The Wireless World

AND RADIO REVIEW

VOLUME XXVIII

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As many of the circuits and apparatus described in these pages are covered by patents, readers are advised, before making use of them, to satisfy themselves that they would not be infringing patents.

Comments on the Stenode Receiver.

THE first description, in *The Wireless World* of December 11th, 1929, of a demonstration by Dr. J. Robinson of the receiving set known as the Stenode Radiostat, aroused intense interest, both in the performance of the receiver and in the wide claims which were made for it. Subsequently, we were able to give, in the issue of May 21st, 1930, a more detailed description of the set, and this information is now supplemented by an abstract of a paper recently read by Dr. Robinson before the Radio Club of America, which we include in this issue. This paper confirms the previous information that the Stenode is essentially a super-heterodyne set with an extremely selective intermediate frequency amplifier. In its most selective form a plate of quartz has been incorporated in the tuned system of the intermediate amplifier. The piezo-electric property of quartz allows of mechanical resonance being set up under the action of an intermediate wave of suitable frequency, and the small damping allows great selectivity to be obtained, so great that an interfering station only one kilocycle off the wanted station can be eliminated. Naturally, the sidebands are heavily cut by such extremely sharp tuning, and it is necessary to incorporate a corrector filter in the note magnifier to bring the high audio frequencies up to their normal level.

It remains to be explained why the heterodyne note of the unwanted station is not raised to its normal intensity by this operation, and it is precisely at this point that we fail to follow Dr. Robinson's argument, which proceeds to attack the sideband theory of a modulated carrier. In our opinion the existence of sidebands would seem to have been proved up to the hilt.

Until proof is produced to the contrary, sidebands must be regarded as being as real as are the spectrum colours into which the light of the sun is analysed by a prism.

Dr. Robinson points out that the waves employed in speech and music are continually changing in frequency, phase, and amplitude, and that the quartz receiver, by virtue of its inertia, requires time to build up and time for the ringing effect to die away. It may be, he thinks, that such waves are accepted by his receiver while the steady note due to a heterodyned interfering station is rejected—but not all musical effects are of this kind. Tuning notes and sustained organ and trumpet notes give steady vibrations maintained over thousands of cycles. Why are such tones received while interfering notes of much the same frequency are eliminated?

We hope that an opportunity will soon be given for the application of scientific tests to the Stenode by a committee of radio experts to enable a full explanation of its performance to be acquired. If the instrument can perform all that has been claimed for it, the chief reception troubles of the future, due to the congested state of the ether, will be removed by one revolutionary stroke.

In This Issue

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The Timing of Wireless Echoes

Alternative Theories of the Heaviside Layer.

By PROFESSOR E. V. APPLETON, F.R.S.

PRACTICALLY all the peculiar phenomena which we experience in wireless transmission can be attributed to the fact that wireless signals travel from one station to another by more than one route. Among these multiple paths there is usually that of a direct line of transmission, straight from sender to receiver, but very often the greater part of the signal which we hear is due to waves which have made a trip to the upper regions of the atmosphere and back. Such waves arrive at the receiving station a fraction of a second after the arrival of the waves which have travelled along the direct path and thus may be said to constitute a wireless echo.

As it is not possible to follow these echo-waves in their circuitous journey, we have to infer where they have been by measuring the time they have taken in travelling. The problem is thus somewhat similar to that of estimating how long a journey a traveller has made on a train journey when the time taken on the journey and the average speed are known. In the wireless case we are able to observe the times at which these vagrant waves start out and arrive, and thus find the time they have taken on their journey; we also know their speed through the air, and from their strength or weakness at the end of the journey we can make deductions as to the kind of time they have had on the way. It sometimes happens that the waves which have made a particularly long or difficult journey are so distorted on arrival as to be almost unrecognisable, so that in justice to our railways we must admit that the analogy with the railway traveller breaks down somewhat. One of the most frequent forms of distortion is that in which waves sent out travelling in a normal erect fashion are found to arrive travelling in a horizontal recumbent position, their bodies, as it were, having been twisted through a right angle. Again we must gratefully admit that our railway analogy had broken down.

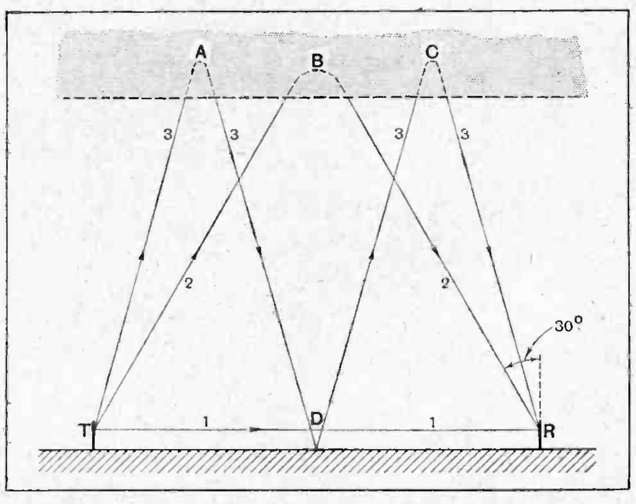

Fig. 1.—Three waves are here shown. The ground wave (1) travels directly between T and R, whilst the singly reflected wave (2) and that doubly reflected (3) take longer paths.

In estimating the extra path traversed by the echo waves we multiply the echo-time by the velocity of light. But as it happens that the echo-times dealt with in this article are quite short, it is useful to take a thousandth of a second (*i.e.*, one milli-second) as our unit of time, and remember that electric waves travel 300 kilometres or 186 miles in one milli-second. For example, if the echo were received one milli-second after the ground signal it would mean that the echo waves had travelled 300 km. further than the ground waves.

The first experiments on the timing of the journeys of wireless waves were carried out almost simultaneously in this country and America, though the methods of timing in the two cases were quite different. The English experiments were carried out using an 80-mile base. That is to say, there were eighty miles between sending and receiving stations. In this case, it was found that at night, but not usually in the day time, for every signal sent out from the sending station two or more were observed at the receiving station, the second coming just over one-third milli-second after the first,

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The Timing of Wireless Echoes.—

and the third about one milli-second after the first, indicating paths about 100 km. and 300 km. greater than that traversed by the first signal.

In interpreting these results it was natural to assume that the first signal had travelled straight along the ground from sender to receiver, that is a distance of 130 km., while the second had travelled 100 km. further, and the third 300 km. further. Now the unexpected result that long waves were able to travel round a spherical earth had led both Kennelly and Heaviside in 1905 to suggest that there is in the upper atmosphere a layer of electricity which is sufficiently conducting to be a reflector of wireless waves. It was therefore natural to assume that the echo signals which were observed were due to waves reflected from the layer. This is made clearer in Fig. 1. The first signal received is shown as the one which travels by the path (1) along the ground, the second is that which has been reflected once at this layer and marked (2), and the third is one which has been doubly reflected and marked (3). Since the path length of the first is known, that of the second and third can be calculated, and it is found that they agree with a layer height of about 100 km. This would indicate that the angle between the direction of the downcoming waves constituting the first echo and the vertical at the receiver was about 30 degrees. In another series of experiments, in which this angle could be measured by an entirely different method, it was found to have an average value of about 30 degrees, thus confirming the results of the first series.

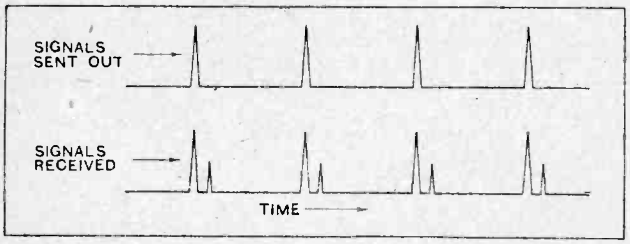

Fig. 2.—Echo time can be estimated by the spacing of direct signal and echo as recorded on a photographic film.

Photographic Film Recording.

The English method of timing the echoes was that of changing the frequency of the sending station by an exceedingly small amount, say, F, and counting the number, N, of signal interference maxima produced at the receiving station. The echo-time, T, is then given very simply by $\frac{N}{F}$. The theory underlying this method is, however, not so easy to understand as that underlying the American method, in which a more direct method of timing was adopted. Here very short signal impulses were emitted by the sending station and were recorded at the receiving station on a high-speed galvanometer. Evidence of echo-signals was obtained, and from the speed of the photographic film used in registering the signals the echo-time could be estimated. Fig. 2 illustrates the kind of records obtained. The upper record shows the spaced dot signals sent out, and the lower record the received signals in which it is seen that each received dot is accompanied by an echo. The first signal of each pair is due to waves which have travelled along the ground from transmitter to receiver, while the echo-signal is due to waves which have travelled up to the reflecting region and back.

But although the American experiments confirmed the English ones in proving that echoes were caused by the reflection of waves from the upper atmosphere, there was at first a curious discrepancy in the echo-times measured. As has been mentioned above, the English experiments indicated that the echo-producing region was situated at a height of about 100 km. Now, in the earlier series of American results, an echo-delay of about 1½ milli-seconds was obtained, indicating a path-length difference of about 450 km. Moreover, since the base line between sending and receiving stations was only a few miles, we must assume that the waves causing the echo had travelled almost straight up and down. The height of the reflecting region therefore came out to be about 220 km.

Echo Time Modified by Wavelength.

Now, there is a big difference between 100 km. and 220 km., and the question arose as to whether there was a real difference between the heights of the echo-producing regions in this country and in America, or whether the discrepancy was due to the different distances and different wavelengths used. In England broadcasting wavelengths of 300 to 400 metres had been used, while in America shorter wavelengths of 75 metres were employed. The question of different distances was ruled out when the English observations were repeated with the receiving station quite close to the sending station (the conditions being thus similar to those in the American experiments), and echo-times of 0.7 of a milli-second were obtained, indicating a height of about 100 km.

In order to settle the matter an extensive series of observations was made in England using different wavelengths, and it was soon found that the difference in the wavelengths used had caused the difference in the echo-times observed in this country and in America. When the same wavelengths were used the same order of echo-time was observed. But this extension of wavelengths led to the recognition of another quite unexpected result. In Fig. 3 is shown the relation obtained between echo-time and the frequency of the waves used for a case in which the echo waves travel practically vertically up and down.

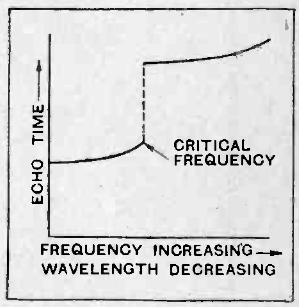

Fig. 3.—Showing the relation between echo time and frequency. Note that there is a critical frequency when the echo time is practically doubled.

It will be seen that as the frequency of the waves is increased (and consequently the wavelength decreased) the echo-time increases slightly until a certain critical frequency is reached, when the echo-time suddenly is practically doubled. High values of echo-time are seen to be associated with the short waves and lower values

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The Timing of Wireless Echoes.—with the long waves. This surprising result strongly suggests that there are two echo-producing regions in the upper atmosphere, and not one, as has usually been supposed, and that the lower reflector sends back the long waves and the upper one the short waves. The original discrepancy between the English and American results will now be obvious. The 400-metre waves used in England had been reflected by the lower region at about 100 km., while the shorter waves used in the American series had penetrated the lower region and been reflected by the upper one.

The existence of a critical wavelength which just penetrates the lower of the reflecting regions is an interesting question, for it sometimes happens that when this wavelength is used echoes from *both* reflecting regions are simultaneously received. Sometimes echoes due to waves which have been reflected twice by the upper atmosphere are also observed. Recognition of these possibilities has led to an alternative explanation of one of the American records. This particular type of record is illustrated in Fig. 4, where it is seen that each

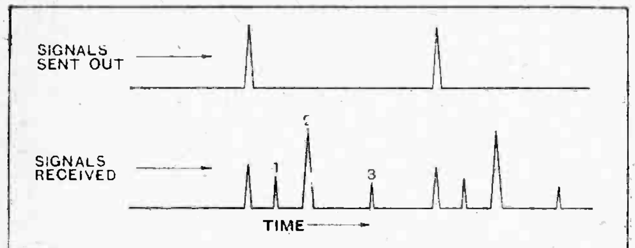

Fig. 4.—At a certain wavelength as many as three echoes are possible.

direct signal is accompanied by three echoes. Now, the echo-times appear to be in the ratio 1 : 2 : 4, and this led to their being interpreted in America as multiple reflected echoes from a single reflecting region. But such an interpretation raises various difficulties. For example, one may ask the following questions:—

(a) Why was there no evidence of a third-order echo due to waves which had been reflected thrice by the reflecting region?

(b) Why was the second echo stronger than the first, although it had made two reflections at the same region and had travelled twice as far?

(c) Why were the echo-times not exactly 1 : 2 : 4 but more nearly 0.9 : 2 : 4?

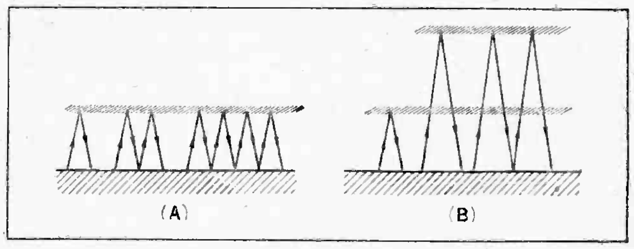

Fig. 5.—Assuming a single reflector the path of the echo waves is shown in (A) but on the hypothesis of two reflecting regions the paths are as in (B).

The difficulties seem to disappear if we adopt the hypothesis of two echo-producing regions at heights of approximately 100 km. and 220 km., and assume that the first echo was due to a single reflection from the lower region and the second and third due to single and double reflections from the upper region. The difference between the alternative explanations will perhaps be made clearer by an examination of Fig. 5.

In Fig. 5(a) are shown the paths of the echo waves, assuming a single reflector theory, while in Fig. 5 (b) are shown the paths if the hypothesis of two reflecting regions is entertained.

In the concluding part of this article I shall deal with the effects of these short-period echoes in television and picture telegraphy.

(*To be concluded.*)

ELECTRICAL REPRODUCTION OF ORGAN MUSIC.

A Novel Application of Public Address Amplifying Equipment.

AN interesting demonstration was given in London recently of the application of public address amplifiers to the reproduction of organ music. The object of the demonstration was to show that organ music of sufficient volume to fill the largest halls and cinemas can be produced by a small pipe organ in conjunction with a microphone amplifier and a group of carefully disposed moving-coil loud speakers.

The organ employed was a small cabinet model made by Barbieri Organs (Gt. Britain), Ltd., 25, Charing Cross Road, London, W.C.2. This organ is electro-mechanically operated, and can be supplied either with a separate single- or two-manual console or with a special contact strip for attachment to the keyboard of an ordinary piano. Stop panels are also supplied for a wide range of combinations.

The amplifying equipment was supplied by Philips Lamps Ltd., 145, Charing Cross Road, London, W.C.2, and consisted of a standard carbon type broadcast microphone, a three-stage transformer-coupled microphone amplifier with non-microphonic valves, and a type 2760 50-watt power amplifier. The loud speakers were of the super-power moving coil type, each capable of handling an undistorted output of 15 watts.

The results obtained were comparable both in quality and value with those given by a full-size cinema organ, yet the total cost of the equipment is but a fraction of the cost of a full-size organ, and the space occupied is, of course, very much less.

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PRINCIPAL TIME SIGNALS OF THE WORLD.

A Correction.—In our issue of December 17th, the times of transmission for the Eiffel Tower signals should read:—07.55-08.06 and 19.55-20.06 G.M.T. on the *short* wavelength, and at 09.25-09.30 and 22.25-22.36 G.M.T. on the *long* wavelength.

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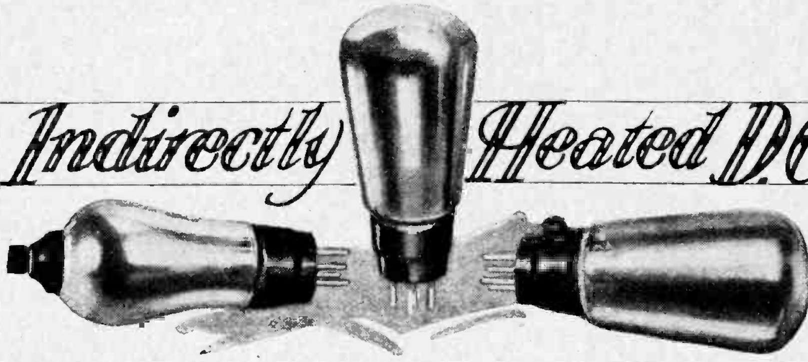
First Indirectly Heated D.C. Valves



Characteristics of the Mazda D.C. Mains Valves and some Notes on their Use.

HITHERTO those who have been concerned with the design of D.C. receivers had either to employ ordinary valves of the battery type with their filaments arranged in series or to use the special A.C. valves drawing one ampere of current from the mains. The first arrangement has many limitations, and in addition demands the use of a very thorough smoothing circuit for the filament supply. The alternative method is inclined to be wasteful, since with the most economical type of filament circuit some 250 watts are drawn from the supply mains.

We are therefore particularly glad to welcome the new Mazda D.C. valves, of which so far three types are available, officially designated the DC/SG, DC/HL and DC/PEN. They are of the indirectly heated type; the two first mentioned operate at 4 volts and take 0.5 amp. of current, while the last mentioned requires 8 volts and consumes 0.5 amp. The valves will be connected, as a matter of course, with the heaters in series so that the difference in operating voltage is of no consequence. The important factor is that only half an ampere is required to run the set, which, at 250 volts, means that the power drawn from the mains is reduced to 125 watts.

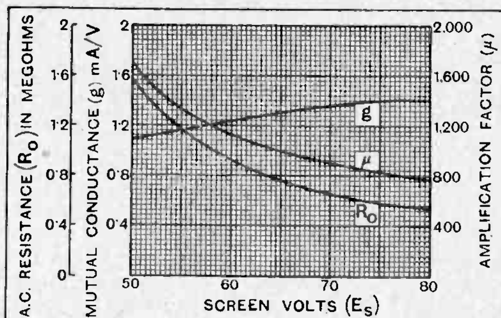


Fig. 1. — Curves showing change in A.C. resistance, amplification and mutual conductance of Mazda DC/SG valve, with various screen voltages. $E_a = 200$, $E_g = -1.5$.

The construction of a resistance to dissipate this wattage is a practical proposition, whereas one to dissipate a quarter of a kilowatt might well assume the proportions of an electric fire.

The electrical characteristics of the DC/SG and the DC/HL are only slightly inferior to those of their A.C. counterparts in spite of the lower current consumption, while the DC/PEN is, to all intents and purposes, the exact counterpart of the AC/PEN, and will deliver an undistorted A.C. output of approximately 1,900 milliwatts.

Some readers may wonder why a super-power triode is not included in this range, but the designers have a very good reason for not doing so. To obtain a large power output the valve must be given a high anode voltage, 200 volts being about the minimum to attain this end. Now a triode to deliver the equivalent output as the DC/PEN will require 40 volts grid bias, which is naturally deducted from the anode potential. In the case of D.C. mains of 200 or 210 volts this will leave only about 150 to 160 volts for the anode, other conditions being unchanged. In addition there will be an appreciable voltage drop in the output choke, thus reducing further

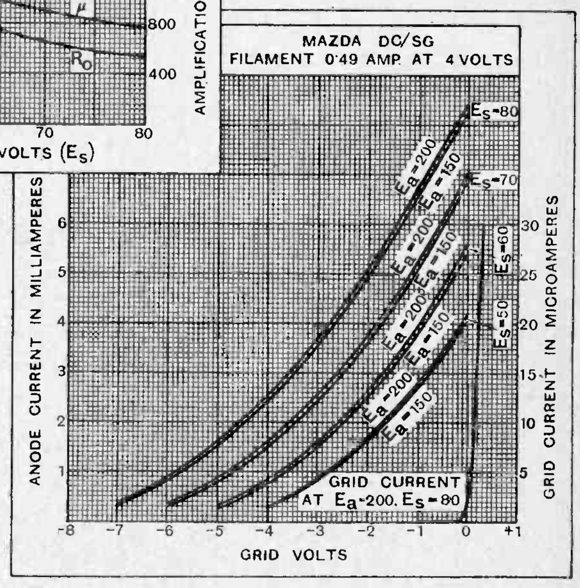


Fig. 2.—Anode current-grid voltage curves of Mazda DC/SG valve with various screen potentials and anode voltages of 150 and 200. Note that grid current does not flow until the grid is given −0.2 volts bias.

the volts actually applied to the anode of the valve.

The DC/PEN requires a grid bias of 10 volts only at 200 volts H.T.—need further comment be made?

DC/SG Valve.

This is fitted with a five-pin base, as is usual with indirectly heated valves, and the pins serve the same

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functions. The anode is brought out at the top of the bulb to an ebonite shrouded terminal. The internal construction follows the same general lines as the AC/SG. The rated characteristics are:—

* A.C. resistance 600,000 ohms.
* Amplification factor 1,200.
* Mutual conductance 2 mA/volt.
Max. anode voltage (E_a) 200.
Screen voltage (E_s) 80.
Filament volts, 4.
Filament current, 0.5 amp.
* at $E_a = 200$, $E_s = 80$, $E_g = 0$.

The first set of curves prepared were those connecting grid voltage with anode current for various values of screen potential, and these are shown in Fig. 2. Grid current was found to commence at 0.2 grid bias, so that only the full-line portion of the curves are available under working conditions. Actually, only a small portion of the curve will be used in practice, as owing to the high amplification afforded by the valve a definite limitation will be imposed by the voltage swing on the anode, if distortion of the wave form is to be avoided.

It will be seen that a grid bias of 1.5 volts in conjunction with the maximum anode and screen voltages will meet the requirements for amplifying conditions.

