel spool in wire-drawing, or for synchronising conveyors in the processing of rubber: lighting control in theatres, etc.: photoelectric distribution to different conveyors: densometer for fibre structure of papers: and numerous other applications already in practice.

THE EXPERIMENTAL INVESTIGATION OF VIBRATIONS IN TURBINE WHEELS AND BLADES [INCLUDING ULTRA-MICROMETRIC METHODS].—B. Pochobradsky, L. B. W. Jolley, and J. S. Thompson. (*Engineering*, 30th Oct., 1931, Vol. 132, pp. 541–543 and plates.)

A REMOTE ELECTRICALLY-RECORDING ACCELEROMETER [ELECTROMAGNETIC ULTRA-MICROMETRIC DEVICE] WITH PARTICULAR REFERENCE TO WHEEL-IMPACT MEASUREMENTS.—F. Aughtie: Dufton. (*Proc. Physical Soc.*, 1st Jan., 1932, Vol. 44, Part 1, No. 241, pp. 31–44.)

Followed by a paper on a load-gauge in connection with the same work. In the subsequent discussion (pp. 49–50), A. F. Dufton mentions a somewhat analogous method of remotely recording small displacements, developed at the Building Research Station. As in the author's method, displacement of the armature (in this case pivoted) increases the inductance of one coil and decreases that of the other; both coils are supplied with a.c. and in series with each is placed the heater of a vacuo-junction; the two junctions are opposed and the resultant current measured on a galvanometer.

AUFZEICHNEN SCHNELLER SCHWINGUNGEN (The Registration of Rapid Vibrations [Ambronn's Piezoelectric Instrument]).—R. Ambronn. (*Zeitschr. V.D.I.*, 12th Dec., 1931, Vol. 75, pp. 1517-1518.)

For the investigation of rapid and very rapid vibrations (above 5 to 10 per sec.) in machine parts, vehicles, bridges, buildings, street surfaces, etc.

NEW APPLICATIONS OF THE CONDENSER PRINCIPLE FOR MEASURING PURPOSES [ULTRA-MICROMETER: IDOMETER: SICCOMETER].—W. Jaekel: Siemens Company. (*Zeitschr. V.D.I.* 14th Nov., 1931, Vol. 75, No. 46, pp. 1420–1421.)

The Idometer is the form of ultra-micrometer, used in the manufacture of rubber, referred to in 1931 Abstracts, p. 575. The Siccometer is a special device for recording the moisture content of paper (*cf.* Olken, Jan. Abstracts, p. 53), one plate of the condenser being perforated while the other plate has projections which nearly fill the holes of the first. It is apparently the varying displacement current in this condenser, as the paper is passed over it, that serves to measure the moisture content.

CONTRIBUTION TO THE DESIGN AND USE OF AN APPARATUS FOR THE MEASUREMENT OF SMALL DEFORMATIONS [OUTLINE OF ELECTROMAGNETIC ULTRA-MICROMETER DEVICES].—A. Guillet. (*Comptes Rendus*, 4th Jan., 1932, Vol. 194, pp. 67–70.) *See* also Feb. Abstracts, p. 114.

THE INSTANTANEOUS [ULTRA-MICROMETER] PRESSURE RECORDER AND ITS APPLICATIONS.—M. Horioka, T. Uchiyama and E. Mizuguchi. (*Res. Electrot. Lab. Tokyo*, No. 303, 1931, 74 pp.)

The ultra-micrometer condenser affects the tuning of the grid circuit of a simple r.f. audion circuit, whose anode current changes give a measure of the pressure. For an air-gap of 0.6 mm a pressure of 2 kg/cm² causes a capacity change of about 30 $\mu\mu$F and a current change of 2 to 5 mA. Among other applications, the oil pressure in oil switches has been measured.

TUBE CONTROL OF HIGH-SPEED LIFTS [PLIOTRON OSCILLATIONS STOPPED BY ENTRANCE OF METAL PLATE BETWEEN GRID AND PLATE COILS].—(*Electronics*, Dec., 1931, p. 231.)

A VACUUM-TUBE DEVICE FOR CURRENT-BALANCE TELEMETERS.—B. E. Lenehan and P. MacGahan. (*Elec. Engineering*, July, 1931, Vol. 50, pp. 510–511.)