Although providing a certain amount of useful information, these curves are not very informative, since they do not show at all clearly such important factors as A.C. resistance, amplification factor and mutual conductance under the many possible working conditions. In common with all screen-grid valves, these values change considerably with any and every variation in screen potential and grid bias. The extent to which the screen potential alone influences the working characteristics of the valve is shown in Fig. 1, this being a set of curves connecting the three principal constants with an anode voltage maintained at 200 and a grid bias throughout of −1.5 volts.

The mutual conductance does not alter very much, being 1.08 mA./volt at $E_s=50$ and rising to 1.41 mA./volt at $E_s=80$. The amplification, and the A.C. resistance, are the two factors which alter to the greatest extent. The average anode current with 200 volts on the anode, 75 volts applied to the screen and a grid bias of −1.5 volts, is of the order of 4.7 milliamps. These values might well be taken as the average operating conditions. The screen current was consistently low throughout the range of measurements made, varying between 0.1 and 0.3 milliamp. Screen potential will best be maintained if it is taken from a potentiometer, which might consist of two resistances in series with the screen supply taken from the junction. If connected between points showing a difference in potential of some 200 volts, suitable values for these two components would be 40,000 ohms and 25,000 ohms, the large value being adjacent to the positive. Conjointly, these will pass about 3 milliamps.

The anode-grid capacity is of the same low order as its A.C. prototype, namely, 0.003 micromicrofarad. Thus, the maximum theoretical amplification that can be attained with this specimen at 200 metres before threshold instability is reached will be 260. In most practical cases the need for reasonably good selectivity will demand the use of a 3 : 1 step-up ratio transformer, or its equivalent, so that the stage gain, assuming the secondary circuit to be of some 250,000 ohms dynamic resistance, will drop to 108. With a less good coil showing a dynamic resistance of 100,000 ohms — a value more likely to be attained in practice—the stage amplification amounts to about 45.

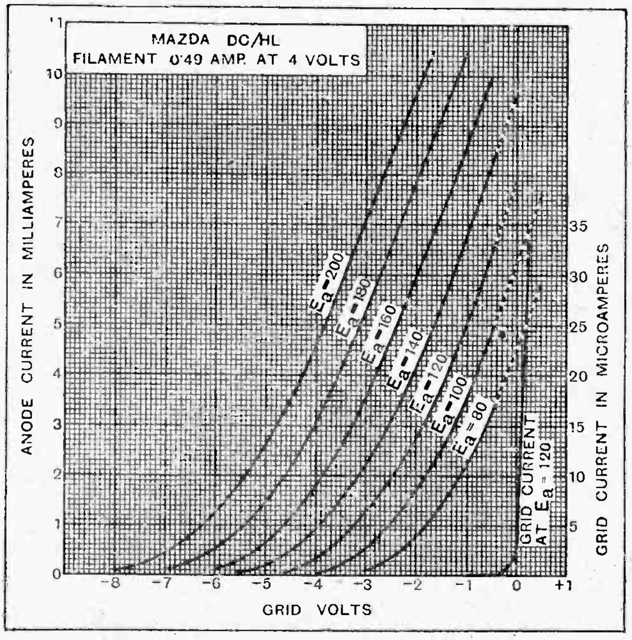

Fig. 3.—Curves connecting anode current and grid voltage of the DC/HL with various values of H.T. grid current starts at −0.4 volts grid bias so that only the full line portion of the curves are available under working conditions.

DC HL.

This might well be regarded as the detector valve of the series, since a 1-v-1 arrangement will meet most receiving requirements. In these enlightened times it will be employed as a power grid detector, for which purpose its characteristics render it perfectly suitable. The makers' rating is:—

* A.C. resistance, 12,000 ohms.
* Amplification factor, 30.
* Mutual conductance, 2.5 mA/volt.
Maximum anode voltage (E_a) 200.
Filament voltage, 4.
Filament current, 0.5 amp.
* at $E_a = 100^v$; $E_g = 0$.

The sample tested exhibited slightly better characteristics than this; measured under the same conditions, we obtained the following values:—

A.C. resistance, 11,000 ohms.
Amplification factor, 32
Mutual conductance, 2.9 mA/volt.

Used as a power grid detector, the standing anode current will be about 7 mA. with 110 volts on the anode, which leaves about 90 volts to be dropped across such resistances and chokes as may be included in the external anode circuit. Obviously, high-value resistances are

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out of the question, and the necessary decoupling and feed arrangements should be planned on the lines discussed in a recent article on power grid detection with low H.T. voltages.[1]

To operate the DC/HL as a low-frequency amplifier the most suitable conditions are: 180 volts on the anode and −3 volts grid bias. This will leave about 20 volts to be dropped across a decoupling choke when 200 volts are available after smoothing. A choke is advised in favour of a resistance since with an anode current of 5 mA. this would be limited to about 4,000 ohms, which is definitely too low to be effective.

DC/PEN.

As stated in the earlier part of this review, the DC/PEN is the only power valve in this series, but since it will deliver a rated power output of close on 1.9 watts moving-coil loud speakers can be operated very satisfactorily indeed. The official characteristics of the valves are as follows:—

* Mutual conductance, 2.5mA/volt.
Maximum anode potential (E_a), 250.
Maximum auxiliary grid volts (E_x), 200.
Filament voltage, 8.
Filament current, 0.5 amp.
* at $E_a = 100$; $E_x = 100$; $E_g = 0$.

A specimen measured under the same conditions as cited above showed considerably better constants, the mutual conductance being 3.4 mA./volt. The A.C. resistance was 36,800 ohms, and the amplification factor 125.

Normally the valve will be operated with the maximum auxiliary grid volts so that the characteristics under these working conditions are of particular interest. With 200 volts on both anode and auxiliary grid and with a grid bias of between −8 and −9 volts the A.C. resistance was 74,000 ohms, the amplification factor 197, and the mutual conductance 2.66 mA./volt.

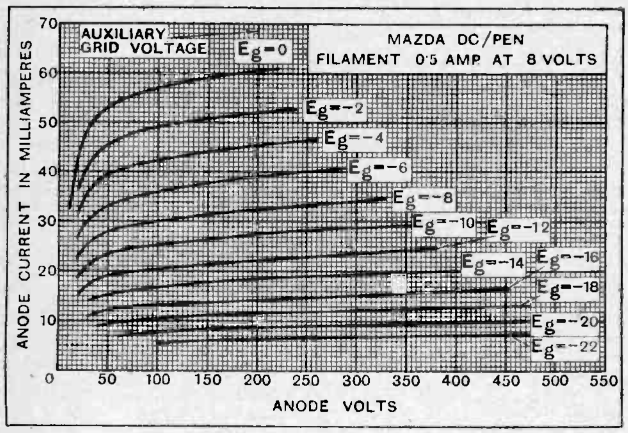

Fig. 4.—Anode voltage-anode current curves of the Mazda DC/PEN with equal increments of grid bias. From these the working impedance and the power output can be determined under normal working conditions.

When dealing with pentode valves the A.C. resistance as normally computed from its curves has little or no relationship to the working output impedance, which is very much lower than this figure. The optimum load resistance of the sample under discussion can be obtained from the anode current—anode voltage curves (Fig. 4) and shown to be about 8,000 ohms,[2] while the power output is approximately 1,820 milliwatts before noticeable distortion sets in. This is with the maximum of 250 volts on the anode, 200 volts on the auxiliary grid, and −9 volts grid bias. The total H.T. current through the valve is sufficiently high to demand the use of a step-down output transformer, or, alternatively, a tapped choke where choke-capacity feed is favoured. Another precaution that should be taken is the inclusion of a separate smoothing choke for the 200-volt supply to the auxiliary grid in conjunction with a fairly large smoothing condenser—4 mfds. The current in this circuit is about 6 mA., with 200 volts all round and normal grid bias, while the corresponding anode current is approximately 32 mA.

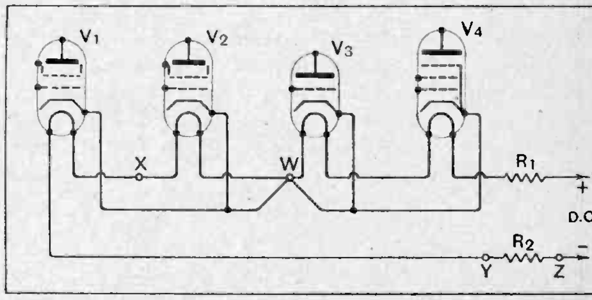

Fig. 5.—The cathodes of the valves must be connected to a point on the filament circuit so that the space current of the DC/PEN does not pass through its filament.

Certain important points must be borne in mind when using these valves. The total space current associated with the pentode valve amounts to some 38 mAs., and this must pass through the valve filaments connected in that portion of the circuit negative to the point where the cathodes are joined to the mains. The DC/SG and the DC/HL are designed to stand up to this extra load, but not so the DC/PEN. In every case the H.T. current must be diverted from its filament, Fig. 5, showing suitable connections for the filaments in a four-valve set consisting of two H.F. stages, a detector and pentode output valve.

By connecting the cathodes to the point W (Fig. 5) the desired conditions are attained. The space current of V_4 does not pass through its filament but finds a path to the negative main *via* V_2 and V_1. Furthermore, this enables grid bias for V_4 to be taken in a convenient manner from the point Z; R_2 being a small resistance designed to drop one or two volts according to the bias given to V_4. The point W is 4 volts positive to X, which is 4 volts positive to Y; thus if R_2 drops 2 volts Z will be 10 volts negative to the cathode of V_4.

Grid bias for the H.F. valves V_1 and V_2 can be obtained by connecting a 400-ohm potentiometer across

[1] "Low Voltage Power Grid Detection," by W. T. Cocking. *The Wireless World*, December 3rd, 1930, p. 618.

[2] "The Pentode Under Working Conditions." *The Wireless World*, December 4th, 1929, p. 630.

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First Indirectly Heated D.C. Valves.—
the filament of V_2 and returning the grids *via* a decoupling resistance of 250,000 ohms in each case to the slider. In the diagram R_1 is the main filament resistance, which limits the current flowing to 0.5 amp.

A suggested circuit for a three-valve local station receiver using a DC/SG, DC/HL, and DC/PEN, is shown in Fig. 6. Unimportant features, such as switching and screening, have been omitted since the nature of this depends on the practical design of the set.

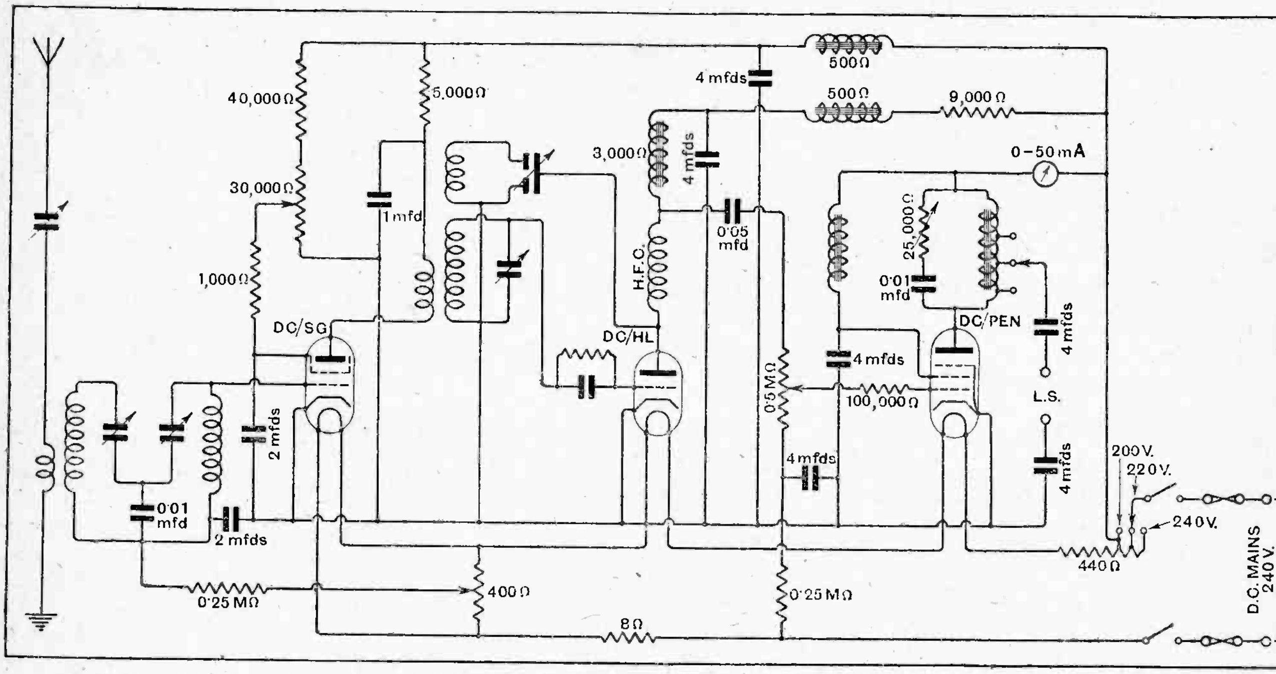

Fig. 6.—Suggested circuit for a three-valve local station receiver using the Mazda indirectly heated D.C. valves. Unimportant features have been omitted.

CLUB NEWS.

The Ideal Receiver.
"Receiver Design" was the title of a lecture given by Mr. M. P. Young at the last meeting of the North Middlesex Radio Society. The various stages of a receiver were discussed in turn, beginning with the filter circuits and H.F. stages. The pros and cons of anode bend and grid (including power grid) detection were dealt with in detail, this part of the lecture leading to much subsequent discussion. The output stage was exhaustively treated.

Several new members, as well as visitors, were present. Visitors are always welcome at the Society's meetings.

Hon. Secretary, Mr. E. H. Laister, "Windflowers," Church Hill, N.21.

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H.T. Eliminators.
At a recent meeting of the Croydon Wireless and Physical Society the chairman, Mr. A. J. Webb, M.A., B.Sc., gave a talk on the subject of "High Tension Eliminators."

Visitors are heartily welcomed at any of the meetings, which are held at 5, Altyre Road, East Croydon. Particulars regarding membership, etc., may be obtained from the Hon. Secretary, Mr. H. T. P. Gee, of Staple House, 51-52, Chancery Lane, London, W.C.2.

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When "Tinned Music" Sounds Real.
The first half of the season of the Bristol and District Radio and Television Society ended with a lecture from Mr. K. Higginson of the Oliver Pell Control Co. His lecture, illustrated with a moving-coil speaker and gramophone records played through an amplifier, dealt with "Tinned Music," and was received with great enthusiasm. He showed with great success that mechanically-produced "music" could still be music.

Hon. Secretary, Mr. S. T. Jordan, 1, Myrtle Road, Cotham, Bristol.

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The Chairman's Set.
The Ilford and District Radio Society is enjoying a period of record attendances at meetings, and on a recent evening there were seventy-one present to hear a demonstration of the Chairman's electric-gramo apparatus. The Society welcomed the presence of a party of members of the Southend and District Radio Society. The quality and volume given by apparatus which had been built by Mr. Newman himself were excellent. The amplifier had three push-pull stages, with 2 L.S.6a valves working an Epoch Moving Coil Speaker, and included a Novotone corrector.

Hon. Secretary, Mr. C. E. Largen, 16, Clements Road, Ilford.

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Northwood Radio Society.
The inaugural meeting of the Northwood Radio and Gramophone Society was recently held in the Council Rooms, Northwood.

The Chairman explained that the objects of the Society would be the furtherance of all matters connected with radio telegraphy, telephony, and other forms of sound reproduction, adding that, if sufficient support was forthcoming, it was intended to hold about ten fortnightly meetings during the season and to pay two or more visits to places of interest in connection with the objects of the Society. The Hon. Secretary (pro tem.) is Mr. D. B. Close, of "Cranleigh," Watford Road, Northwood, from whom further particulars of the Society may be obtained.

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Demonstrating a Modern Receiver.
High selectivity and great amplification were both to the fore when Mr. Hall, of Philips Lamps, Ltd., recently demonstrated the firm's All-Mains Four receiver at a meeting of the Woodford, Wanstead and District Radio Society. The lecturer gave a minute explanation of the design of the instrument, and concluded with a demonstration of foreign reception, using an aerial six yards in length.

Joint Hon. Secretaries, Mr. W. H. Crown, 1, Thornton Road, Leytonstone, and Mr. H. O. Crisp, 2, Ramsay Road, Forest Gate, E.7.

Demonstrating the Novotone.
Scepticism vanished at a recent meeting of the Grimsby and District Radio Society, when Capt. Goodwin, M.C. (of Messrs. Gambrell. Ltd.) demonstrated the Novotone. Although reproduction was good with the Gambrell All-Mains Three-valve Set without the Novotone, it was immensely improved when the device was added.

New members will be welcomed at the Society's meetings, which are held on alternate Wednesday nights at Abbey Park Hotel, Wellowgate, Grimsby.

Hon. Secretary, Mr W. Markham, 104, Torrington Street, Grimsby.

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Sunday Programmes.
Despite some protests, the majority of participants in the South Croydon and District Radio Society's recent debate on Sunday programmes appreciated the B.B.C.'s policy of giving listeners what they ought to want. One speaker foresaw that a very low intellectual level of entertainment would result if the B.B.C. gave listeners that which was demanded by popular opinion.

Considerable controversy was aroused over the subject of talks. It was obvious that nearly every talk broadcast found a large number of listeners eager to hear it. Members appealed for more talks of a practical scientific nature.

Hon. Secretary: Mr. E. L. Cumbers, 14, Campden Road, S. Croydon.

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New Club Set.
A test of loud speakers and the club's receiver, which has now been converted to all A.C., was carried out at a recent meeting of Slade Radio (Birmingham).

A full description of the receiver was given by Mr. R. Heaton, who also drew the circuit diagrams of the various stages. A demonstration followed, and a number of stations were received at good strength, the set proving fairly selective.

Details of the society may be obtained on application to the Hon. Secretary, 110, Hillaries Road, Gravelly Hill, Birmingham.

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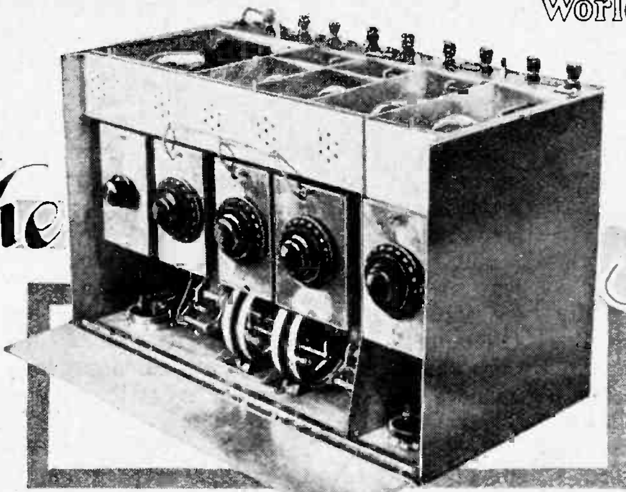
The Stenode



The Inventor's Explanation of the Principles of the Receiver.

By J. ROBINSON, D.Sc., Ph.D., M.I.E.E., F.Inst.P.

THE Inventor's explanation of the Stenode, together with some of the difficulties connected with the application of the sideband theory, will be found in this abstract of a paper read by Dr. Robinson recently before the Radio Club of America. The author's original figure numbers have been adhered to throughout.

THE ideal receiver for broadcasting purposes is usually considered to be one in which the radio-frequency response curve is square-topped with very steeply sloping sides. Such a receiver responds equally to the carrier and sidebands of the desired station, but cuts off very sharply outside the usual range of 5,000 cycles on either side of resonance. A tuned circuit of very low decrement, however, responds chiefly to the resonance frequency, and only slightly to the sideband frequencies. It has been thought, therefore, that such circuits are quite unsuited to telephonic reception.

It is of importance, however, to investigate whether this generally accepted deduction from the Fourier theories is of universal application. If a receiver with an effective band-width of less than 100 cycles be employed, and a continuous wave of its own frequency be applied to it, a current will build up in the circuit. Now, if the transmitter be keyed at a very slow rate, say, one per second, the current will obviously follow the input wave exactly. If the frequency of the signalling be increased, there is still a change of response, although general radio opinion has stated that with speeds of 5,000 cycles per second there would be no response, because the sidebands would be cut off. There can be no discontinuity in the nature of the physical response as we go from a signalling speed of one per second to 5,000 per second. Thus, it is essential to examine the phenomenon from a new point of view if we are to find an explanation of the working principles of the stenode.

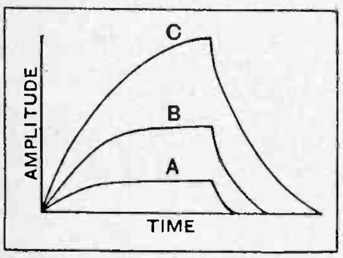


Fig. 2.—The curves show the build up of oscillations in circuits of varying decrement, and the rate at which they die away when the applied wave ceases. Curve A refers to the circuit of highest damping, and curve C to that of the lowest.

Let us consider a resonance circuit which can be obtained in different conditions as regards the logarithmic decrement, the remaining conditions being constant. We shall examine these conditions by plotting the rate of rise of the oscillations which arrive at the circuits. This is shown in Fig. 2, where the amplitude of the oscillations is plotted against time. We find that for the curve A, the most highly damped circuit, the oscillations build up to a comparatively low steady state, whereas in the case of low damping, curve C, a large, steady state is finally obtained. The amplitude of the steady state, in fact, is inversely proportional to the resistance in circuit, as Fig. 2 clearly shows.

Another very important point emerges from these curves; although the curve C reaches a higher amplitude than curve A, a longer time is required for it to reach its steady state. When the incoming waves cease, the receiver is in a state of oscillation, and these oscillations will commence to die away at a rate depending upon the logarithmic decrement. In each case we have an exponential fall of the oscillations, and a highly damped circuit comes to rest much more quickly than one of low damping.

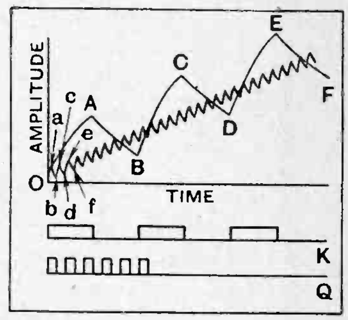


Fig. 3.—The curves show the response of a highly selective circuit when signals K and Q of varying speeds are applied. The curve OABCD refers to the signalling speed K, and the curve Oabcd to the speed Q. It is the variations in these curves which give the audible signal.

If it be necessary for the circuit to respond fully to

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a signal, therefore, it is obvious that the rate of signalling must depend upon the damping. In the case of curve A a comparatively short time is required to build up to the maximum value and to die down to rest again. With a circuit of low damping, curve C, however, a much longer time is required for the receiver to build up to its maximum value and to die down again.

High Signalling Speeds.

Let us now examine what would happen if we actually did employ very high signalling speeds with these circuits of exceedingly low damping. In Fig. 3 we again plot the amplitude of response of a very selective circuit against time, and the actual response to telegraphic signals of two different speeds is also shown. First of all, we shall consider signals as shown at K, and we must assume that the transmitter is active and at rest for equal intervals. For the first active portion, the amplitude of oscillation will build up to the point A. When the incoming wave ceases, these oscillations will tend to die away; and as a comparatively large time is required for this process, we cannot afford to ignore the exponential effect, which, in fact, becomes of very great importance. In the period of rest, therefore, the receiver will only die away to the point B, and it will still be in the state of oscillation when the next signal arrives. This will now (provided that we arrange for it to start in the correct phase) build to the amplitude of oscillation of the point C. Again, the amplitude falls to the point D in the period of rest. Thus, for signals K, we find that the receiver continues to build up according to the curve OABCD, finally reaching a steady state with the amplitude varying according to the signals.

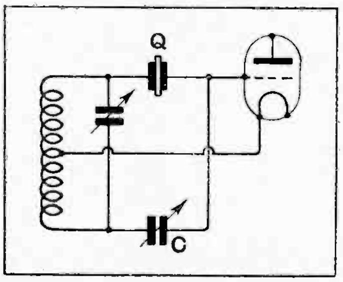

Fig. 6.—The method by which the quartz crystal Q is connected in circuit. It is necessary to neutralise the capacity of the crystal holder by the bridge scheme shown and the balancing condenser C.

If, however, the signalling speed be increased, as shown at Q, the built-up curve becomes Oabcd; again, the amplitude building up to a steady state with a fluctuation. The rate of this fluctuation corresponds to the signalling speed, but its amplitude depends upon the signalling speed. Fig. 3 is sufficient to show that, no matter what telegraphic signalling speed be employed, provided that this is lower than the frequency of the carrier, we shall have the amplitude of the receiver fluctuating with the signals, and the amount of fluctuation depending upon the signalling speed.

Telephony.

In place of telegraphic signals of square form, as shown at K and Q, it is obvious that we can employ signals of trigonometrical form, and that similar reasoning will apply. Now, such a signal of trigonometrical form is equivalent to a trigonometrical modulation of the carrier; and we find, therefore, that when the carrier waves are modulated by any frequency, the amplitude of oscillation fluctuates at the same rate as the modulation.

The important deduction to be drawn is that in this very selective circuit all modulation frequencies are present, although not in their original proportions. We can, in fact, deduce a general principle, which is that when modulated waves impinge upon a receiver the percentage modulation is changed after going through the receiver to an amount which depends upon the logarithmic decrement and also upon the modulation frequency.

Having reached this very important deduction, the way was shown to the construction of a suitable receiver by employing a very selective device, and arranging for the correction of the modulation frequencies so that they should appear in their desired proportions. For instance, one method of bringing this about is to pass the modulated waves through a highly selective circuit, such as a quartz piezo-electric crystal, then to rectify the effects, and to pass the result through a low-frequency amplifer which has the characteristic of amplifying the frequencies so that the amplification factor is proportional to the frequency.

The conclusion which has just been arrived at, that the percentage modulation is reduced as the selectivity increases, helps us to appreciate that the *magnitude* of the modulated response is not small. Although the percentage modulation has been diminished, the *total* response of the circuit at resonance has increased, as some resistance has been cut out of the resonance circuit to produce the selectivity. Hence, although the percentage modulation is diminished, the *absolute* value of the modulation is not necessarily lowered.

We have, thus, the following results:—

(1) No matter how selective a circuit may be, all modulation frequencies are present.

(2) From a quantitative point of view, the signals need not be weaker than they are in a highly damped receiver.

(3) We can now employ selectivity as high as is practically possible, and there is no need to place a limit to progress as regards selectivity.

(4) The percentage modulation of waves is changed after they pass through a very selective device by a factor which is proportional to the logarithmic decrement and approximately inversely proportional to the modulation frequency.

It is known that when a quartz crystal is cut in a special manner it has a definite frequency, and that it can be employed as a resonator. Such a resonator is very selective, and as we require our indications actually in the quartz crystal circuit itself, it is connected between one end of the resonance circuit and the grid of a valve (see Fig. 6). In order to prevent energy from passing through the capacity of the crystal holder, however, it is necessary to employ a balanced bridge circuit, utilising a centre-tapped coil and the balancing condenser C.

As reception with a crystal obviously occurs only over a narrow band of frequencies, it is necessary to employ the supersonic principle in order to receive over a wide range of frequencies. The incoming signals have their

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frequencies changed to that of the crystal, just as in an ordinary superheterodyne receiver. After passing through the crystal the signals are rectified, and are then passed through a low-frequency amplifier which is designed to amplify in proportion to frequency.

Interference.

According to the general conception of the sideband theory, interference should result when the interference is on a frequency less than 10 kc. from the desired station, and we shall now consider the interference obtained from the carrier wave of a neighbouring station. Such a carrier wave will produce an effect in the selective circuit, although this effect is small. In most of the experiments up to date, it is found that such an interfering carrier does produce a small interference; and although this does not form part of the present paper, means can be employed to remove this interference.

By making a receiver of the highest possible selectivity, the modulation response of a transmission whose frequency is less than 5,000 cycles away from resonance can be made negligible.

This result appears to be a contradiction of the sideband theory. It is, however, very significant that there are certain phases of radio analysis where it is customary to employ the actual modulated waves instead of the Fourier components, such as in the problems of rectification. It is open to question, therefore, whether the sideband theory gives a complete statement of the case.

Still another factor which must be taken into account, in the case of the Stenode, is that we must consider free oscillations which are given by the exponential term in the solution to the basic differential equation for oscillating circuits. This exponential term is not easy to subject to mathematical computation.

When attempts to apply the sideband theory to the Stenode are made, the question arises as to the vectorial addition of the various sideband effects. Such additions can be made, provided that each term is entirely independent of the other terms. When the exponential term is of large importance, however, the sideband effects are not independent of each other,* and thus simple addition cannot be applied.

APPENDIX.

If the depth of modulation of the incoming wave be m, then the depth of modulation m_1 after passing through the selective circuit is given by:

$$m_1 = \frac{\delta n m}{2\pi f}$$

where δ = circuit decrement $= \frac{R}{2fL}$

n = carrier frequency.

f = modulation frequency.

R = series resistance of circuit in ohms.

L = inductance in henrys.

PHILIPS DE LUXE ELECTRIC GRAMOPHONE.

Three-stage Amplifier with an Output of 15 watts.

DESIGNED for high-quality reproduction of gramophone records in hotels, restaurants, and dance halls, this 190-guinea A.C. model is housed in a massive cabinet of dignified design which is available either in walnut or mahogany. The lid hinge is fitted wtih a pneumatic stop which prevents the lid from being accidentally slammed.

A super-power moving-coil loud speaker is fitted, and the amplifier is designed to deliver the full 15 watts of undistorted power which it is capable of handling. There are three stages, and the output valve is a Type M.C.1/50 working at 1,000 volts and 50 mA. The H.T. rectifier is a Type 2,769, and the loud speaker field is supplied from a Type 506A. valve. Although intended primarily as a gramophone reproducer, provision is made for feeding the amplifier from a radio receiver or local microphone.

Philips Senior Reproducer.

The pick-up is a special design originally evolved for talkie installations. It is oil-damped, and has a dog clutch for clamping the needle; thus, the long needle set screw is detached from the vibrating system during the playing of a record.

Another interesting feature is the delayed-action pilot lamp. This is connected across the loud speaker field, and does not light until the gas-filled rectifier strikes. The short time interval which elapses after switching on allows the A.C. heaters of the amplifier valve filaments to reach their working temperature, so that the equipment is all ready for use immediately the pilot light appears.

The makers are Philips Lamps, Ltd., 135, Charing Cross Road, London, W.C.2.

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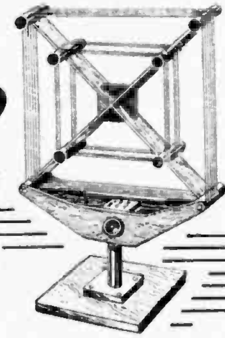
Dual-Range Frame Aerial



Specially Designed for the Band-pass Superheterodyne Receiver.

By A. L. M. SOWERBY, M.Sc., and H. B. DENT.

ON looking through the indexes of recent volumes of *The Wireless World*, a good many entries were observed under the head of "Frame Aerial." Practically all of them were found to be replies to readers' queries—which encourages the writers to hope that, although the frame aerial here described has primarily been designed for use with *The Wireless World* Band-pass Superheterodyne, there may be users of other receivers who will be interested in it.

At first glance the design of a frame aerial would appear to involve nothing more difficult than finding the number of turns that would tune over the required wave-range. For a frame which has to cover only one waveband this simple recipe is perfectly adequate, and anyone who cares to take the trouble can build up a frame that will be completely satisfactory on whatever waveband it is intended to cover. If, however, an attempt is made to cover both the long and medium wavelengths commonly used for broadcasting, it is found that there are certain pitfalls. Usually such a dual-range frame works beautifully on the longer waves, but gives very poor signal strength indeed on the medium waves.

The reasons for this have been discussed in an article entitled "The Experimenter's Frame Aerial,"[1] in which it was pointed out that the unused long-wave sections are very liable, unless carefully proportioned, to act as tuned acceptor circuits for certain wavelengths on the medium band, thus making the reception of signals on these particular wavelengths practically impossible. In addition, the proximity of the long-wave sections is almost certain to raise the high-frequency resistance of the medium-wave frame at all wavelengths within its range.

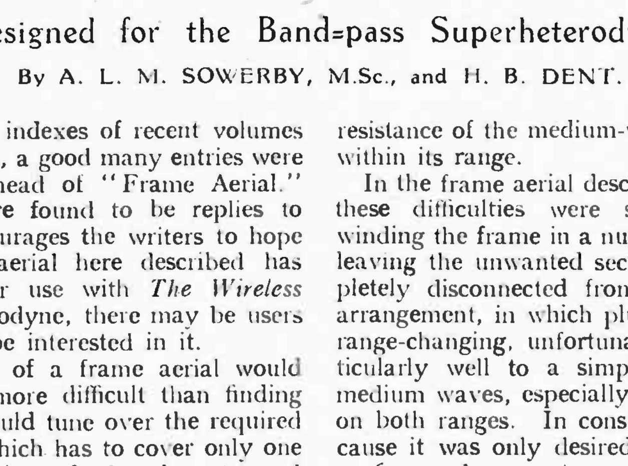


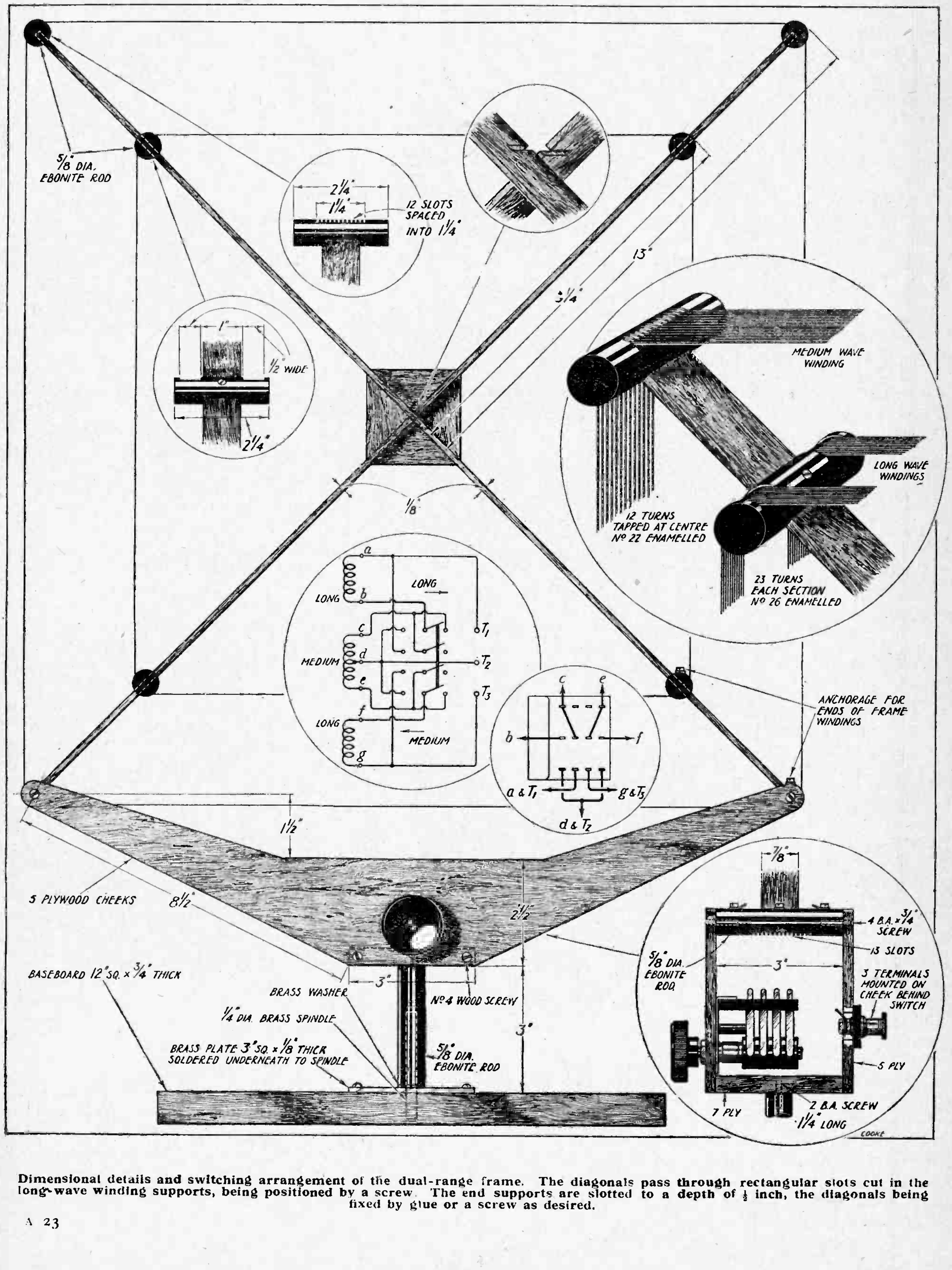
Fig. 1.—Sensitivity of frame at wavelengths from 225 to 600 metres. The vertical scale shows the number of millivolts developed across the tuned frame when exposed to a field of one millivolt per metre.

In the frame aerial described in the article mentioned, these difficulties were satisfactorily surmounted by winding the frame in a number of separate sections, and leaving the unwanted sections open-circuited and completely disconnected from the sections in use. This arrangement, in which plugs and sockets were used for range-changing, unfortunately does not lend itself particularly well to a simple switch-over from long to medium waves, especially when a centre-tap is required on both ranges. In consideration of this fact, and because it was only desired to cover the two bands 200 to 600 and 1,000 to 2,000 metres, the problem was tackled afresh for the present design.

The task undertaken was therefore to design a frame suitable for these two wavebands, capable of being switched readily from one to the other, and maintaining the centre-tap on both ranges so as to be suitable for use with the Band-pass Superheterodyne, with which a centre-tapped frame is desirable.

The question of size was settled out of hand by picking on a square of eighteen-inch sides, which is small enough to be reasonably handy, while large enough for a sensitive set. A number of experimental windings were made in turn upon a framework of this size, and eventually the reluctant conclusion was drawn that the sections out of use when receiving on the lower band always raised the high-frequency resistance of the sections still in circuit to some extent. In an endeavour to lessen this loss the long-wave sections were finally wound on a second smaller framework concentric with that on which the medium-wave frame was wound, in the manner shown in the illustrations.

[1] H. B. Dent, *The Wireless World*, July 27th, 1927, page 99.



Dimensional details and switching arrangement of the dual-range frame. The diagonals pass through rectangular slots cut in the long-wave winding supports, being positioned by a screw. The end supports are slotted to a depth of ½ inch, the diagonals being fixed by glue or a screw as desired.

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Dual-range Frame Aerial.—
This device, by increasing the physical distance between the two windings, was found to reduce very appreciably the losses introduced by the long-wave sections when out of use.

With a winding made up of four sections there are a surprisingly large number of ways in which the long-wave windings may be connected when receiving on the medium-wave band. By trying all in turn, and noting in each case the voltage developed across the tuned frame by the transmissions from the London Regional and London National stations, a rough comparison was made of their relative efficiencies. This simple experiment showed that the greatest voltages were developed when the two long-wave sections were connected in parallel with the corresponding medium-wave sections; further, it was found that with this arrangement the voltage was in both cases within a few per cent. of that developed across a frame carrying a medium-wave winding only. This mode of construction was therefore adopted.

Further investigation showed that the long-wave sections tuned, with their own self-capacity, to a wavelength between 60 and 65 metres, which is well away from the danger zone.

The high-frequency resistance of the complete frame, connected as for reception of medium waves, was measured at a number of different wavelengths. Special attention was paid to those wavelengths which were an exact multiple of that at which the long-wave sections resonated, there being still a suspicion that the resistance might turn out to be abnormally high at these points. No such peaks, however, were present, and the frame was found efficient over the whole waveband. Fig. 1 gives the sensitivity of the frame at wavelengths from 225 to 600 metres, the sensitivity being expressed as the number of millivolts developed across the frame when the field-strength from the transmitter is one millivolt per metre. The sensitivity is reasonably constant over the range, being the same at 225 metres as at 600, and only 50 per cent. higher at its best point, 330 metres.

The diagrams provide practically all the information that will be required in making and winding the frame, but one or two points deserve special mention. The 4-pole change-over switch is connected to high-potential points in the tuned circuit, so that if the dielectric properties of the insulating material are not good a serious lack of sensitivity at the bottom end of the medium-wave band will be experienced. There are switches available in which the contacts are carried on ebonite; one of these should certainly be chosen in preference to a switch built on any synthetic insulating material. Capacity, through air, between adjacent contacts does not lead to losses, and so need not be taken into account.

Details of the framework may be modified as far as desired, so long as the dimensions and spacing specified for the actual windings do not suffer appreciable change.

All four sections are wound in the same direction, 12 turns of No. 22 enamel wire, spaced out to $1\frac{1}{4}$in., and tapped at the centre, making up the two medium-wave sections. It will be found easiest to wind the whole 12 turns continuously, and make the tap afterwards. The pull exercised by a few turns of wire, wound on under tension, is very much greater than one would expect, and will distort the framework very noticeably unless measures are taken to counteract it. A length of stout string, tied as tightly as possible round the frame on the side opposite to that on which the first section is wound, will be found quite effective.

The two long-wave sections, which are separated by a distance of one inch are each wound with 23 turns of No. 26 enamel wire, the space occupied by each being half an inch. In connecting these to the switch, care should be taken that the inside of each section is joined to the centre-tap of the outer frame when switched to medium waves.

Since the frame is primarily intended for the Band-pass Superheterodyne, the inductance has roughly been matched to the tuning coils in that receiver; with a tuning condenser of 0.0005 mfd. capacity the maximum wavelengths are 600 and 2,000 metres. The lowest wavelengths attainable depend on the minimum value of parallel capacity, and so cannot be stated as a property of the frame. In any reasonable circumstances, however, 200 metres and 700 metres should comfortably be reached.

TRANSMITTERS' NOTES.

R.S.G.B. Tests and Competitions.

February 22nd to 28th is devoted to the "British Empire Radio Week," and a Challenge Trophy is offered for the member of the R.S.G.B. or B.E.R.U. who obtains the highest number of effective points for working stations in other parts of the Empire. For the purpose of this competition the Empire is divided into twelve groups: (1) British Isles; (2) Canada, Newfoundland, and Nova Scotia; (3) West Indies, Bahamas, Bermuda, and British Guiana; (4) South Africa and Rhodesia; (5) Kenya, Uganda, and Tanganyika; (6) Egypt and Sudan; (7) Iraq; (8) India, Burmah, and Ceylon; (9) Malaya; (10) Hong Kong; (11) New Zealand; (12) Australia.

One point is counted for each station worked, but the same station may be worked on two or more wavebands, each of which is counted as a point. A maximum of 20 contacts on each waveband will be allowed in any one of the twelve groups.

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Low-power Tests.

We hear that the Contact Bureau of the R.S.G.B. intends to organise some low-power tests next April, in which the maximum power allowed will be 1 watt. We hope to give full particulars at a later date.

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New Call-signs and Changes of Address.

G2WW (Ex 2BCQ). L. C. Davis, Jnr., 24, Fallowfield Ave., Hall Green, Birmingham.

G2WX S. Borgars, 28, Welldon Cres., Harrow-on-the Hill, Middlesex.

G5OG C. I. Orr-Ewing, Pond Cottage, Weald, Sevenoaks, Kent.

G5PH B. F. Phillips, 144a, Cwm Rd., Bonymaen, Swansea. (Change of address.) Transmitting on 7 and 14 mC. and welcomes reports.

2ANS J. Cuthbertson, 15, West View, Aklam Rd., Linthorpe, Middlesbrough, Yorks, experimenting on 40.8 metres.