TELEMETERING OVER THE TELEPHONE NETWORK.—(*Elektrot. u. Masch:bau*, No. 20, Vol. 49, 1931, p. 393.)

ELECTRONIC EQUIPMENT IN TRAIN CONTROL.—(*Electronics*, Dec., 1931, pp. 218–220.)

"Approximately 7000 miles of track are protected by continuous control signal apparatus and 4500 engines are equipped with amplifier receivers."

STATIONARY AND NON-STATIONARY CONDITIONS IN INDUCTIVE [RESONANCE PRINCIPLE] TRAIN CONTROL.—A. Kammerer. (*E.T.Z.*, 22nd and 29th Oct., 1931, Vol. 52, pp. 1333–1336 and 1359–1362.)

ON CONTACT CONDUCTION AND RECTIFICATION [ON THE ELECTRONIC THEORY].—G. Hara. (Long summary in *Physik. Ber.*, 1st July, 1931, Vol. 12, p. 1478.)

ELECTROSTATIC MACHINES: THE CHAUMAT PRINCIPLE APPLIED TO THE RAMSDEN FRICTIONAL MACHINE.—H. Chaumat and E. Lefrand. (*Comptes Rendus*, 28th Dec., 1931, Vol. 193, pp. 1404–1405.)

Further development of the researches dealt with in Feb. Abstracts, pp. 112–113.

THE USE OF THE PROJECTION MICROSCOPE AND PHOTOELECTRIC CELL (DETERMINATION OF AREAS OF IRREGULARLY SHAPED MICROSCOPIC OBJECTS).—A. Savage and J. M. Isa. (*Canadian Journ. of Res.*, Nov., 1931, Vol. 5, No. 5, pp. 544–549.)

Further development of the work referred to in 1931 Abstracts, p. 170.

PHOTOELECTRIC METHOD OF MEASURING EVENNESS OF YARN.—G. R. Stanbury. (Summary in *Electronics*, November, 1931, p. 206.)

PHOTOTUBES CONTROL FURNACE TEMPERATURES.—L. R. Koller. (*Electronics*, November, 1931, p. 192.)

PHOTO CELLS AND THEIR APPLICATION.—II: COLOUR COMPARISONS.—R. C. Walker. (*Wireless World*, 30th December, 1931, Vol. 29, pp. 744–746.)

Details of apparatus used for the examination of fabrics, papers, powders and paints to detect small differences in colour.

COMMERCIAL APPLICATIONS OF PHOTOELECTRIC CELLS.—E. H. Vedder. (*Electr. Journ.*, Vol. 27, p. 335: summary in *E.T.Z.*, 14th Jan., 1932, Vol. 53, pp. 42–43.)

THE "PHOTOELECTROGRAPH" DEVICE [FOR THE BLIND]. (*Electrician*, 15th January, 1932, Vol. 108, p. 75; *Elec. Review*, 15th January 1932, Vol. 110, p. 80.)

"An appliance which is called the 'photoelectrograph' has been devised by two French inventors, MM. Thomas and Couland, to enable blind persons to read ordinary print. A ray of light passing over the printed matter causes each letter to be presented in relief in magnified form." *Cf.* Fournier: Auger, 1931 Abstracts, p. 504. No details are given.

THE NECESSITY OF COMPRESSION IN PAPERS AND LETTERS TO TECHNICAL AND SCIENTIFIC JOURNALS DURING THE PRESENT CONDITIONS.—(*E.N.T.*, Jan., 1932, Vol. 9, pp. 38–39.)

Some Recent Patents.

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.

GANGED TUNING-CONTROLS.

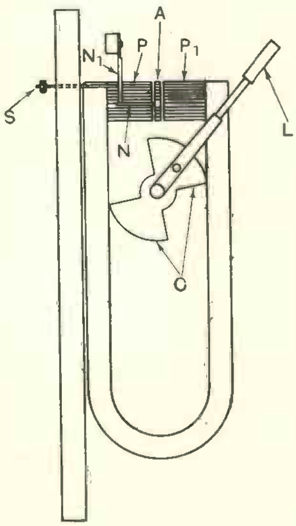
Application date, 5th September, 1930. *No.* 360107.