2ABQ R. Cave, Holiday House, Mill Lane, Walton-on-Naze, Essex (willing to report upon any amateur's signals, preferably on the 7 mC. waveband after 19.00 G.M.T. or any time on Sundays).

2ABW E. Gaukrodger, 4, Montrose Villas, Chewton Rd., Keynsham, Somerset.

2ANJ E. F. Baker, 5, Currie Rd., St. John's, Tunbridge Wells.

2ADC F. S. Mizen, 28, Brunel Rd., Bridgwater Rd., Nr. Bristol.

2AMZ F. R. Drew, Frampton Cotterell, Nr. Bristol.

INDIA.

VU 2FX C. D. Connerton, Aircraft Park, Royal Air Force, Lahore, India, licensed to transmit on 10.509, 21.018, 42.036, and 168.144 metres.

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Current Topics

EVENTS of the WEEK in BRIEF REVIEW

THE TEST OF RICHES.

The North Monaghan (Ontario) Council has decided that the possession of a wireless set will debar a resident of that municipality from participating in the unemployment relief scheme.

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MYSTERY OF MOORSIDE EDGE.

Vigilant listeners report the reception of "tuning signals" from the new Northern Regional station at Moorside Edge. Whilst declining to confirm such reports, the B.B.C. states that emission tests are made from time to time. Public tests may be expected very shortly.

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STILL THEY COME.

At the end of November there were 3,307,878 British receiving licence holders, in addition to 19,020 blind persons holding free licences. This is an increase of 60,196 and 491 respectively over the figures for the previous month. In the last twelve months the total has advanced by 409,112.

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MUSIC ON HOLLYWOOD EXPRESS.

The "Sunshine Special" expresses of the Missouri Pacific Lines, running from St. Louis along the Pacific coast to Los Angeles, have been wired for radio reception.

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ANOTHER 100-KILOWATTER.

The urge for power in Europe will receive another manifestation in 1932, when a new 100-kW. station will be launched on the ether at Budapest. During the present year, writes our Berlin correspondent, the Hungarians hope to erect two "intermediate" stations in W. and N.E. Hungary, each with a power of 10 kilowatts.

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PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

The Twenty-first Annual Exhibition of the Physical and Optical Societies is now running at the Imperial College of Science, South Kensington, to-morrow (Thursday) being the concluding day. Over eighty firms are exhibiting in the Trade Section, while an interesting collection of research and experimental exhibits (including wireless) is also on view. Tickets obtainable from the Secretary, 1, Lowther Gardens, Exhibition Road, S.W.7, are necessary for to-day (Wednesday), but members of the public will be admitted to-morrow without tickets.

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ITALY'S BEST AND CHEAPEST.

The prize for the best all-Italian wireless receiver has been won by the firm of Ansaldo-Lorenz for an instrument fulfilling all the conditions, writes our Turin correspondent. The competition, which was organised last spring by the Italian broadcasting authorities, was to encourage the home manufacturers to turn out a receiver entirely Italian in construction, highly selective as well as sensitive, productive of good quality, easy to operate, and, last but not least, cheap!

HAMBURG ENTERTAINS EUROPE.

To celebrate the opening of the new radio building in Hamburg to-morrow (Thursday), the Norag broadcasting organisation will provide a special symphony concert at 7 p.m. (G.M.T.) in the main hall, to be internationally relayed to many stations in Europe.

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MUSIC AND WIRELESS.

Fifteen years ago a man who dared to predict that wireless and music would ever walk hand in hand would probably have been sent to a Home of Rest. Yet during the present month a well-known journal of the music trade is regaling its readers with a "Glossary of Radio Terms"!

NEW USE FOR SEAWEED.—Among the architectural refinements included in the new "Broadcasting House," Portland Place, are special soundproof studio walls packed with seaweed.

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RADIO ON DEMONSTRATION TRAIN.

An exhibition car devoted entirely to wireless is included in a special electrical demonstration train run by the Orleans Railway Company. The train is taken to remote districts on the railway system and is proving highly successful in spreading the gospel of electricity among the peasant community.

SUBSIDISING THE RESEARCH WORKER.

Professor Dunoyer, of the French Optical Institute, has been granted a subsidy of £80 by the Academy of Science to assist him in photo-electric cell research.

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WIRELESS AT B.I.F.

The wireless section of the British Industries Fair, Olympia, February 16th to 27th, will occupy a large section of the ground floor of the National Hall. A number of prominent firms have already booked space.

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A TRANSOCEAN TRIUMPH.

With the extension of the Transatlantic Telephone Service to all parts of Canada and Mexico on January 1st, Europe was brought into telephonic touch with the whole Continent of North America, including Cuba.

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NEW AUSTRIAN BROADCASTER.

At Salzburg, Austria, the birthplace of Mozart, a new broadcasting station was opened on December 21st, working on the international common wave of 218.5 metres. Salzburg relays the programmes from Vienna. The power is ½ kilowatt.

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ANTI-PARASITE CAMPAIGN.

A grand campaign against man-made static has been launched by the Electrotechnical Association of Czecho-Slovakia. Owners of electrical apparatus have been subjected to an avalanche of 500,000 circulars describing the woes of the listener troubled with interference, and how they can be averted by a little consideration on the part of "parasite producers."

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THE LATE DR. FERRANTI.

The life and work of Dr. Ferranti will form the subject of a memorial address to be delivered by Mr. Frank Bailey, chief engineer and managing director of the City of London Electric Lighting Co., on Wednesday next, January 14th, at 7.15 p.m., in the Large Hall of the Manchester College of Technology. The lecture will be given under the auspices of the Electrical Power Engineers' Association, and the chairman will be Mr. V. Z. de Ferranti.

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I.E.E. WIRELESS SECTION.

At the meeting this evening (Wednesday) of the Wireless Section of the Institution of Electrical Engineers the following papers will be read and discussed: "A New Method of Measurement of Resistance and Reactance at Radio Frequencies" (with demonstrations), by Messrs. F. M. Colebrook, B.Sc., and R. M. Wilmotte, M.A.; and "A Variable Capacity Cylindrical Condenser for Precision Measurements" (with demonstrations), by Mr. E. B. Moullin, M.A. The meeting will be held at 6 p.m. at Savoy Place, W.C.2.

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RADIO TO JUNGLE EXPEDITION.

Broadcast messages from KDKA to members of the Matto Grosso Expedition in the heart of the South American jungle will be available for world consumption in the course of the next few weeks. The explorers intend to keep in short-wave touch with the outer world when they are as far as 2,500 miles up the Paraguay River. Special messages from relatives and friends will be transmitted on short waves from KDKA every Saturday night at 11.15 (4.15 a.m. Sunday G.M.T.), and also relayed on the normal broadcast wavelength. It is possible that messages from the expedition may also be relayed on the longer wavelength.

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MUNICIPAL WIRELESS COURSE.

A special course of lectures for wireless service agents and others interested in broadcast reception opens at the Manchester Municipal College of Technology on Wednesday next, January 14th. The lectures, which will deal with the performance of broadcast receivers, will be given by Mr. W. Jackson, M.Sc., and will not demand a high degree of technical knowledge The fee for the course is 10s. 6d. Full particulars can be obtained from the Registrar at the College.

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PLEA FOR "ONE-MAN RADIO."

America never needed a good five-cent cigar as it now needs a good one-man radio set, according to W. R. Bryans, Professor of Mechanical and Machine Design at New York University, whose remarks are quoted by the *New York Times*.

"Loud speakers are driving hundreds into the divorce courts annually," said Professor Bryans. "No two members of a family want to hear the same radio programme. What is music to one ear is merely a neurosis-producing racket to another.

"In this apartment age each person should be equipped with a small portable radio set which could be plugged into a light-socket. Then, without annoying each other, mother, with comfortable sponge-rubber earphones, could tune in on the opera, dad on the fights, sister on the dance orchestras, and little brother could do his home-work, at last, in peace."

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McMICHAEL MAINS THREE.

We regret that a wrong address was given in the review of the McMichael Mains Three receiver in our issue of December 31st The address of the manufacturers, Messrs. L. McMichael, Ltd., is Wexham Road, Slough, Bucks.

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RADIO COMMISSION CRITICISED.

Strong criticism is descending on the annual report just submitted to the U.S. Congress by the Federal Radio Commission. The critics draw attention to the fact that the report contains not a word about the pressing problem of high power, nor a syllable in recognition of the broadcasters' demand for yearly instead of three monthly licences. The report is also silent upon what is described as the fundamentally unsound zone system of administering radio by segments of states, regardless of the fact that radio knows no artificial geographical boundaries.

The Commission includes among its recommendations a plea for power to penalise offending stations by ordering them "off the air" for thirty days.

The Commission refuses to "recognise visual broadcasting as having developed to the point where it has real entertainment value"

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THE KITE SET.

The kite aerial is one of the oldest devices in wireless, but the kite set is fairly new. Kites carrying short-wave transmitters and weighing little more than 1 lb. are used in D.F. tests now being conducted by the Department of Scientific and Industrial Research at the Slough experimental station.

The transmitters each carry a number of dry cells and a valve, together with an aerial of about 100ft. Ranges up to half a mile are obtained, the kites being flown at heights up to 500ft.

Radio bearings are taken on the kites from a ground station, extraordinarily accurate results being obtained.

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PAPAL RADIO RESEARCH.

Any existing notions that the new Vatican City wireless station is to be devoted solely to religious uses will be dispelled by the news that elaborate arrangements are in hand for research work in connection with wireless echoes. A Turin correspondent informs us that, although the station is equipped with Marconi duplex telephony gear capable of world-wide communication, the transmission periods will be infrequent, thus permitting Father Gianfranceschi, the station director, to collaborate with the Pontifical Academy of Science in the investigation of many radio phenomena now perplexing radio scientists.

In addition to the subject of radio echoes, the experimenters will probe into the questions of fading, atmospherics, and the influence of the sun on electromagnetic waves.

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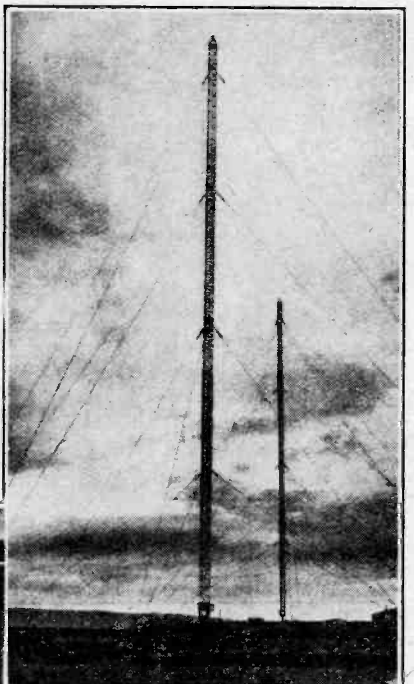
IS AMERICA GREEDY?

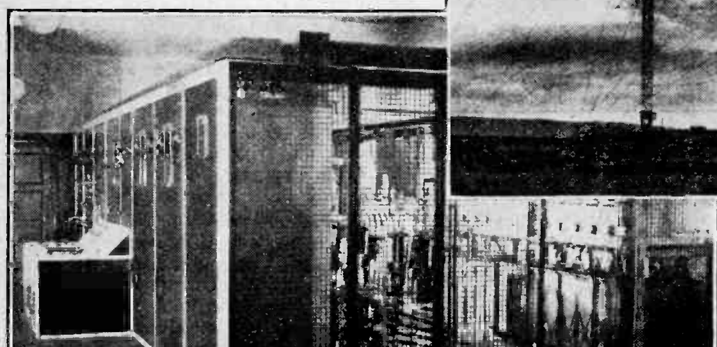
The growing opposition of Canada and Mexico to the "squatter sovereignty" exercised over the major portion of the broadcast band by the United States is referred to in a message from our Washington correspondent. American dominance (he writes) is readily explained: American inventive genius and business enterprise have been quickest to realise the potentialities of radio.

On the other hand, the rights of other nations to a share of the broadcasting facilities cannot be dismissed as mere academic theory. In fact, Mexico is already building stations on the channels now occupied by stations in the United States and Canada with much resultant interference to the latter. Canada has been more passive in its demands.

Some see the widening of the broadcasting band to include more channels as a solution; others think technical advances, such as synchronisation of chains of stations on identical wavelengths or narrowing the paths of broadcast transmission, may solve the problems before the legislators and diplomats need to be called upon.



(Above) A general view of the station.



(Below) The transmitter and control cabinet.

ICELAND CALLING. Transmissions will shortly begin from the new 16-kilowatt broadcasting station erected by the Marconi Company near Reykjavik, the capital of Iceland. The station is equipped for telegraphy as well as telephony work, and will be used for ship traffic in addition to broadcasting.

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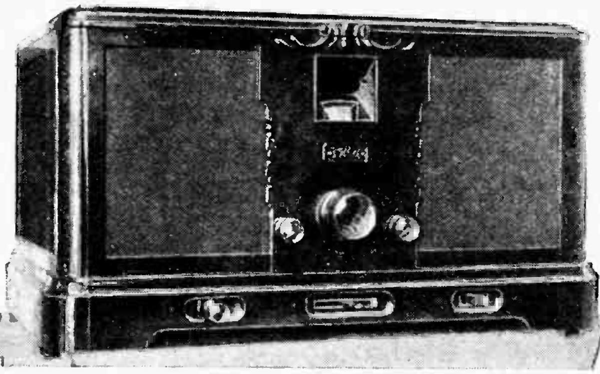
EKCO MODEL 313



THREE VALVE ALL-ELECTRIC

A Robust Three-valve Mains Receiver with an Excellent All-round Performance.

IN the Ekco Model 313 we have an excellent example of what is probably the most popular type of receiver on the market at the present time, namely, the mains-driven three-valve set with a single screen-grid H.F. stage, detector and pentode output valve.

The set is housed in a moulded case of unique design and the construction of the chassis shows evidence of careful preparation and development. In fact, it is a worthy first product of the new Southend factory of Messrs. E. K. Cole, Ltd.

In general principle the three-valve circuit follows conventional practice, but there are numerous detail refinements of special interest. For instance, the variable aerial coupling, which serves both as a pre-detector volume control and as a means of compromising between range and selectivity, takes the form of variable magnetic coupling between the aerial and tuned grid circuits. The grid coils are single-layer windings on a 1¾in. former and the aerial coupling coils are mounted on a spindle inside the grid coil former. The coupling is varied by rotating the aerial coils through the medium of a simple crank mechanism. The makers claim that this form of coupling produces a negligible change in the tuning of the grid circuit, and our experience with this set indicates that the claim is justified.

SPECIFICATION.

CIRCUIT: Screen-grid H.F. (tuned transformer coupling), leaky grid detector (with reaction), transformer-coupled pentode output valve. Westinghouse half-wave rectifier.
CONTROLS: (1) Single-dial ganged tuning. (2) Gang trimming condenser. (3) Wave-range switch. (4) Input volume control (variable magnetic coupling). (5) Reaction. (6) Mains switch.
SPECIAL FEATURES: Choice of three output impedances. Terminals for L.S. field current. Sockets for pick-up (no switching). Mains aerial.
Price: £22 10s. "Ekcone" L.S. £4 10s., "Ekcoil" L.S. £11 extra.
Makers: E. K. Cole, Ltd., Southend-on-Sea.

The Mains Aerial.

The aerial is connected to the coupling coil through a small fixed series condenser, two alternative values being provided in order that the set may be adjusted to local requirements. A third aerial socket is connected directly to the high-potential end of the grid coil. This is intended for short indoor aerials or the mains aerial provided with the set. The latter takes the form of a third wire bound up with the mains leads, and functions by virtue of its capacity to the mains. To prevent 50-cycle hum when using the mains aerial a small stopping condenser and high resistance shunt are connected in series with the grid of the H.F. valve. The screen grid potential, in common with the H.T. supply to the detector valve, is taken from a potentiometer resistance connected across the smoothed output from the mains rectifier. The tapping point on the resistance is adjusted at the works before despatch.

The H.T. supply to the anode circuit of the S.G. valve is decoupled, and the H.F. coupling to the detector valve is through the medium of a tuned transformer. The tuning condensers for the transformer secondary and the input circuit to the S.G. valve are ganged, and trimming condensers are connected in parallel with both elements of the condenser. The trimmer on the H.F. transformer secondary is adjustable from the front of the set, while that on the input circuit is pre-set at the works.

The detector functions as a grid rectifier with zero grid bias. Terminals are arranged in the input to the detector by means of which a gramophone pick-up may be connected with the appropriate negative bias. No switching is provided for the pick-up terminals, so that the pick-up must be entirely disconnected for radio reception, and conversely, the radio circuits should be detuned when reproducing gramophone records.

A reaction coil in the anode circuit of the detector is coupled to the H.F. transformer, the reaction current being controlled by a series variable condenser. On long waves a fixed condenser is automatically switched in parallel with the variable to increase the reaction effect.

The output valve, which is transformer-coupled to the detector, is a P.M.24B pentode with directly heated filament. Its anode circuit contains a tapped choke by means of which the output impedance may be matched to the loud speaker in use.

High-tension current for the set is supplied through a half-wave rectifier, the output from which is smoothed by the usual large-capacity condensers and a choke in

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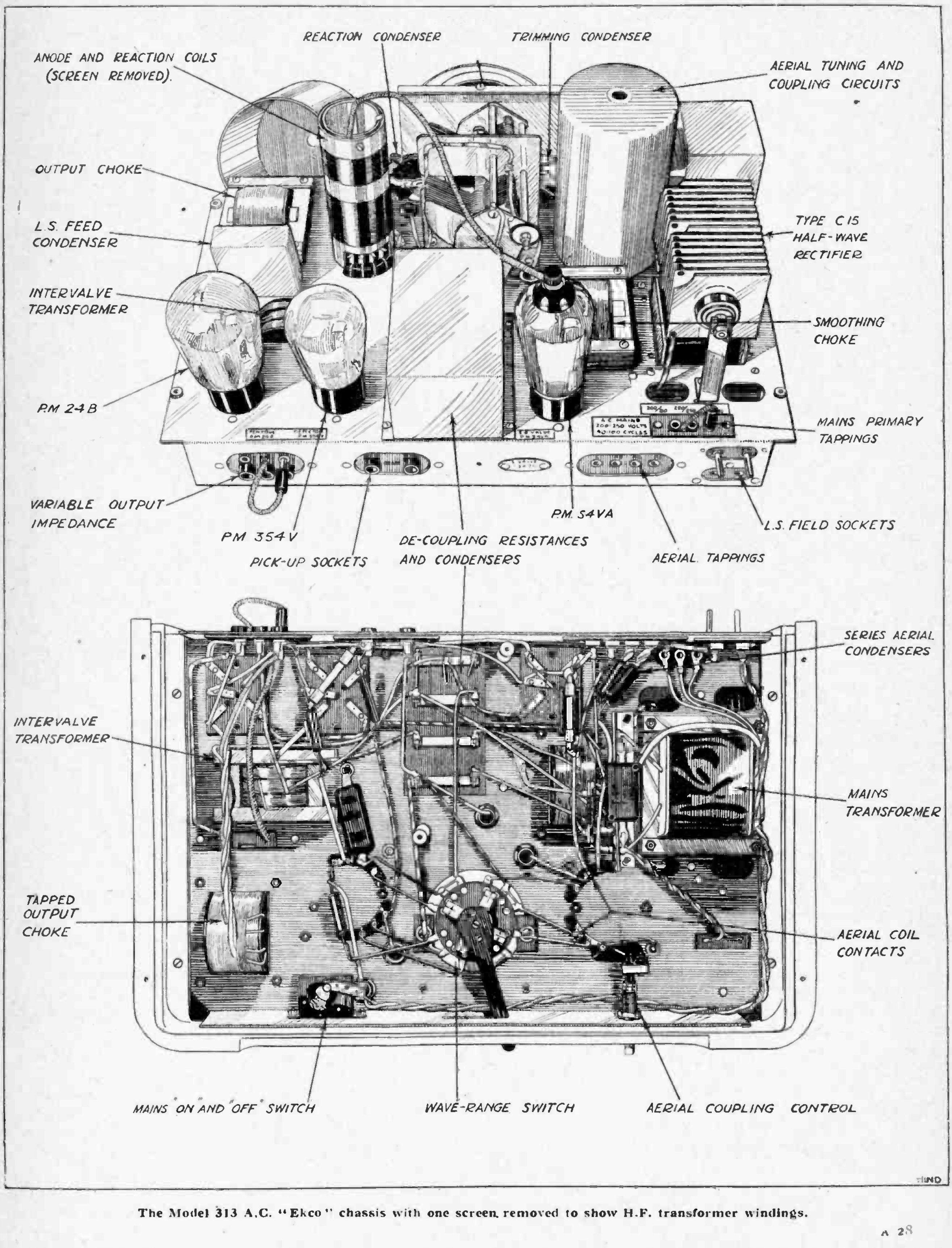


The Model 313 A.C. "Ekco" chassis with one screen removed to show H.F. transformer windings.

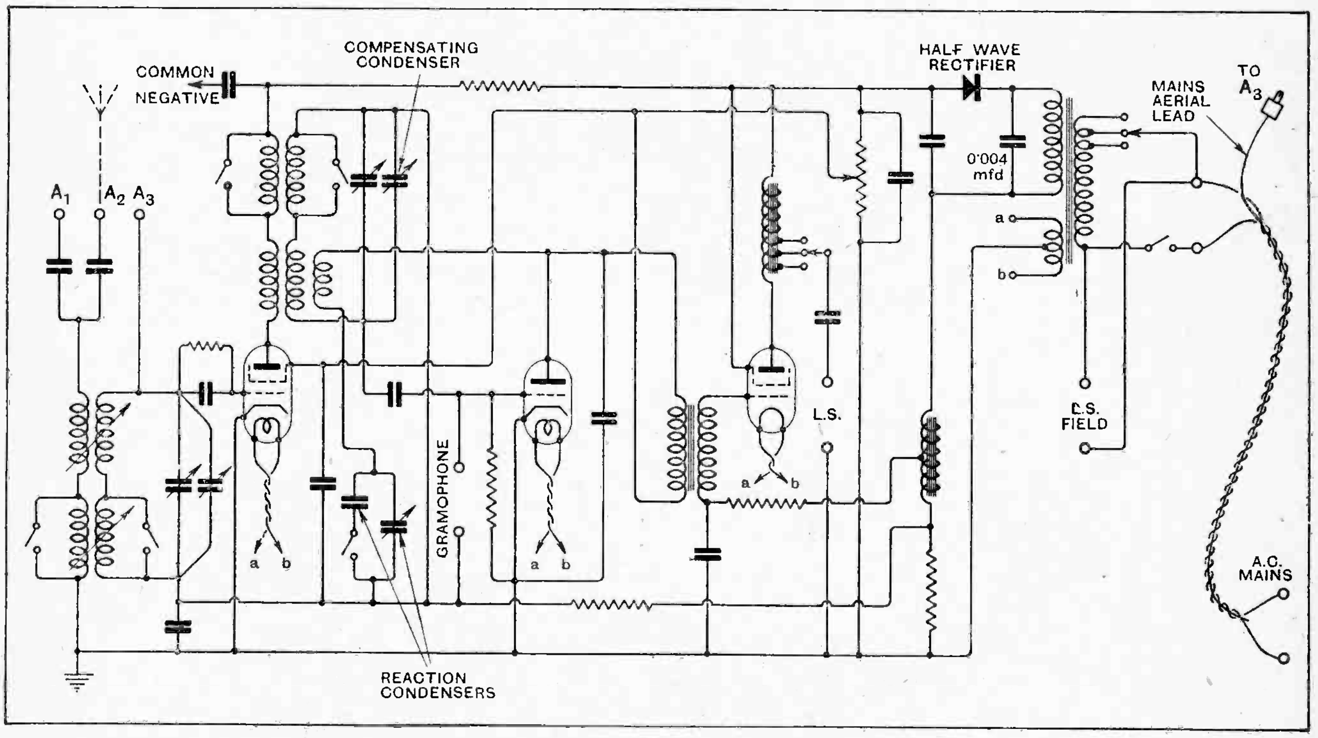
Ekco Model 313—Three Valve All-electric.—
the *negative* H.T. lead. This arrangement has the advantage that grid bias can be derived from the voltage drop in the D.C. resistance of the choke. In practice the voltage available is increased by a small resistance in series with the choke. The grid bias connections are efficiently decoupled.

In connection with the mains supply to the set, it is interesting to note that sockets are provided for energising the field winding of a moving-coil loud speaker, thus obviating the necessity of duplicating connections to the supply point. Incidentally, the mains supply leads are detachable from the set, so that all risk of shocks is provided against if the plug is removed from the receiver before making adjustments.

Tested at a distance of only five miles from Brookmans Park and making use of an outdoor aerial 50 feet in length, Langenberg and three other Continental stations on medium waves were received at good loud speaker strength in broad daylight. This in itself is convincing proof of the sensitivity of the H.F. portion of the circuit, and the performance after dark adds further confirmation. With both regional transmitters working, 27 foreign stations were received on the medium wave band. Of these 15 were at good programme strength, and in the case of four of these the volume control had to be used to prevent overloading the loud speaker. On Sunday evening, before the commencement of the B.B.C. transmissions, an additional 17 stations were received, 13 at programme strength and three requiring the volume control, bringing the total medium-wave score up to 44, an exceptional performance for a three-valve set. By making careful use of the aerial coupling and reaction controls, London Regional could be confined to a band from 310 to 365 metres, and the National transmitter from 210 to 280 metres. The fact that three foreign stations could be received between the two transmitters at a distance of five miles is an excellent testimonial to the selectivity on medium waves.

The long waves provided eight stations in addition to 5XX, the selectivity being just sufficient to isolate Königswusterhausen and more than sufficient to separate 5XX from Eiffel Tower and Radio Paris.

The mains aerial is surprisingly efficient and enabled eight foreign stations to be received on medium waves and four on long at good loud speaker strength. The selectivity, on the other hand, is by no means so good as with an outdoor aerial, and it was found to be impossible to separate the London transmitters at five miles.



Circuit diagram of the "Ekco" Model 313 A.C. mains receiver.

A further test in Central London was more successful, however, and either station could be limited to a band approximately 20 metres in width.

We are unable to find any fault with the quality of reproduction, which is in keeping with the high standard of performance in other respects. Some mains hum was noticeable, however, during intervals in the transmission, but was not sufficiently serious to merit condemnation.

Finally, a word of praise is due to the instruction booklet issued with the set. This applies to both A.C. and D.C. models, and, in addition to very lucid instructions for setting up and operating the set, gives a logical sequence of tests for tracing minor faults.

The price of the A.C. Model 313 is £22 10s., and the makers are Messrs. E. K. Cole, Ltd., Southend-on-Sea.

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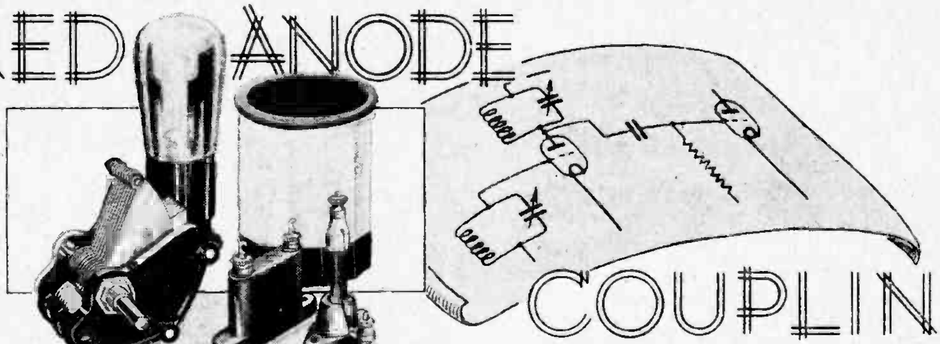
The TUNED ANODE COUPLING



Determination of Voltage Amplification and Selectivity.

By S. O. PEARSON, B.Sc., A.M.I.E.E

ONE of the most widely used intervalve coupling arrangements employed in high-frequency amplifiers is that known as the tuned anode coupling. As the name implies, an inductance or tuning coil is connected in the anode circuit of a valve which is to be coupled to a succeeding one, and this inductance is tuned, by means of a condenser of variable capacity, to the particular frequency being received.

In the first place let us consider the simple circuit of Fig. 1 (a) where a coil of inductance L henrys and high-frequency resistance R ohms is connected in the anode circuit of a three-electrode valve. This coil is tuned to resonance by the condenser C, the assumption being made for the present that there are no stray capacities or incidental sources of power loss.

If a high-frequency alternating voltage whose R.M.S. value is V_g volts is applied to the grid of the valve, a voltage μV_g of equal frequency and in phase with V_g will in effect be set up in the anode circuit, and this voltage tends to drive round the anode circuit an alternating component of current additional to the steady direct current supplied by the high-tension source. The symbol μ represents the amplification factor of the valve under working conditions.

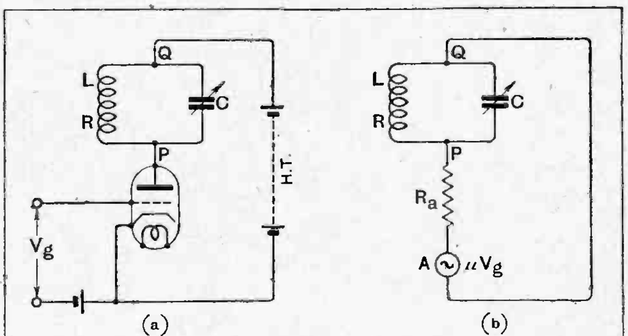


Fig. 1.—At (a) is shown the tuned anode circuit arrangement. LC is tuned to the frequency of the signal voltage V_g applied to the grid of the valve. The A.C. circuit equivalent to the anode circuit is given at (b).

Denoting the internal cathode-to-anode A.C. resistance or differential resistance of the valve by R_a, we can, as far as the A.C. components only are concerned, represent the complete anode circuit by the simplified equivalent circuit shown at (b) in Fig. 1. The voltage μV_g injected into the anode circuit by the action of the grid is represented by a small alternator or generator at A. In the equivalent circuit the high-tension battery is omitted because it is supposed to have a negligibly small internal resistance and therefore has no effect on the alternating components of the current.

Dynamic Resistance.

A glance at Fig. 1 (b) shows that the complete anode circuit consists essentially of a parallel-tuned circuit LC in series with a high-resistance R_a, that of the valve itself. The properties of the parallel-tuned circuit were discussed in some detail by the present writer in *The Wireless World* for January 8th, 15th, and 29th, 1930. The main feature of the parallel-tuned circuit is that it offers the greatest impedance to currents at the frequency to which it is tuned; that is, at the resonant frequency. If L is the inductance of the coil in henrys and C the capacity in farads, the resonant frequency is $f=\frac{1}{2\pi\sqrt{LC}}$ cycles per second. Another important feature of the parallel-tuned circuit is that at the resonant frequency the current passing in at one end of the circuit and out at the other is exactly in phase or in step with the voltage applied to its ends. The significance of this is that, for currents at the frequency of resonance, the tuned circuit virtually behaves like a non-inductive resistance for which the current and voltage are always in phase. For this reason the impedance between the ends of the tuned circuit is referred to as the *dynamic resistance.* Its value in ohms is given by

$$R_d=\frac{L}{CR} \text{ ohms} \quad \ldots\ldots\ldots\ldots \quad (1)$$

where R is the effective high-frequency resistance of the coil. The merits of the tuned circuit can be judged by the value of the dynamic resistance.

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The Tuned Anode Coupling.—

Voltage Amplification.

In view of the fact that the tuned portion of the anode circuit acts like a pure resistance of R_d ohms, it follows that the voltage amplification obtained from the stage can be calculated by exactly the same method as for resistance-capacity coupling, when the effects of stray capacities and the grid-leak resistance are neglected. But in the case of the tuned anode coupling the various stray capacities and losses have totally different effects from those in the case of resistance coupling. The exact nature of these effects will be dealt with as we proceed.

Neglecting incidental capacities and losses for the present, the voltage amplification obtained, that is, the ratio of the alternating voltage established across the tuned circuit to the alternating voltage applied to the grid of the valve in Fig. 1 (a), is given in the usual way by

$$n = \frac{\mu R_d}{R_a + R_d} \quad \ldots\ldots (2)$$

where $R_d = \frac{L}{CR}$ ohms. This, of course, only applies to the particular frequency to which the circuit is tuned.

Numerical Calculation.

As a numerical example, let us suppose that the anode coil has an inductance value of 200 microhenrys, and that it is to be tuned to a frequency of 10^6 cycles per second, corresponding to a wavelength of 300 metres. This calls for a tuning capacity value of $C = 0.000127$ microfarad. Assuming the coil to be a good one, having an effective high-frequency resistance of 10 ohms at 1,000 kilocycles per second, the dynamic resistance of the tuned circuit works out to $R_d = \frac{200}{0.000127 \times 10} =$ 158,000 ohms, from equation (1).

For the time being it will be assumed that we are dealing with an ordinary three-electrode valve of the AC/HL class, having an A.C. resistance of $R_a = 16{,}000$ ohms and an amplification factor of $\mu = 35$ under working conditions. (Screen-grid valves will be considered in due course.) Then from equation (2) the voltage amplification obtained is

$$n = \frac{35 \times 158{,}000}{16{,}000 + 158{,}000} = 31.8 \text{ times.}$$

That is to say, the voltage developed across the tuned circuit, between the points P and Q in Fig. 1, is 31.8 times as great as the voltage applied between the grid and cathode of the valve, referring to alternating components only.

If we assume the tuned grid circuit preceding the valve to have the same constants as the tuned portion of the anode circuit, the last statement means that the oscillating energy in the coil and condenser of the anode circuit is 31.8^2, or just over 1,000 times as great as that in the coil and condenser of the preceding grid circuit. This is a point of great significance regarding the stability of the amplifier—if even a minute fraction of the anode energy can find its way back to the grid circuit the valve will generate continuous oscillations of large amplitude and obliterate the required signal variations. The reasons for and methods of preventing instability will form the subject of a future article.

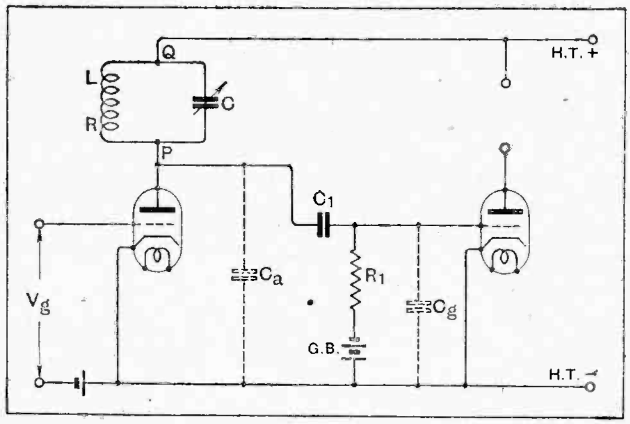

Fig. 2.—Tuned anode coupling between two valves. The imaginary condensers C_a and C_g represent the anode-to-cathode capacity of the first valve and the grid-to-cathode capacity of the second respectively.

Details of the Coupling.

We must now consider what occurs when the valve with the tuned anode circuit is capacity-coupled to a succeeding valve in the manner indicated by Fig. 2. It will be noted that the circuit is the same as that given on page 584 of November 19th issue for resistance-capacity coupling except that the tuned circuit LC is substituted for the simple anode resistance. Thus in exactly the same way the complete circuit between the valves can be represented by the equivalent A.C. circuit shown in Fig. 3 (a). The anode-to-cathode capacity of the first valve and the grid-to-cathode capacity of the second are represented in Figs. 2 and 3 (a) by the imaginary condensers C_a and C_g respectively.

In a normal receiver the coupling condenser C_1 would have a capacity of about 0.0003 mfd. and the grid-leak resistance R_1 would have a value of between 1 and 2 megohms. At a frequency of 1,000 kilocycles per second the coupling condenser would thus have a reactance of $\frac{1}{2\pi f c_1} = 530$ ohms. This reactance is in series with the grid leak R_1 and is obviously quite negligible compared with R_1—it is only about $\frac{1}{1{,}900}$ of a megohm. Consequently, the condenser C_1 in Fig. 3 (a) can be omitted altogether without making any perceptible change as regards the equivalent A.C. circuit, which may therefore be further simplified to the form shown at (b) in Fig. 3, where C_s stands for the sum of the intervalve capacities and any other stray capacities across the circuit, C_a and C_g being in parallel now that C_1 is removed.

It is clearly seen from Fig. 3 (b) that the tuning coil L, the tuning condenser C, the stray capacity C_s, and the grid-leak resistance R_1 are all virtually in parallel in the actual circuit between the valves. The coil L is thus tuned to resonance by the sum of the capacities C and C_s. For a given frequency the capacity $C + C_s$ therefore has a definite value, so that the higher the interelectrode capacities the lower will the setting of C have to be. Consequently in the case of tuned anode coupling

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The Tuned Anode Coupling.—

the valve capacities between anode and cathode and between grid and cathode have no direct effect on the functioning of the tuned circuit. In the case of resistance amplification, these capacities were seen to reduce the amplification as the frequency increased.

Damping Effect of the Grid Leak.

The grid-leak resistance R_1, virtually in parallel with the tuned circuit, results in a lowering of the dynamic resistance of the latter. As pointed out previously, the tuned circuit itself acts like a non-inductive resistance at the resonant frequency, the dynamic resistance being $R_d = \frac{L}{(C+C_s)R}$ ohms in this case. In parallel with it is the grid-leak resistance R_1 ohms, so that if R'_d represents the combined equivalent dynamic resistance, we have $\frac{1}{R'_d} = \frac{1}{R_d} + \frac{1}{R_1}$ or $R'_d = \frac{R_d R_1}{R_d + R_1}$ ohms.

For the numerical values already cited, namely, $L = 200$ microhenrys and $f = 1{,}000$ kilocycles per second, the dynamic resistance of the tuned circuit, apart from the effects of the grid-leak resistance, was found to be 0.158 megohm. With a grid-leak resistance of 1 megohm the effective dynamic resistance is reduced to $R'_d = \frac{0.158 \times 1}{0.158 + 1} = 0.136$ megohm. This is not at all a serious reduction, the voltage amplification being now 31.3, compared with 31.8 calculated without taking into account the effects of the grid leak.

If the second valve is a "power grid" detector the grid leak would be of the order of 0.25 megohm, and this alone would reduce the effective dynamic resistance of the tuned circuit to 96,700 ohms. But a grid detector depends for its action on the flow of grid current during the positive half-waves of the voltage applied to the grid. The average value of the grid current, which is unidirectional, depends on the value of the grid-leak resistance, the value of the grid-bias voltage, and on the strength of the signal voltage. Since the grid current is not directly proportional to the applied alternating voltage, the exact damping effect on the tuned circuit is not easy to calculate. Its damping effect, however, is comparatively large, and in a receiver where a high degree of selectivity is of the first importance, special artifices must be resorted to for reducing the damping to a reasonable level.

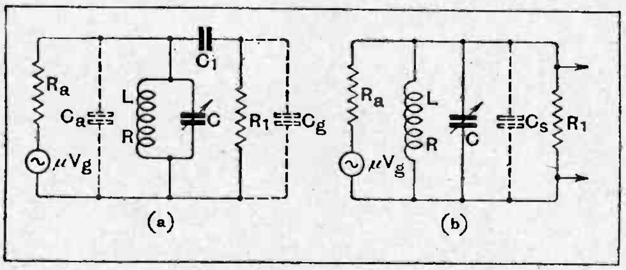

Fig. 3.—A.C. circuits equivalent to the tuned anode coupling of Fig. 2. (a) Equivalent circuit with coupling condenser C_1 included. (b) Simplified equivalent circuit with coupling condenser omitted, its reactance being negligibly small. C_s represents C_a and C_g in parallel.

Selectivity.

The degree of selectivity is usually expressed numerically by a "selectivity number," which is defined as the ratio of the resonant frequency to the change of frequency necessary to reduce the voltage amplification to 10 per cent. of its value at resonance. On page 47 of July 9th, 1930, issue of *The Wireless World* it was shown that for a simple parallel-tuned circuit the selectivity number is given by $\frac{1}{5R}\sqrt{\frac{L}{C}}$ where R is the effective high-frequency resistance of the tuning coil. In the present case, however, we are dealing not with an isolated parallel-tuned circuit, but with one which is connected in series with the A.C. resistance of a valve; and for this reason the above expression for the selectivity will not give a highly accurate result. This is because, at the resonant frequency, the current entering and leaving the tuned circuit is in phase with the voltage across it, whereas at any other frequency they are out of phase.

At a frequency somewhat removed from the resonant value the resistance of the tuned circuit becomes negligibly small compared with the resultant reactance, the current being therefore nearly a quarter of a cycle out of phase with respect to the voltage across that portion of the circuit. Thus, to be strictly accurate, if X is the reactance of the tuned circuit at the non-resonant frequency, the voltage amplification at this frequency would be $\frac{X}{\sqrt{R^2_a + X^2}}$. But if the selectivity is to be calculated on a 10 per cent. basis as defined above, X will be of the order of 10 per cent. of R_a, and therefore X^2 would be only 1 per cent. of R^2_a. Consequently, the value of the calculated amplification would be reduced by less than one-half of 1 per cent. if X^2 were omitted from the calculation altogether, the approximate voltage amplification being simply $\mu X/R_a$. In making this approximation the phase angle has been ignored altogether, and therefore in finding the selectivity number the usual formula $\frac{1}{5R}\sqrt{\frac{L}{C}}$ will give the result to within the same degree of accuracy as the voltage amplification.

If R'_d is the dynamic resistance of the combined circuit at resonance, the equivalent series resistance within the tuning coil can be found from the expression: $R = \frac{(2\pi f L)^2}{R'_d}$ ohms. For instance, if $L = 200\mu H$ and $R'_d = 0.136$ megohm, as previously found for a frequency of 1,000 kilocycles per second, the value of the equivalent series resistance is

$$R = \frac{(2\pi \times 10^6 \times 200 \times 10^{-6})^2}{136{,}000} = 11.6 \text{ ohms.}$$

It will be remembered that the coil alone had a resistance of 10 ohms, so that the presence of the one megohm grid leak has had the effect of increasing the coil resistance by 16 per cent. The selectivity number becomes:—

$$\frac{1}{5R}\sqrt{\frac{L}{C}} = \frac{1}{5 \times 11.6}\sqrt{\frac{200}{0.000127}} = 19.2 \text{ approximately.}$$

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BROADCAST BREVITIES

By Our Special Correspondent.

A Cry from Mühlacker.

The lady whose cry of distress enlivened the Epilogue from London Regional on the last Sunday in 1930 was not in the B.B.C. studio, but was participating in a dramatic programme relayed by Mühlacker. In one sense this is reassuring; in another it is very disconcerting. The lady could quite well have been personifying the vexed spirit of European broadcasting.

o o o o

Sinbad Again.

Mühlacker has become the Old Man of the Sea, sitting on the Savoy Hill Sinbad. Two or three weeks ago the Old Man reduced modulation and Sinbad took a "breather," but the incubus is now heavier than ever.

Great-hearted Graz came along and exchanged wavelengths with London Regional, but only for one wet Tuesday. Next day came a gentle cable from Austria returning our wavelength with thanks.

o o o o

Nonplussed.

The truth is that Mr. Noel Ashbridge and his band of engineers are temporarily at a loss for means of tackling a problem which grows in intensity almost from week to week.

Mühlacker is the immediate source of anxiety, but high-power stations are cropping up in all directions, and it is evident that the existing broadcast band will be severely strained before the end of 1931.

o o o o

A Bigger Band?

It is suggested, I understand, that the medium band might be extended to make possible a bigger kilocycle separation between stations. Unfortunately, the Bureau Internationale de Radiofusion is quite powerless to take such a drastic step, which could only be effected by the International Wireless Conference, meeting next in 1932 at Madrid.

o o o o

Governments and Broadcasting.