It is usual to earth the moving vanes of ganged condensers by connecting one end of the common control spindle to the earth terminal of the set. Currents flowing to earth through this path are likely to give rise to undesirable back coupling. According to the invention, an earthed bus-bar is provided to which each tuning-condenser is separately connected, as also are the low-potential ends of each of the inductances in the ganged circuits.

Patent issued to The Gramophone Co., Ltd., and D. W. Pugh.

LOUD-SPEAKER MOVEMENTS.

Convention date (Germany) 5th September, 1930. *No.* 362704.



No. 362704.

The air-gap between the armature *A* and the pole pieces *P*, P_1 of a loud-speaker movement is adjusted by means of a shaped cam *C* pivoted between the sides of the magnet and rotated by a lever *L* so as to force them more or less apart. The vibrations of the armature *A* are transmitted to the diaphragm spindle *S* through resilient levers *N*, N_1 Both the pole-pieces and armature are built up of iron lamellæ, separated by layers of hard paper of specified thickness, thereby ensuring exact dimensions.

Patent issued to H. A. H. Schuler.

RECTIFIER VALVES.

Convention date (Germany), 4th May, 1929. *No.* 360419.

In cold-cathode rectifiers the voltage-drop through the tube is large and the output small, whereas in hot-cathode rectifiers the voltage drop is comparatively small whilst the output is large. In order to combine the advantages of both types, a cold cathode is used comprising a core of nickel covered with a coating of barium and magnesium-cuprate, the tube being filled with rare gas at a pressure of 5 mm., with a trace of mercury vapour. Such a rectifier will pass an output current of from 1 milliamp to 1 ampere.

Patent issued to The Edison Swan Electric Co., Ltd.

MAINS-DRIVEN SETS.

Convention date (Austria), 19th May, 1930. *No.* 360679.

With the object of minimising inductive pick-up and undesired back-coupling in a multivalve set driven from the mains, the heating-filament is earthed in the usual way, but the ordinary earth connection from the cathode is omitted. The amplifier system is thus only coupled to the mains through the extremely small capacity existing between the cathode and heating-filament inside the valve, and this offers a very high impedance to disturbing frequencies.

Patent issued to N. V. Philips Gloeilampenfabrieken.

TUNING ADJUSTMENTS.

Convention date (Germany) 11th March, 1930. *No.* 362270.

In a long-range receiver it is usually necessary to readjust the volume-control to prevent "blasting," particularly when switching-over say from a distant station to the local B.B.C. transmitter. To obviate this, the main tuning-condenser is provided with a contact arm which automatically reduces the aerial coupling to a predetermined value for a selected number of stations, by short-circuiting some of the aerial turns, or by interposing a metal screen, or by bringing a damping-resistance into circuit. The arrangement can also be used to cut down local field strength when searching for a distant station.

Patent issued to C. Lorenz Akt.

CONDENSER CIRCUITS.

Application date 6th September, 1930. *No.* 362511.

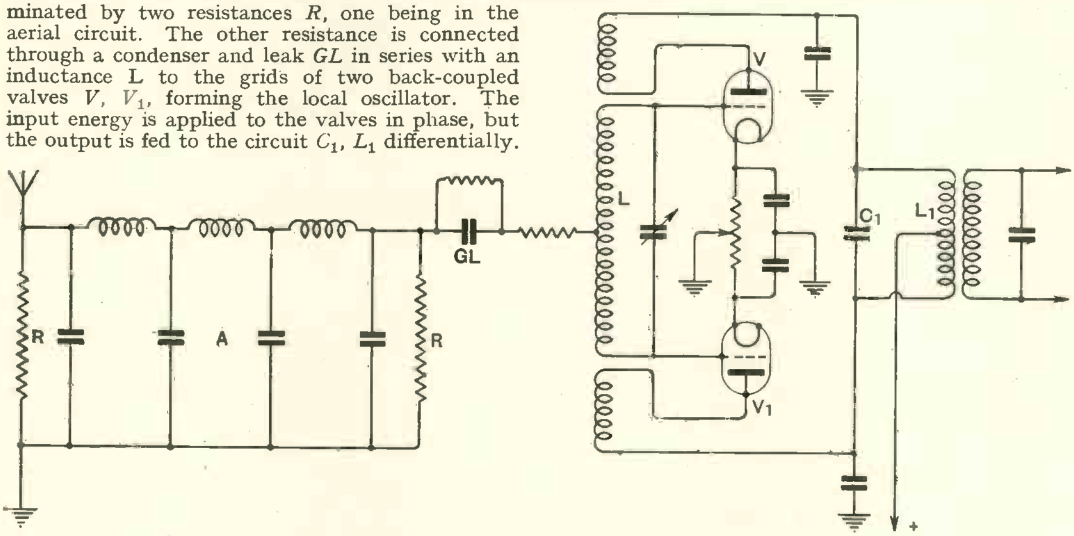
In order to remove any residual charge on a condenser when it is disconnected from its circuit, a pair of normally closed contacts, similar to an ordinary telephone jack, are fitted across the condenser plates. A third movable contact is used in connecting the condenser to the "load" circuit, and simultaneously separates the first two contacts. When the load circuit is disconnected, the first two contacts automatically "short" and discharge the plates.