Even so, it is highly debatable whether the governments of the world would sanction any further encroachments on the commercial wave channels. The sacrosanct wavelength of 600 metres, devoted since the earliest days to shipping, and, incidentally, to SOS calls, is already approached by several European stations; no expansion in this neighbourhood seems possible.

o o o o

Seconds Out of the Ring.

One method of conquering Mühlacker's interference would be to increase the power of London Regional; but this would probably give birth to a new brood of troubles in the shape of interference with other British stations.

It is not a nice problem. On the whole, I prefer to leave it with Mr. Ashbridge.

o o o o

Those Sunday Programmes.

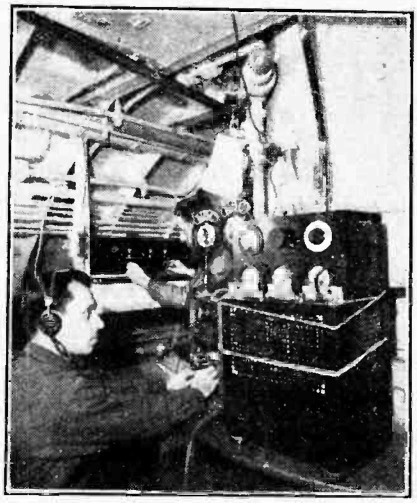
People continue to deplore the Sunday programmes, but I wonder whether the majority are merely voicing a parrot cry. Presumably those who are hungering after entertainment on the Sabbath desire "popular" music. It seems to me that they get it.

Glancing casually at the programmes for the last Sunday in December, I see that the music offered included "Selection from Carmen," "Onaway, Awake," "Siegfrid Idyll," "Maritana," and at least a dozen others which every butcher's boy could whistle on request.

o o o o

Overworking the Microphone.

Welcome to a broadcast orchestra containing the serviceable number of ten performers! Harold Lowe's Hilary Players, who made their first studio appearance in "World for Sale" on Friday last, constitute a miniature orchestra which is to be heard frequently in future B.B.C. programmes.



A SUBMARINE "O.B." Listeners on the American National Broadcasting Company's chain of stations recently enjoyed a description of life on the U.S. submarine O-8, both on and under the water. The picture shows the microphones and short-wave transmitter inside the vessel.

Of late the tendency has been to overload the microphone with tremendous combinations, which may sound magnificent in a public hall, but are far more than adequate for the ordinary man's loud speaker.

o o o o

A Somerset Maugham Tale.

"Mackintosh," the short story by W. Somerset Maugham, has been adopted for broadcasting by Joan Bartlett, and Val Gielgud will act as producer for the microphone performance on the National wavelengths on January 22nd.

o o o o

Broadcast Research in America.

American interest in international relay broadcasting has been one of the highlights of the past year. In a review of the technical side of broadcasting during 1930, Mr. O. B. Hanson, manager of plant operation and engineering of the American National Broadcasting Company, reports that research has been carried out which enables engineers to predict with 90 per cent. accuracy thirty days before a broadcast whether international programmes may be relayed by wireless with reasonable chance of success.

These results are now possible as a result of intensive research on the effect of magnetic disturbances on short-wave transmission.

o o o o

Parabolic Reflector Microphone.

Experiments have also been carried out with the parabolic reflector microphone for broadcasting large symphony orchestras and stage presentations. Mr. Hanson claims that this type of "mike" secures a better balance and a better reproduction of the rich overtones which are usually attenuated when a large hall is used.

The reflector, which has a diameter of three feet, has been found rather bulky by the N.B.C. engineers, and tests are being made to reduce its size without prejudicing the tone quality.

o o o o

A "Soccer" Commentary.

A running commentary by G. F. Allison on the second half of the Arsenal v. Aston Villa match at Highbury on January 10th will be broadcast in the National programme. This match is in the third round of the F.A. Cup Tie.

o o o o

"The Immortal Memory."

Scotland has never had cause to complain that the B.B.C. has neglected her national poet. Each year the birthday of Burns is commemorated in a suitable programme, and 1931 will provide no exception. A Burns programme arranged by Dr. Devon will be broadcast on the National wavelengths on January 24th.

o o o o

Economy at Savoy Hill.

The lessons of the B.B.C.'s 1930 balance-sheet are being taken to heart. During a visit to headquarters last week I was unable to shut my ears to a discussion which was raging apropos an official order to reduce the wattage of lamps in use in the staff offices.

The fiat is the outcome of a fuse in a lighting circuit some days ago, when several rooms and one studio were plunged in darkness during a transmission.

o o o o

What is his Wattage?

So the New Year sees Savoy Hill in a dim religious light. The person who, a few days ago, was working serenely in a 100-watt glare, now makes hay to the tune of 60 watts, whilst the erstwhile 60-watter "doth to the moon complain."

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WIRELESS WORLD LABORATORY TESTS

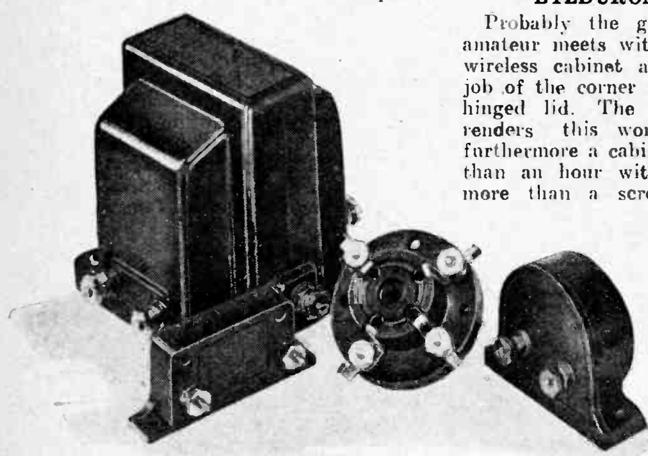
A Review of Manufacturers' Recent Products.

NEW TELSEN COMPONENTS.

The Telsen Electric Co., Ltd., Miller Street, Birmingham, have introduced a range of small components consisting of valve holders, fixed condensers and an H.F. choke. In addition the L.F. transformers, for which they are noted, have been remodelled.

We have tested a 3 to 1 sample of the Radiogrand, and measured its primary inductance when passing D.C. up to 6 mA. With no D.C. flowing the inductance at 50 cycles is 21.5 henrys, which, with 2 mA. passing, becomes 20.7 henrys, and with 4 mA. 19.5 henrys. Increasing the current to 6 mA. brings the inductance down to 17.7 henrys. The D.C. resistance of the winding is 800 ohms.

Best results should be obtained when the transformer is preceded by a valve of the "L" class having a fairly low A.C. resistance. The transformer is housed in a neat brown bakelite case, and provision is made to earth the core. The price is 12s. 6d. This type is available in 5 : 1 and 7 : 1 ratios at the same price.



Some new Telsen components including Radiogrand transformer, valve holder, fixed condenser and miniature H.F. choke.

Where space is strictly limited, the "Ace" model should prove popular; the finish is similar to that of the Radiogrand, and the price is 8s. 6d. in 3 : 1 and 5 : 1 ratios.

Brown bakelite cases are used also for the fixed condensers, which can be mounted upright, or on their side. A 0.0005 mfd. sample was measured, its actual capacity being 0.00072 mfd., while that of a 0.0002 mfd. size was found to be 0.000236 mfd. These are made in sizes up to 0.002 mfd., and the price is 1s. in each case.

Both four- and five-pin type valve holders are made, the contacts being one-piece stampings. The springs contact with the sides of the valve pins, but do not grip them. As the metal is very resilient this arrangement should prove satisfactory. The four-pin model costs 1s., and the five-pin style 1s. 3d.; both are provided with soldering tags and terminals, and are of the non-floating type.

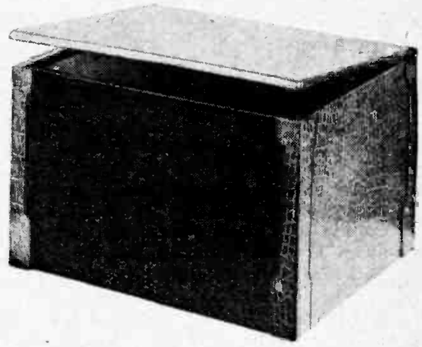
The H.F. choke is very compact, and is enclosed in a brown bakelite moulding. The D.C. resistance is 400 ohms, and its rated inductance 150,000 microhenrys. The price is 2s. 6d.

o o o o

"BYLDURONE" CABINETS.

Probably the greatest difficulties the amateur meets with when constructing a wireless cabinet are in making a neat job of the corner joints and in fitting a hinged lid. The "Byldurone" system renders this work delightfully easy; furthermore a cabinet can be built in less than an hour with the aid of nothing more than a screwdriver and a saw. This is made possible by using specially shaped metal corner pieces, the two for the back corners being fitted with hinges. Thus it is only necessary to cut the four side members, the top and bottom, and assemble them by screwing on the "Byldurone" corner pieces. During the assembly metal screens can be inserted, thus forming a fully screened container. Screens in aluminium, or tin, can be obtained cut to the required size at a reasonable price.

If desired, plywood finished in mahogany, walnut, or metal faced can be supplied to any size, or the cabinet may be covered with such materials as crocodile, lizard, or leather, and the angle pieces finished to match. Plain nickel-plated corner pieces cost



Wireless cabinet constructed with "Byldurone" material which renders this work delightfully easy.

4s. 6d. a set, and oxy-silvered, or covered to match the chosen material, 5s. 6d. the set. The suppliers are Messrs. J. J. Eastick and Sons, Eelex House, 118, Bunhill Row, London, E.C.1.

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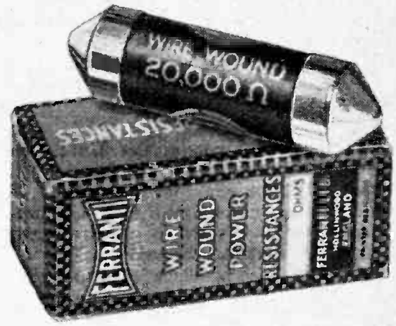
MODIFICATION TO FERRANTI WIRE-WOUND RESISTANCES.

A new style of cartridge container is now fitted to Ferranti anode-feed resistances. This takes the form of a black bakelite tube with nickel end-caps which,



New-type Ferranti wire-wound resistance with bakelite tube.

in addition to enhancing their appearance, renders them practically fireproof. Some recent additions to the range in-

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clude three new sizes, viz., 500 ohms, 650 ohms, and 1,250 ohms, rated to carry 60 mA. in the case of the two first mentioned, and 50 mA. for the last mentioned size. The price is 3s. 9d. each without holder.

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SIFAM CIRCUIT TESTING ADAPTER.

With the aid of this component, any pocket-type voltmeter can be converted into a circuit-testing instrument for continuity tests, etc. It consists of a 1½-volt Siemens cell housed in an ebonite tube, at one end of which is a spring contact socket for fitting over the spike terminal of the voltmeter. The opposite end is provided with a flexible lead and terminal point.

Normally, the unit is sent out with the socket positive and the flexible lead negative, but the battery contact washers inside the tube are so formed that the battery can be reversed to suit meters with negative spike terminals.

The unit is entirely British made, and is sold by the Sifam Electrical Instrument Co., Ltd., Bush House, Aldwych, London, W.C.2. The price is 2s. 6d.

Sifam circuit testing unit for attachment to pocket voltmeters.

oooo

HIGH-GRADE AERIAL WIRE.

In the past the most popular material for outdoor aerials has been 7/22 copper or phosphor-bronze wire. Where this wire is bare the effect as far as H.F. resistance is concerned is little better than solid wire of the same cross-sectional area.

With the object of reducing H.F. resistance and also improving the flexibility of the wire, the Saxon Radio Co., Henry Street, Blackpool, have introduced a 20-strand enamelled wire in which the individual strands are insulated. In the specimen submitted the strands are 30 S.W.G., and the total diameter of the wire is approximately $\frac{3}{32}$in. We understand, however, that 28 S.W.G. is to be standardised in future, which will bring the diameter approximately up to that of standard 7/22 wire.

The 20-strand wire is certainly a pleasure to manipulate, and should materially assist in maintaining aerial efficiency owing to the resistance to oxidation afforded by the enamel coating. Care should be taken, however, to see that each strand is properly tinned before making the joint to the lead-in tube.

The wire is packed in cartons containing 100ft. lengths, and the price is 5s. 6d.

Saxon 20-strand aerial wire.

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PIFCO "ALL-IN-ONE" METER.

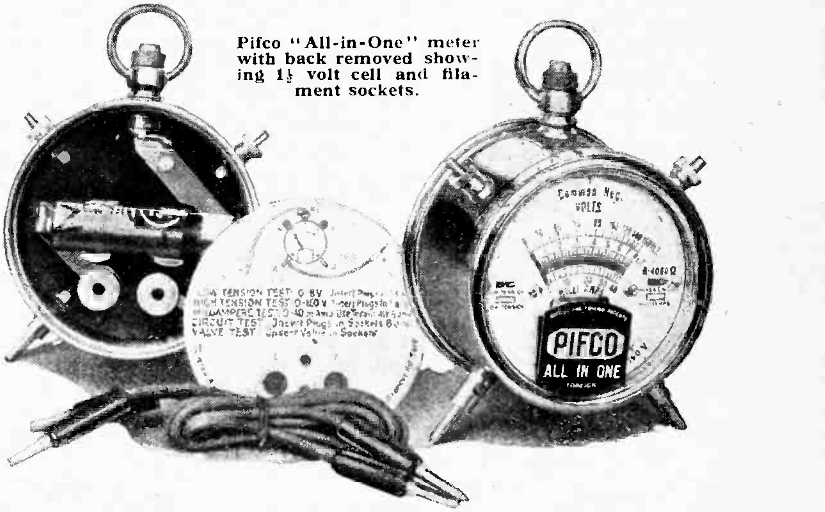
A full description of the scope of this little instrument appeared in the Manchester Show Report. In addition to the usual H.T., L.T., and milliampere ranges usually available in pocket voltmeters, the Pifco meter can be used for general continuity tests and also for testing valve filaments for breakage. For this purpose a 1½-volt cell is incorporated in the instrument, and the back panel is provided with sockets for the valve test. The instrument will accommodate the latest type of five-pin A.C. valves.

The low-tension and high-tension ranges are 0 to 8 and 0 to 160 volts respectively. The current taken for a full-scale deflection on the latter range is 40 mA., which is rather high for testing small-capacity H.T. batteries, but the readings should be reasonably accurate when the battery is new and the internal resistance low. The current scale is 0-40 mA., and tests against a standard instrument with the Pifco meter in both horizontal and vertical positions gave the following results:—

Standard. (mA).	Pifco. Horiz.	Pifco. Vert.
10	11.0	11.5
15	15.0	16.0
20	20	20
25	24	24.5
30	28	29
35	33.5	34
40	38	38.5

The width of the needle is about 1-40th of the full scale deflection on the current range, so that the error is within the accuracy of reading of the meter. The accuracy of the voltage ranges is of the same order.

The meter is marketed by Pifco, Ltd., Pifco House, High Street, Manchester, and the price is 12s. 6d. Replacement cells for the continuity tests are available, the price being 3d.



Pifco "All-in-One" meter with back removed showing 1½ volt cell and filament sockets.

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New Branch Office.

H. Clarke and Co. (Manchester), Ltd., Atlas Works, Eastnor Street, Old Trafford, Manchester, have opened a London office at 60, Chandos Street, Strand, London, W.C.2. The telephone number is Temple Bar 7130.

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WIRELESS WORLD FOUR.
A Correction.

In the description of the Wireless World Four, Battery Model, the voltage applied to the anodes of the H.F. valves should have been stated on page 673 as 155, and not 120. This potential provides the correct working condition for the valves, and is produced by a voltage drop of 25 volts through 10,000 ohms as results with the component values specified.

In the right-hand column on page 644 it is stated that a current of 25 mA. passes through a resistance of 40 ohms, giving a bias of 1 volt. This is quite correct, but it should have been mention that this current is made up of the anode and screen current of the two H.F. stages, the current taken by the screen potentiometer and also the detector.

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Letters to the Editor.

The Editor does not hold himself responsible for the opinions of his correspondents.

Correspondence should be addressed to the Editor, "The Wireless World," Dorset House, Tudor Street, E.C.4, and must be accompanied by the writer's name and address.

REACTION AND THE BAND-PASS FILTER.

Sir,—In his letter, published in last week's issue, Mr. Barclay criticises formula (2) in my article "Reaction and the Band-pass Filter," and suggests a simpler and more accurate expression.

While it is true that Mr. Barclay's formula is accurate under all conditions, and that mine is correct only when R^2 is small compared with $1/\omega^2C^2_m$, I am of the opinion that my expression has advantages under the particular circumstances. Its derivation from the standard formulæ can be seen at a glance by the non-mathematical; and this is valuable, since it renders those factors affecting band-width and efficiency readily intelligible.

It is interesting to note that Mr. Barclay's formula can be obtained directly from mine by making the above assumption a second time, namely, that R is very small. It is well known that at the peak frequencies

$$(\omega L - 1/\omega C) = \sqrt{R^2 + 1/\omega^2 C^2_m} = 1/\omega C_m$$

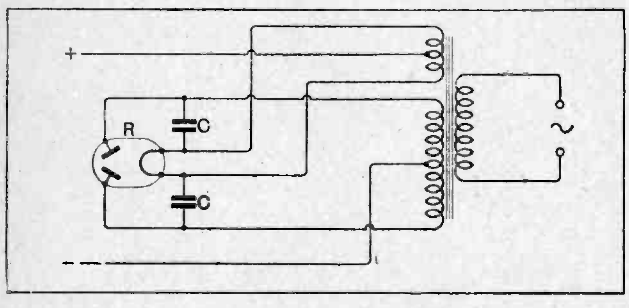
when R is small. Substituting this for $(\omega L - 1/\omega C)$ in my formula, we get $e/E = 1/2R\omega C$.

I would like to make it clear that this question of formulæ does not in the least affect the arguments in my article, since the two expressions have the same value when R is zero or closely approaches zero. The question really arises when it is desired to calculate the magnification at the peak frequencies in a practical case where reaction is not used. Unfortunately, it is then necessary to use the full standard expression for most work, since the magnification at resonance and at the peak frequencies alone is insufficient for design purposes. The important point is usually the shape of the resonance curve between these frequencies. W. T. COCKING.

Southgate, N.14.

HUM IN A.C. MAINS RECEIVERS.

Sir,—It is perhaps not generally recognised that hum in an A.C. all-mains receiver may arise through the generation of H.F. currents in the power rectifier valve of the H.T. eliminator. Smoothing arrangements for anode current supply are usually constructed on the basis that only audio-frequency currents are to be eliminated, but this is only partly correct. High-frequency currents generated by the power rectifier may be very serious in their effects, for they are modulated at audio frequencies (e.g., 50 or 100 ~), and, it seems, they may be radiated and picked up by the detector valve of the receiver, where they are rectified and amplified, the resulting L.F. hum being further amplified in subsequent stages of the receiver.



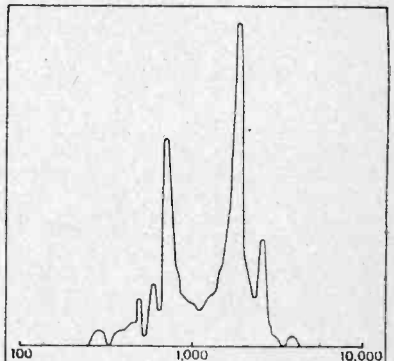
Thus, in a receiver of the "Power Pentode Two" type (cf. *The Wireless World*, May 7, 1930), constructed by the writer, slight hum was found to be present in the anode circuit of the power grid detector (Mazda AC/HL). This hum was found to be diminished, but not entirely eliminated, by substituting lead-sheathed twin wire for the ordinary flex used as leads from the transformer to the heater of the detector, the lead sheath being earthed. The trouble was finally and completely overcome, however, by connecting small condensers (0.01 mfds.) between the anodes and filament of the power rectifier valve (Osram U5); this effectively isolates the H.F. currents from the receiver.[1] The writer owes this remedy to a recently issued patent (Philips' Gloeilampenfabrieken; English patent 336047), in which the use is protected of a "rectifying arrangement suitable for supplying anode current to thermionic valves in wireless sets, the production of high-frequency oscillations being avoided by connecting condensers C between the anodes and cathode of the rectifier R. . . ."

"IDEAS."

[[1] This method of hum elimination has already been referred to in the description of the Burndept Radiogramophone (*The Wireless World*, March 26, 1930, p. 335).—ED.]

THE EAR AND COMPLEX SOUNDS.

Sir,—It is an undeniable fact that a horn-type loud speaker having a frequency response as illustrated will reproduce the note of, let us say, a violin, so that, although distorted, it is still recognisable as a violin, or a human voice in such a way that for all the distortion the speaker can still be identified. Now if we examine a chart of the overtones of a violin and compare them with, say, an oboe, we find that the differences in amplitude of the various overtones of the two instruments are not greater than the changes in amplitude that a speaker of this type would produce in one of them. But, however poor the speaker may be, the violin, though it may have acquired a nasty quality, is still recognisable as a violin. There is no confusion between the violin and the oboe. In the case of human voices the differences in the intensity of the overtones would probably be even less, but you rarely confuse one man's voice with another's. We can recognise the speaker with the ordinary desk telephone, with a response curve far worse.



Again, a good moving-coil speaker with a response curve that is all but flat and an amplifier that is above suspicion still falls short of reality.

I have a theory of the way in which the ear deals with a complex sound which will explain these facts. Briefly a sound wave is a function of four variables, frequency, amplitude, phase and decrement. The analysis into fundamental and overtones by means of resonators (a Fourier series) is an analysis in terms of frequency and amplitude only. The complex wave may be resolved into other simpler components by other methods. It may be resolved into components involving frequency amplitude and decrement, that is to say, into *damped* wave trains. At first sight it will seem ridiculous to say that a continuous wave train can be resolved into damped wave trains, but it certainly can, and I can put up a good argument for the idea that that is how the ear makes its analysis. My theory will show how a loud speaker with an almost perfect frequency curve may still give distortion, and how a loud speaker, with a curve as foul as the one illustrated, may, if it passes a reasonable band of frequencies, still give a reproduction that is satisfying to the ear. To develop this theory fully would require a good deal of space and several diagrams. D. F. VINCENT, B.Sc.

Reading.

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READERS' PROBLEMS

Replies to Readers' Questions of General Interest.

Technical enquiries addressed to our Information Department are used as the basis of the replies which we publish in these pages, a selection being made from amongst those questions which are of general interest.

Screened Wiring.

With the object of obtaining complete immunity from interaction, I have been thinking of enclosing the internal wiring of my receiver in earthed metal tubes. Is it correct to assume that the plate and grid leads should not be screened in this way?

Frankly, we cannot see any great advantage in this method of construction. Surely it would be easier to use lead-covered wire for all low-potential leads if desired, or probably better still, to adopt the principles of "Scientific Wiring" as described in our issue of April 25th, 1929? Wires at high oscillating potential (in grid and plate circuits) should certainly not be screened if this can be avoided; the only possible exception is with regard to the anode leads of S.G. valves. Even in this case care should be taken to allow a reasonable spacing between the wire and the metal tubes.

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Power Grid Detection and Resistance Coupling.

In cases where a fairly small L.F. output is adequate, would it not be possible to use resistance coupling between a power grid detector and an output valve?

Yes, this plan would be satisfactory, but it would suffer from the drawback that a fairly high H.T. voltage would be needed to compensate for loss in the coupling resistance. On the other hand, there is admittedly the compensating factor that, due to low overall magnification, a minimum of decoupling would be necessary, and so there would be little need to allow for any additional sacrifice of anode voltage.

○○○○

Battery Resistance.

My receiver has recently developed L.F. oscillation, which I am inclined to ascribe to increasing resistance of the H.T. battery. However, a decrease of less than 10 per cent. in voltage is shown when the battery is checked by means of a high-resistance voltmeter, so it seems hardly likely that the cells can be at fault. What do you think?

Your voltage reading was probably taken when the cells were on "open circuit" so that it is quite likely that their internal resistance may be sufficient to provoke self-oscillation in the L.F. amplifier. We suggest that a further measurement should be made while the battery is delivering current to the set.

Battery-to-A.C. Conversion.

I am about to fit indirectly-heated valves in my H.F.-det-L.F. receiver (with anode bend detection) and should like, if possible, to retain the existing bias control potentiometer for the detector. Battery bias is to be retained, but as there will be no L.T. battery, I cannot see how the potentiometer will be connected; will you please advise me?

We would point out that this seems a case where automatic bias would be an advantage; further, it is doubtful whether a potentiometer is strictly necessary for controlling the detector grid voltage of an A.C. valve, as sufficiently close adjustment could probably be made by the use of a tapped bias battery.

However, as you definitely say that you wish to use a potentiometer, we give herewith a circuit diagram (Fig. 1) showing how it can be connected. A tapped battery will be used for coarse adjustment, final regulation being made by means of the potentiometer. To prevent unnecessary drain on the dry cells, a switch must be included in the potentiometer circuit; it may be convenient to combine this with the main on-off switch.

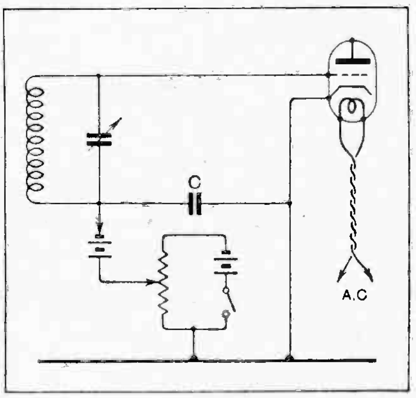

Fig. 1.—Continuous control of grid voltage for an A.C. valve.

○○○○

One or Two L.F. Stages?

It is noticed that the majority of modern A.C. mains receivers include but a single L.F. stage; is there any real reason why two stages should not be used when exceptionally high magnification is desired?

Modern valves—particularly those of the A.C.-fed variety—are so efficient that a single stage is almost always adequate, and it is generally agreed that if greater magnification is desired it should be introduced before the process of detection. Of course, the large output obtainable from the present-day detector has an important bearing on the matter.

When two L.F. stages are used amplification is generally altogether excessive, and a good deal of the available gain has to be thrown away in one or both stages.

○○○○

Compensation for High Note Loss.

I have come to the conclusion that undue "cutting" of side-bands is taking place in the tuned circuits of my receiver; would it be likely that the substitution of a pentode for the present triode output valve would tend to compensate for this loss?

Yes; this is a very real advantage of the pentode valve. If you use a simple form of tone control, consisting of a resistance and condenser connected in series across the output choke, it will be possible to introduce compensation to almost any desired extent.

○○○○

Effect of Temperature Rise.

My 2 H.F.-det.-L.F. A.C.-mains receiver functions quite well when first switched on, but after a time—generally about a quarter of an hour—signals fail altogether. Occasionally they can be restored by tapping the side of the cabinet, but the same trouble generally asserts itself again after a few moments.

Thorough tests have been made with the help of a dry battery and galvanometer, but each individual circuit appears to be perfect as regards continuity, and I am certain that there is no short-circuit. Can you make any suggestion?

This fault may, we think, be attributable to a rise in temperature which will take place after the valves have been worked some little time. Probably it will eventually be traced to one of the valves itself: it may be that an electrode has become sufficiently misplaced to cause an actual short-circuit when expansion takes place, but it is also possible that a faulty contact may develop between one of the valve pins and its socket through the same cause.

The fault will be traced most easily by a process of elimination.

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Anti-fading Device.

With regard to the anti-fading device suggested in the "Correspondence" section of your issue for December 10th, will you please show me how this arrangement may be applied to an H.F.-det.-L.F. receiver, of which the coupling transformer is wound on the lines suggested in your journal, with a reaction coil placed between the medium- and long-wave sections.

Will it be necessary to alter the reaction coil beyond the addition of a centre tap?

A suitable method of connection is shown in Fig. 2. As one half of the reaction coil only will be effective for either positive or negative reaction, it will be necessary that this coil should have approximately twice the normal number of turns.

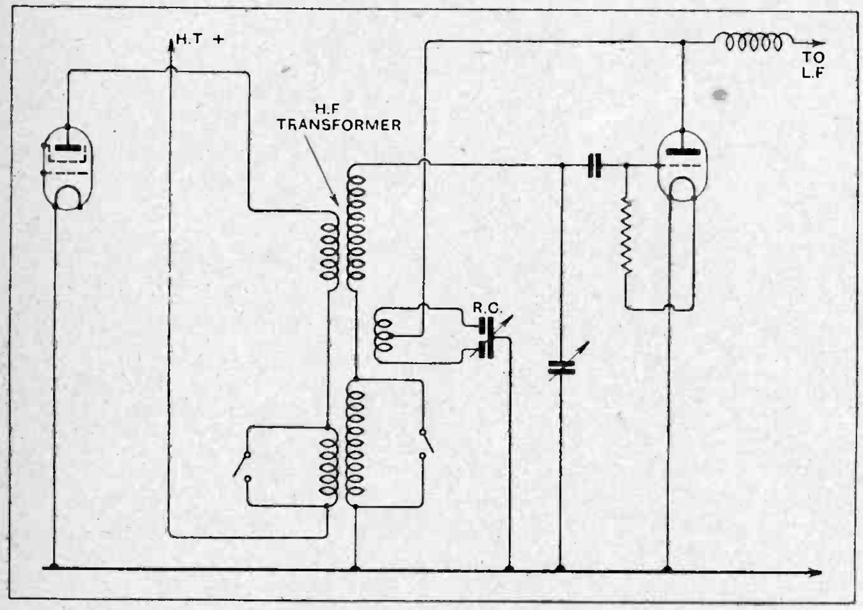

Fig. 2.—Optional positive or negative reaction applied to an intervalve coupling by means of a differential condenser. The use of negative reaction tends to offset the effects of fading.

oooo

Auto-transformer Coupling.

In spite of the fact that my receiver includes a two-circuit tuner, reception of the London Regional transmission has lately been marred by interference. Will you please suggest how I can improve the selectivity of the tuner, which is of the type described in your pages some time ago, in which a few turns in the secondary circuit are common to the tuned aerial circuit.

It seems probable that the coupling between your primary and secondary circuits is fixed; if so, it will inevitably have been chosen on a compromise basis, and may be rather too "close" for maximum selectivity under your own receiving conditions. Accordingly, we advise you to move the connections from the low-potential end of the aerial coil nearer to the earthed end of the secondary inductance. It is likely that two or three common turns will provide a suitable coupling.

oooo

Weak Oscillations.

It is noticed that the sensitivity of my "Band-Pass Superheterodyne" falls off noticeably at the upper end of the medium waveband—at about 500 metres. The difference between its performance at this end of the tuning scale and its normal behaviour is so marked that I am inclined to think that something is wrong; can you suggest where a fault likely to have this effect will be found?

It is natural enough that the effectiveness of the signal-frequency amplifier should fall off at the upper end of the medium waveband, but the effects of this falling off should be less marked in a superheterodyne than in a normal type of receiver with H.F. amplification. We think it probable that your oscillator valve may be responsible; it is probably oscillating very feebly at this end of the wavelength scale, and you should try the effect of increasing its anode voltage, or substituting another valve.

oooo

Checking the H.F. Amplifier.

The sensitivity of my recently constructed receiver is most disappointing, and I think that the H.F. stage is not "pulling its weight." Is it possible to check this point in a simple manner?

A simple, but nevertheless effective, test of the H.F. amplifier may be made by detaching the anode lead of the S.G. valve and joining this wire to the aerial through a condenser of 0.0001 or 0.0002 mfd. If there is no appreciable diminution of signal strength when this change has been made, your assumption will almost certainly be correct.

Unearthed Screening Box.

With reference to the published description of the "Band-Pass Superheterodyne," I notice that no earth connection is shown for the large aluminium screening box in which the H.F. amplifying components and the first detector are mounted; will you please tell me if this is correct?

This screening box is not earthed directly, but is connected to the negative bus-bar through the condenser C_5. By adopting this plan the necessity for insulating the H.F. tuning condenser spindle is obviated.

oooo

Filter Circuit Screening.

It seems to me that it should be unnecessary to screen both the filter coils of a receiver with band-pass tuning but without H.F. amplification; if one of the inductances is totally enclosed, it is obvious that inter-action cannot take place. Can you confirm this?

Your statement is correct enough as far as it goes, but in practice the tuning of coupled filter circuits is always done by a ganged condenser; if one of the coils is unscreened, practical difficulties are likely to arise in balancing their inductance values.

FOREIGN BROADCAST GUIDE.

MÜHLACKER

(Germany).

Geographical position: 48° 58′ N. 8° 52′ E.

Approximate air line from London: 454 miles.

Wavelength: 360.1 m.* Frequency: 833 kc. Power: 75 kw.

Time: Central European (one hour in advance of G.M.T.).

Standard Daily Transmissions.

05.15, G.M.T., weather forecast; morning physical exercises: 09.00, gramophone records; sacred service (Sun.); 11.15, concert or relay; 12.30, 15.00, concert; 17.00, talks; 19.00, main evening entertainment; 21.00, news, weather forecast, outside broadcast, dance music, etc.

Frequently exchanges programmes with Frankfurt-am-Main during the day.

Male announcer. Opening call: *Achtung! Hier Suedfunk, Stuttgart und Freiburg-im-Breisgau.*

Interval signal:

followed by *Achtung! Suedfunk.*

Closes down with National Anthem (*Deutschlandslied*) followed by usual German good-night greetings.

Relay: Freiburg-im-Breisgau, 570 m., 527 kcm., 0.3 kw.

*** Liable to alteration later.**

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The Wireless World

AND RADIO REVIEW
(18th Year of Publication)

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IN the Correspondence columns of this issue we include two letters on the subject of relay services—one from the General Post Office and another from Capt. P. P. Eckersley, lately Chief Engineer of the B.B.C.

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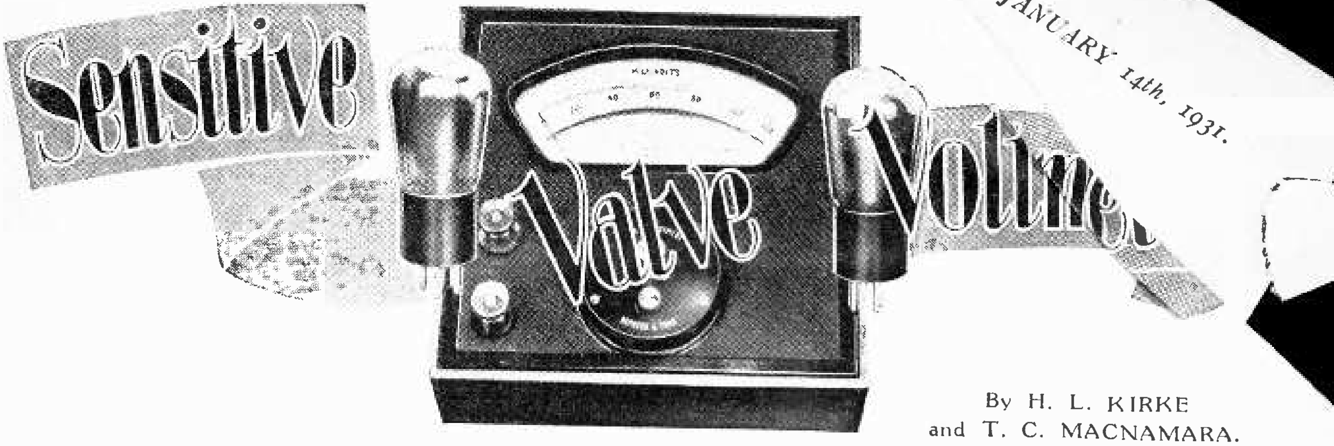

Sensitive Valve Voltmeter

By H. L. KIRKE
and T. C. MACNAMARA.

Measuring Peak Voltage and Percentage Modulation.

Of the various instruments used in measuring peak voltage, the slide-back valve voltmeter is probably one of the best known. Designed according to conventional practice it has, however, certain disadvantages, and it is the purpose of this article to describe a more sensitive type and to show its applications.

The original slide-back meter consists essentially of a rectifier, a biasing voltage, and a sensitive galvanometer, the rectifier being such that in one direction it passes no current at all. The simplest example is that of a diode rectifier having a circuit arrangement as shown in Fig. 1. The operation is as follows: The terminals *a* and *b* are short-circuited, and the slider of the biasing battery potential divider adjusted until current as indicated by the galvanometer G ceases. In ordinary cases this will occur when the terminal *b* is at the same potential as the negative end of the filament; if the positive end of the biasing battery is connected to the negative end of the filament then the slider will be at the end of its travel, and the voltmeter will read zero. The terminals *a, b,* are then unshorted and connected to the source of voltage to be measured. It is necessary to arrange that there is a continuous conducting circuit between the terminals, otherwise no direct current can pass. The slider is then again adjusted until current ceases. For this adjustment the peak voltage of the signal just balances the D.C. voltage between the slider and filament when the anode of the valve reaches zero potential relative to the filament once per cycle, but never becomes positive; if this occurred current would be indicated in the galvanometer.

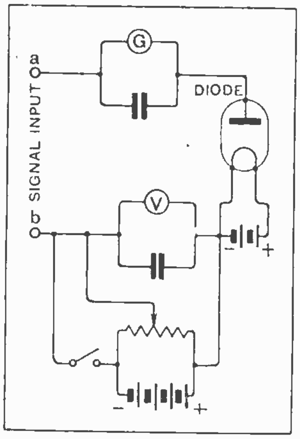

Fig. 1.—The simplest slide-back valve voltmeter, using a diode rectifier.

When the input circuit to the slide-back meter is a tuned circuit of fairly high dynamic resistance its tuning will be affected somewhat by any current taken by the valve, and it will be necessary to retune slightly as the slider is moved negative. The key shown in Fig. 1 is an aid to accurate operation. It short-circuits the negative end of the potential divider and applies the full negative voltage of the biasing battery to the anode. This makes it easy to detect a minute deflection of the galvanometer needle when the slide-back voltage is almost equal to the peak signal voltage. When an easily adjusted potential divider is used the key is not necessary.

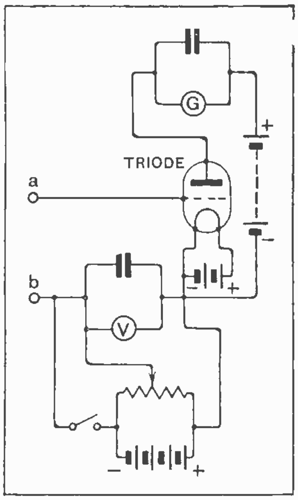

Fig. 2.—Triode valve voltmeter, with provision for slide - back measurement. For low voltages it is insensitive and rather inaccurate.

A modification of this simple device is the use of a three-electrode valve. The signal is impressed on the grid circuit, the anode circuit comprising the usual H.T. battery and a galvanometer. The biasing battery is in the grid circuit, and is adjusted for zero anode current. With this method a zero adjustment is always necessary, i.e., with terminals *a* and *b* short-circuited the grid bias has to be adjusted negative until the anode current ceases. Call this voltage V_1. The signal is then applied to terminals *a* and *b* and the bias again adjusted. Call this voltage V_2. Then the signal voltage will be $V_1 - V_2$. The circuit is shown in Fig. 2.

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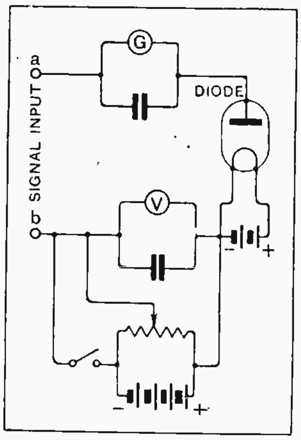

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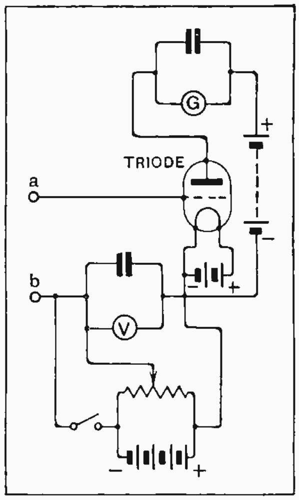

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Sensitive Valve Voltmeter.—

high resistance is included in the slide-back anode circuit, and its terminals connected to the grid and filament of the D.C. amplifier. The connections of such

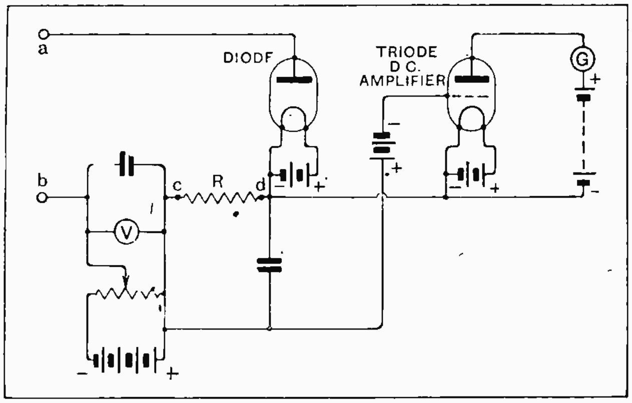

Fig. 3 (a).—Increased sensitivity is obtained by using a D.C. amplifier after the slide-back valve.

circuits are shown in Figs. 3 (*a*) and 3 (*b*). In any such device the higher the voltage to be measured the greater the accuracy.

The device can be used for measurements at high or low frequency. When the D.C. amplifier method is used a change in reading in the meter in the anode circuit indicates that the peak voltage of the signal exceeds that of the biasing battery when the diode rectifier is used, and for the triode when the signal voltage is equal to the difference between the two readings of bias voltage. For normal connection, as shown in the diagrams, the anode current will decrease where the peak signal voltage exceeds the bias voltage. It is preferable to use a valve with high amplification factor. The grid of the D.C. amplifier should be made slightly negative to reduce grid current to zero.

The device may be used as an indication of percentage modulation in a transmitting circuit. The procedure is to arrange that a pick-up circuit is coupled to the transmitter, and adjusted until a convenient value of carrier

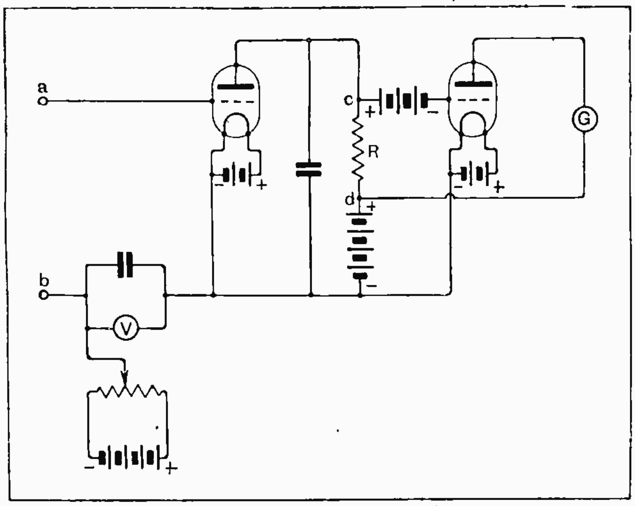

Fig. 3 (b).—A valve voltmeter with two triodes—the first acting as a rectifier, the second as a D.C. amplifier.

peak voltage is obtained. The circuit may be tuned, but not too sharply, otherwise sidebands will be cut. The higher the value of carrier voltage the greater will be the accuracy of the measurement.