Patent issued to Electrical Research Products Inc.; F. W. Wort; and C. J. P. Small.

SUPERHETERODYNE RECEIVERS.

Convention date (U.S.A.), 20th November, 1929. No. 359760.

A low-pass filter A is tuned below the upper limit of the waveband to be received and is terminated by two resistances R, one being in the aerial circuit. The other resistance is connected through a condenser and leak GL in series with an inductance L to the grids of two back-coupled valves V, V_1, forming the local oscillator. The input energy is applied to the valves in phase, but the output is fed to the circuit C_1, L_1 differentially.



No. 359760.

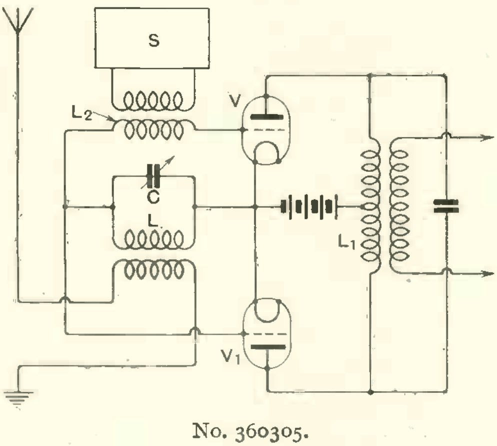
Components determined by the phase-difference between the local and applied oscillations (*i.e.*, the beat frequency) are added in the output circuit, whilst undesired or interfering signals are cancelled out. The circuit L_1, C_1 is tuned to the beat frequency and is coupled to further stages of intermediate amplification.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

Convention date (U.S.A.), 19th February, 1930. No. 360305.

To reduce interference from undesired signals, the input is applied to a pair of valves in push-pull, whilst the local oscillations are applied across the grid and filament of one only of the pair of valves. As shown the aerial is coupled to a tuned circuit L, C which energises the valves V, V_1 in phase, so that the input frequencies and harmonics thereof are cancelled out in the output coil L_1 feeding the intermediate-frequency amplifier. Local oscillations from a source S are applied to a coil L_2 so as to produce beat frequencies in the output from the valve V only. In a modified arrangement the local-oscillations are applied in phase to both valves, and the aerial input is coupled to the coil L_2.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.



No. 360305.

VALVE CATHODES.

Application date, 14th January, 1931. No. 361184.

Several strands of thin wire are twisted around a similar wire, forming a core, and the assembly is then carbonised by heating in the vapour of an organic compound. The outer strands are thus carbonised to the full extent required for satisfactory emission, whilst the core is left in a less brittle condition. The resulting product is a more robust filament which gives a uniform emission throughout its whole length.

Patent issued to M. O. Valve Co., Ltd., and J. H. Phillips.

REGULATING SELECTIVITY.

Convention date (Holland), 3rd October, 1929. No. 359660.

In receivers designed to operate over a wide range of wavelengths the selectivity of the circuits varies, in general, with the wavelength. Also when receiving a modulated carrier wave it is often desirable to limit the response of the circuits to a definite width of side-band. According to the invention, in order to regulate to a desired degree the resonance response of a circuit comprising inductance, capacity, and resistance, an additional variable resistance of the order of 100 ohms is inserted in series and may be shunted by a condenser.

Patent issued to N. V. Philips Gloeilampenfabrieken.

LOUD-SPEAKERS.

Convention date, (U.S.A.), 17th August, 1929. No. 360030.

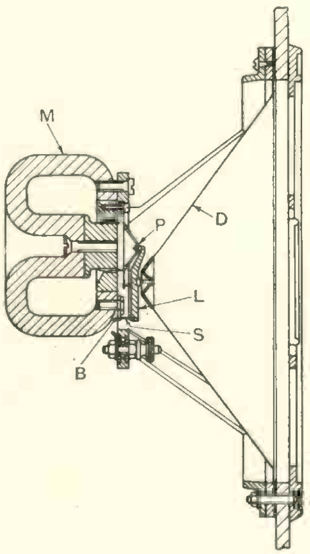
The diaphragm of a loud-speaker comprises a number of strings or filaments so highly tensioned that sound waves are propagated through them with the same velocity as in air. The strings are tensioned across a lateral frame and are impulsed at one or more separate points. They may be arranged so closely together that there is only a negligible air-leakage, or they may be "backed" by a coated sheet of paper interlaced between them.

Patent issued to Electrical Research Products, Inc.

Application date, 9th September, 1930. No. 361464.

The diaphragm D of a moving-coil speaker is mounted on a lever L connected at one end to the conical apex P of the cone or former carrying the windings of the moving-coil, and having a slot at the other end to receive a steel strip S mounted on a fixed block B. The strip or fulcrum S allows the vibratory movements imparted to the end of the lever L by the cone P to be transmitted to the main diaphragm. The mounting is stated to give satisfactory results when using a smaller size of permanent magnet M than usual.

Patent issued to S. G. Brown.



No. 361464.

H.F. TRANSFORMERS.

Convention date (Holland), 25th October, 1929. No. 359169.

In order to ensure a uniform characteristic over a broad band of frequencies, the primary winding of the transformer is regarded as a long transmission line and is terminated by an ohmic resistance equal to the surge impedance of that line. The primary current is then independent of frequency, and its speed of propagation is equal to that of the current in the secondary winding. The secondary winding may also be tapped at one or more points to a resistance equal to its surge impedance. A screen of conducting material is provided to form the second conductor of the transmission line, of which the transformer winding forms the first conductor.

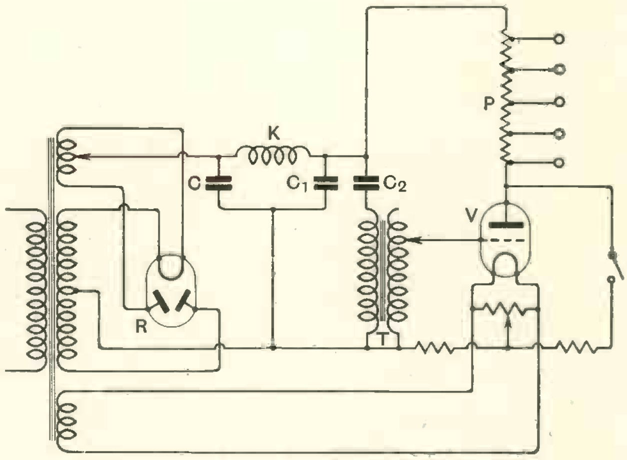
Patent issued to N. V. Philips Gloeilampenfabrieken.

SMOOTHING CIRCUITS.

Convention date (U.S.A.), 20th November, 1929. No. 359761.

To save the cost of large chokes and condensers, a thermionic valve is utilised to smooth the output from a rectifier supplying current to a wireless receiver from the mains. As shown, a choke K and condensers C, C_1 effect a preliminary smoothing of the output current from the rectifier R. The plate-to-filament path of the valve V is also shunted across the supply, in series with a potentiometer P having suitable tapping points. Compensating voltages, 180° out of phase with those existing in the rectified output, are applied to the grid of the valve from the secondary winding of a transformer T, inserted on series with a condenser C_2 which blocks the passage of any direct current. The tapping point to the grid is so chosen that the out-of-phase voltage is 1/mu times that of any fluctuating voltage to be smoothed out.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.



No. 359761.

LOUD SPEAKERS.

Convention date (France) 12th April, 1930.
No. 362277.

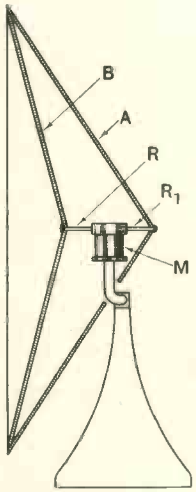
In order to offset the effect of inherent resonance, due either to the construction or housing of a loud speaker, a mechanically vibrating "compensator" is attached to the diaphragm. The compensator consists of a flexible blade separately mounted on a rigid support and carrying a "bob" or small weight at its free end, which is connected through a light spiral spring with a clip fixed to the speaker diaphragm. The natural resonance of the compensator is adjusted to counterbalance any undesired resonance in the loud speaker.

Patent issued to J. Bethenod.

Application date 14th January, 1931. No. 363170.

A compound diaphragm is formed by connecting the peripheries of two cones *A*, *B* of equal diameter but different pitch. The driving-unit *M* is placed midway between the two cones, and energises both independently through rods *R*, R_1.

Patent issued to Kolster-Brandes, Ltd.



No. 363170.

CONVERTIBLE AMPLIFIERS.

Application date 18th December, 1930.
No. 362687.

In a radio-gramophone a pentode valve, normally used as the final amplifying stage when receiving wireless signals, is converted into a triode amplifier when coupled to a gramophone pick-up. The change-over is effected by means of a switch, which either open-circuits the normal anode or else connects it to the second or "accelerating" grid, the latter being simultaneously connected across the two ends of the loud-speaker primary.

Patent issued to I. Schoenberg and W. H. Connell.

SUPERHETERODYNE RECEIVERS.

Application date 7th October, 1930. No. 362075.

The first detector in a superhet set is a thermionic valve as usual, but the second or audio-frequency detector consists of a dry-contact rectifier, preferably of the copper-copper-oxide type. It is inserted in the last oscillatory circuit of the intermediate-frequency stage, in series with a tuning inductance and capacity, and supplies the primary winding of a low-frequency transformer.

Patent issued to The General Electric Co., Ltd. and N. R. Bligh.

SIGNALLING BY FREQUENCY-MODULATION.

Application date 9th September, 1930.
No. 362914.

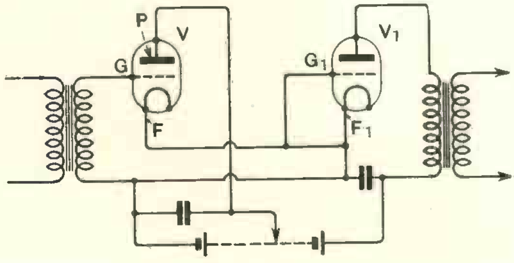
Frequency modulations superposed on a carrier wave are isolated and received independently of any amplitude variations by applying the carrier wave to a pair of electrodes mounted in a cathode-ray tube so as to cause the ray to move in a closed path. One or more auxiliary electrodes in the tube are swept by the moving ray and are thereby periodically rendered active so as to energise a resonator circuit tuned to a frequency approximating to the upper or lower limit of the signalling frequency. Any amplitude variations that may be present merely increase the degree to which the ray overlaps the frequency-analysing electrodes, but do not otherwise affect the recorded signals.

Patent issued to J. Robinson and British Radiostat Corporation, Ltd.

VALVE AMPLIFIERS.

Convention date (U.S.A.), 21st September, 1929.
No. 362504.

The circuit shown is designed to prevent distortion due to the flow of grid current, without the use of a definite biasing voltage and corresponding restriction in power output. Incoming signals are applied across the grid *G* of what may be called a "compensating" valve *V*, and the filament F_1 of the amplifying-valve proper V_1. Variations of the voltage on the grid *G* alter the internal resistance of the valve *V*, and since a part *F*, *G*, of this internal resistance is in the grid-filament circuit of the valve V_1, the potential of the grid G_2, is also varied relatively to its filament F_1, so as to control the effective output of the valve V_1. So long as the grid G_1 is negative, no current will flow in the lead connecting G_1 and *F*, and the signals are amplified without distortion. When the grid G_1 is positive, electrons will flow from F_1 to G_1, but current is also flowing between the filament *F* and plate *P* in the same direction. A circuit through F_1, G_1, *F*, and *P* is therefore completed, and the potential drop across this circuit varies automatically in such a manner as to prevent any distortion due to grid current during the positive half-cycle of the grid G_1.



No. 362504.

Patent issued to Revelation Patents Holding Co.

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