The carrier peak voltage is then measured; call this voltage V_c. Then let the carrier be modulated and the peak voltage of the modulated carrier measured; call this voltage V_m. Then if k is the coefficient of modulation (peak value) $V_m = V_c\,(1 + k)$ and $k = \frac{V_m}{V_c} - 1$.

The instrument may be used on service on a broadcast or other modulated transmitter to indicate when the coefficient of modulation exceeds a certain predetermined amount, as follows:—

Supposing it is desired to indicate when the modulation exceeds 70 per cent. The carrier peak voltage is measured. This is V_m. The biasing voltage is then set to a value slightly less than $V_m\,(1 + k)$. When the peak signal voltage exceeds $1 + k$ the change in anode current in the D.C. amplifier will cause the meter needle to flick downwards.

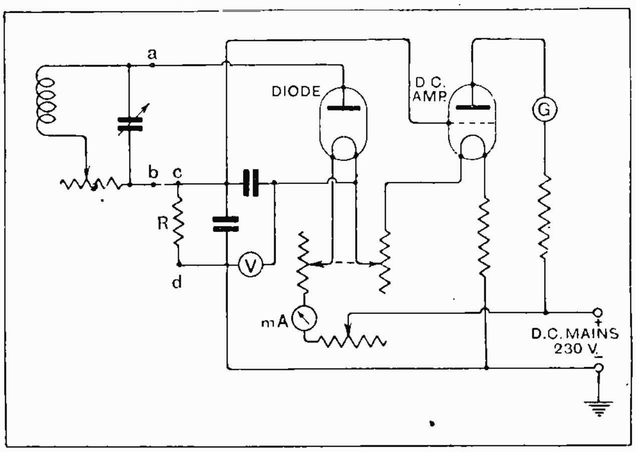

Fig. 4.—A valve voltmeter with diode and D.C. amplifier as used in the Brookmans Park transmitter to check the percentage modulation.

The readings are not strictly accurate since the effect is a ballistic one, the peaks of the signal charging the condenser by-passing R. The charge and consequently the voltage developed and applied to the grid of the D.C. amplifier, will depend on the amplitude and number of the peaks. Nevertheless, the method affords a useful and practical way of modulation indication.

The device is in use at the Brookmans Park transmitter of the B.B.C., and is operated from the 230-volt D.C. mains. The circuit is shown in Fig. 4. A pair of resistances with the sliders mechanically coupled form part of the series circuit containing the two valve filaments H.210s), the diode being produced by strapping across the grid and anode. The resistances are connected so that when one is decreasing the other is increasing. The effect is to slide the valve filament along in potential with regard to point *d* (Fig. 4), while keeping the filament current, H.T. and grid bias to the D.C. amplifier constant. A variable resistance is provided in series with the tuned coupling circuit. This serves as an adjustment for amplitude, being handier than an

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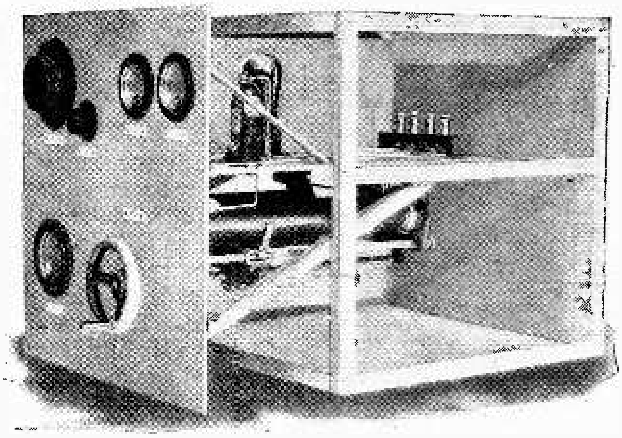
Sensitive Valve Voltmeter.—
adjustment of coupling. The arrangement is coupled to the output circuit of the transmitter.

The illustration shows the actual instrument. An indicating milliammeter, voltmeter, and filament circuit milliammeter are provided on the instrument itself, while a second indicating milliammeter, connected in series with the one on the instrument, is provided on the control desk.

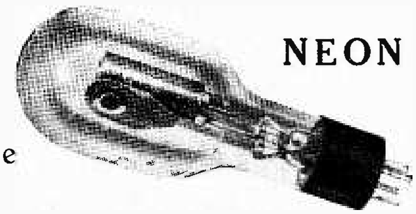


The slide-back peak valve voltmeter described in the article.

The actual instrument is mounted on a metal frame, one arm of the mechanically coupled differential resistance being clearly visible. The other arm is behind the one discernible. As the valves in use are each 2 volt 0.1 amp. filaments in series and across the 230-volt mains, the differential resistance must be critically variable and capable of carrying 0.1 amp., which necessitates quite a heavy construction.

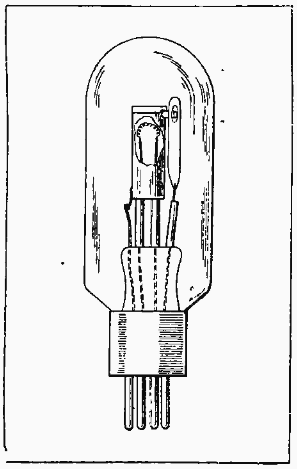
On the panel front is a variable condenser, which, together with a suitable inductance coil tunes the input circuit to the carrier frequency at which measurements are to be taken. In addition there is the variable resistance control in the tuned circuit slightly to the right and below the tuning condenser; an indicating meter is provided in the anode circuit of the amplifying valve reading 0-1.5 mA., together with a filament current meter reading to 250 mA. and a voltmeter. The anode resistance of 100,000 ohms in the amplifying valve is that necessary to apply the working voltage for an H210, to give an anode current of approximately 1 mA. This anode resistance is shown just in front of the amplifying valve on the top side of the baseboard. To enable the meter to be read at a distance from the instrument a series extension is taken from the anode current meter.

NEW NEON LAMP.



Modulation Over a Wide Range of Frequencies.

An interesting invention known as the Lichtspritz neon lamp, which has lately been developed, is designed to provide a light source of high intrinsic brilliance which can be modulated over a wide range of frequency. The light is obtained from a low-voltage neon glow discharge which, by special electrode construction, is concentrated into a very small area.

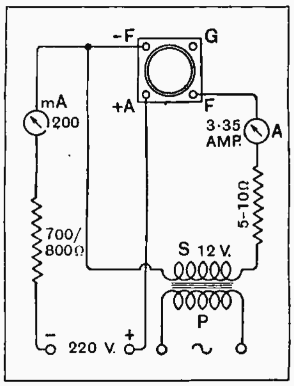


The Lichtspritz Neon lamp.

The electrodes include a hot cathode, heated by a current of 2-3 amperes and totally enclosed within a metal cylinder $1\frac{1}{2}$in. long, $\frac{1}{2}$in. diameter. The only outlet is through a small metal side tube about $\frac{1}{4}$in. long, one end being fixed to the cylinder so that the tube is at right angles to the axis. Opposite the end of this tube is the anode, a metal plate having a hole in it concentric with the short tube, but of much greater diameter.

The mode of operation is as follows: the cathode, when heated, emits a stream of electrons which passes out through the side tube towards the anode, ionising the neon on leaving the opening.

It is necessary, in the first place, to prevent the ordinary neon discharge taking place between the anode and the cylinder. Application of a positive potential to the cylinder prevents this, and also enables the electrons to acquire velocity before they emerge from the side tube, thus aiding the formation of the point discharge.



Method of modulating the light source.

Once the point discharge has formed in the mouth of the side tube, the potential of the cylinder adjusts itself to the correct value, being of the order of 30 volts. In the case of a sample tube with which measurements were made, the discharge current between anode and filament was 200 milliamperes, and the potential drop was then about 60 volts.

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Cortlandt Street New York

An Astonishing Radio Market and "Junk" Heap.

By A. DINSDALE.

JUST ten years ago, at the time of writing, radio broadcasting burst upon an astounded world. As I am writing from New York, you will readily understand that "the world" does not extend beyond the frontiers of God's Own Country. With that clear in your minds, you can sit back comfortably and read this article, quite prepared for anything that may come along. The things to be described here just could not happen anywhere else, so you need not worry—or sigh wistfully, according to whether you are a seller or a buyer of radio goods.

Those of you with long memories will remember how radio began in England. Like me, you will undoubtedly shudder as you recollect those weird and wonderful wireless sets which were hastily put on the market at fantastic prices. Exactly the same thing had happened previously in the United States. But Cortlandt Street was already on the job, providing a financial way out for the wise who knew exactly what they wanted and how to choose it, and sad disillusionment for the uninitiated seekers after bargains.

I should, perhaps, explain that New York's down-town financial district, with its skyscrapers, occupies what might be described as the central or inland portion of the southern tip of Manhattan Island. Extending east and west from the financial district to the East and Hudson Rivers are various unbeautiful streets of varying widths and degrees of prosperity. Ten years ago Cortlandt Street, although wide at its western end where it abuts on to the docks of Hudson River, was more or less derelict. Its old five-storey buildings were squalid tenements, some of the street-level apartments of which had been turned into even more squalid shops, the occupants of which traded in all sorts of dubious junk, and were here to-day and gone to-morrow.

Immediately after the war small traders in Government surplus stores, including wireless equipment, were attracted to the area by reason of the low rents, and because it was possible to clear out at a moment's notice. The wireless amateurs of the day soon learned where to go to pick up odds and ends of more or less good quality apparatus and components at cheap

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Cortlandt Street, New York.—

prices. In most cases the apparatus purchased had to be altered in some way to suit the purchaser's requirements, but that did not matter, for he was an expert. And why pay fantastic prices for allegedly suitable apparatus when a keen eye for a bargain, plus a little ingenuity, resulted in something which really was good, and at a reasonable figure?

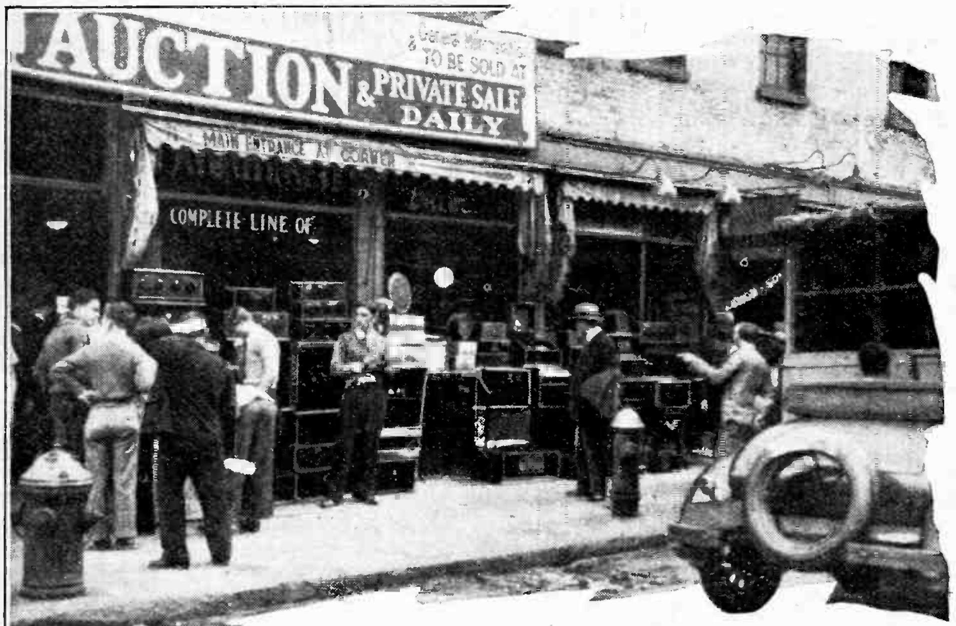
And then the deluge, i.e., broadcasting, started. More cut-rate (I nearly wrote cut-throat) stores sprang up like mushrooms. You remember how it was? Smith got interested in this new-fangled wireless, but hadn't the slightest idea what it was all about. Then he remembered that friend Brown had been one of these wireless fiends for years; he'd go and consult him. Brown, with a lofty scorn for the just-marketed, ready-made sets, confidentially offered to make Smith a "real" set at half the price. Cortlandt Street thrived—and so did Brown. To-day Brown is a prosperous radio manufacturer or dealer; Cortlandt Street is the centre of an important industry; and Smith is still the goat.

As time went on the Cortlandt Street market increased in volume and in the variety of its stock-in-trade. Every new craze was eagerly seized upon and ridden to death—low-loss coils and condensers, patent aerials that looked like maps or pictures or anything else on earth except an aerial (some worked and some didn't), all sorts of weird components specially designed for incorporation in the latest set by some publication's star designer (commission on sales to the designer and/or radio editor), etc. And through it all the market had this in common with a pawnshop; if you knew exactly what you wanted, and could recognise it when you saw it, you could pick up marvellous bargains. And the same holds true to-day.

Going dirt cheap! Old timers which only want buyers.

Six or seven years ago I badly wanted a low-frequency note filter which would peak around 1,000 cycles. I wanted it for telegraph reception, to eliminate the terrific interference which was then beginning to result from congestion of the ether. I estimated that one medium-high, followed by a very high-ratio transformer, would do the trick if incorporated in a two-stage L.F. amplifier, the output being fed to a carefully chosen loud speaker.

So I rummaged around Cortlandt Street, and ultimately found two old Western Electric transformers, one with a ratio of 7 to 1, and the other with a 29 to 1



This array of oddments, just off Cortlandt Street, would make anybody scratch his head in perplexity!

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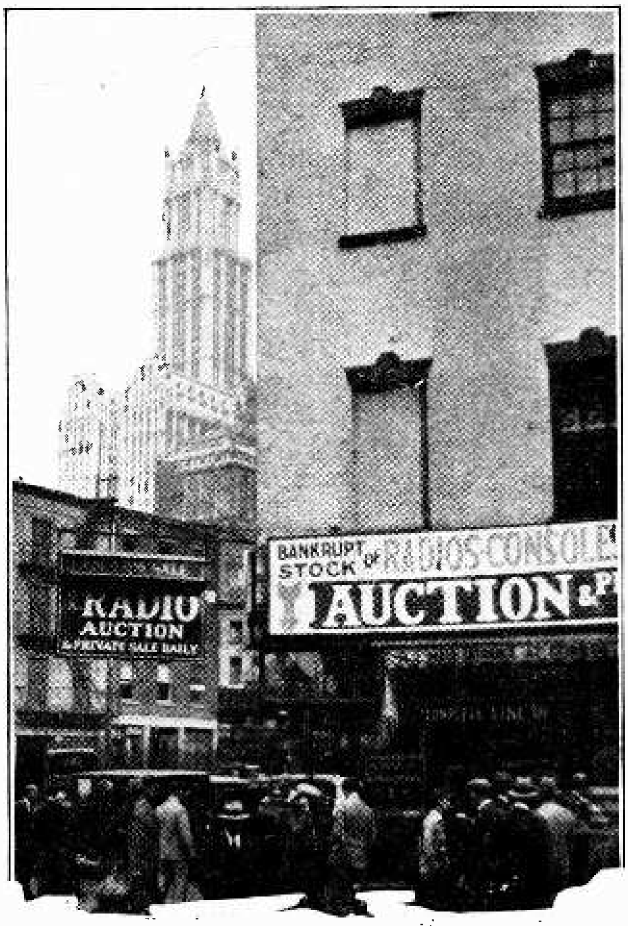
Cortlandt Street, New York.—
ratio. In spite of the fact that I told the salesman what I wanted them for, he solemnly assured me that these transformers would give me marvellous straight-line amplification in a broadcast receiver. The two transformers cost me 7s. 6d. Then I set out to find a loud speaker that would peak somewhere near 1,000 cycles. I knew they existed. In fact, I was excruciatingly aware of the fact. But could I find a salesman who appreciated what I wanted? Every one of them persisted in plugging dozens of horn-type speakers into broadcast receivers and extolling their marvellous (?) straight-line reproduction. There was only one thing for it. I made them haul out antiquated and promising-looking wrecks from dusty shelves, and concentrated on the reproduction instead of the voluble sales talk until I found a speaker with a distinct peak at 1,000 cycles. I got it for 5s. It only remains to be said that my note filter, when built, functioned beautifully on telegraphy, just as I wanted it to, but those salesmen must have made a mistake somewhere, for when it was switched on to broadcasting—well, you know how it was without me telling you.

With the passage of time, Cortlandt Street has grown out of all recognition. The little junk shops have expanded and taken the premises next door, and the next door to that. Many of them have rebuilt the lower floors of the five-storey buildings and made palatial radio shops out of them. Even the buildings themselves have been spruced up. Rents have gone up, and the little junk shop man with his collection of museum pieces has been crowded off Cortlandt Street and round the corner into the little cross streets where, on a fine day, his wares overflow on to the pavement. But I still shudder to think of the fate of the impecunious bargain-hunter, uninitiated in the mysteries of radio, who is so ill-advised as to stray into such a sea of sharks.

In addition to the smart shops there are many auction rooms, with their even more diabolical traps for the unwary. At this point I must utter a lament—another grievance against "this new-fangled wireless business." Gone for ever is the old-time, rip-roaring auctioneer with lungs of brass, to be heard not only out on the pavement but half a block away as well. His place has been taken by an apparently sane and mild-mannered individual (but with the old glint still in his eye), who talks in a normal, conversational tone. But in front of him is the ubiquitous microphone, strung on a taut wire, which he pushes up and down the counter as he moves about. Loud speakers reinforce the hearing of those at the back of the room, and a dynamic speaker of generous output over the doorway provides dynamic evidence to all and sundry within a couple of blocks that the old firm is still at work.



In the shadow of the Woolworth Building. One of the side streets off Cortlandt Street, where the "junk merchants" thrive.

What constitutes the stock-in-trade of the modern Cortlandt Street market? What bargains are obtainable, and how can they do it? These and other pertinent questions from the mystified stranger are easily answered. Apart from the second-hand junk shops, the better-class shops deal almost exclusively in "bootleg" components, such as valves, made and sold at cut rates by manufacturers who pay no royalties to the patent holders, and somehow get away with it; also brand-new sets and components, in the manufacturers' original cartons or crates, which have been acquired from the constant procession of regular radio dealers who go bankrupt and have to sell out their stocks in bulk for whatever they will fetch, which must be mighty little. For this reason, exactly the same article may be quoted at widely divergent prices at adjacent shops.

Here are a few sample bargains:—

R.C.A. Radiola Type 106 dynamic speaker in a very attractive cabinet, £3 5s.; quoted next door, in manufacturer's sealed crate, at 19s.

Crossley 6-valve battery operated set, £2 16s. Crossley 5-valve "Bandbox Junior," £2 8s.; also battery operated. Both brand new.

Kolster Type K.20 7-valve A.C. all-electric set, including loud speaker, in handsome console, brand new, £5 10s. New Atwater Kent 7-valve D.C. all-mains console set, with loud speaker, £6.

New Radiola Type 41 7-valve screen grid A.C. all-electric, with dynamic speaker, in console, £8. The manufacturer's list price for this set is £59.

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Cortlandt Street, New York.—

All these new sets, and dozens of others, may be purchased with complete confidence in most cases.

As to components, valves vary from 2s. to 8s., according to type. L.T. and H.T. battery eliminators (single units), £2 to £3. 45-volt H.T. heavy-duty batteries, about 5s. 6-volt accumulators, 5s. to 10s. Loud speakers, 2s. upwards, according to type and vintage. Gramophones, all types, may be obtained from two to three shillings upwards, second-hand and new.

Such is the radio market in Cortlandt Street, New York, a paradise for the discriminating expert, and a plague spot for the uninitiated. Nowhere else in the world could such a unique set of circumstances combine to produce such a surprising, paradoxical, and colourful result, and all within a radius of a quarter of a mile. And to think that, with such a market at his door, a very prominent New York radio engineer should ring me up the other day to ask me that amazingly disconcerting question: "What is the best radio set on the English market?" It transpired that he wanted to make a present of one to a friend in England —a really good one, something in the neighbourhood of £20 ——. Ah, well!

TRANSMITTERS' NOTES.

The New Call-book.

The winter issue of the Radio Amateur Call-book is now available, and may be obtained in Great Britain from Mr. F. T. Carter, Flat A. Gleneagle Mansions, Streatham.

For the benefit of those readers, if there are still any, who do not know of this world-wide list of Amateur Transmitting Stations, we would state again that the price for single copies is 4s. 6d., post free, or 14s. 6d. for the four quarterly issues. The present number contains over 122 closely printed pages giving the call-signs, names and addresses of all known amateur transmitters in the world, a list of the principal short-wave broadcasting stations, the International "Q" code and miscellaneous abbreviations, and a quantity of information of service to listeners. We are glad to note that the useful list of short-wave commercial stations has been reinstated in this issue.

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French Time Signals.

As from January 1st, 1931, the Paris, Pontoise Station FYB, takes the place of Issy-les-Moulins FLJ for the transmission of the French Time Signals on short wavelengths. The ordinary International Time Signals followed by the Rhythmic signals are now transmitted simultaneously from Bordeaux, Croix d'Hins FYL, on 18.900 metres (15.87 kC.) and from Paris, Pontoise FYB, on 28.35 metres (10,581 kC.) at 0756 to 0806 and 1955 to 2006 G.M.T.

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American Amateurs.

According to the annual report issued by the Director of Radio of the American Department of Commerce, there are now 18,994 licensed amateur stations in the United States, an increase of 2,165 during the past year.

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Wireless Society of Ireland.

During the past year the Transmitters' Section has increased in numbers from 17 to 44, and this small but enthusiastic band of amateurs has shown remarkable enterprise and activity. The Wireless Society's transmitter has been rebuilt and is now crystal-controlled, so that it is probable that EI3B will now be more frequently heard than of late. During the flight of the "Southern Cross" across the Atlantic the Transmitters' Section kept in constant touch, and it was mainly through their efforts that the public in Ireland received news of the aeroplane's flight, while some of the messages received were telephoned to London. At the Dublin Radio Exhibition the Section introduced a novelty by transmitting messages across the Exhibition grounds, and there was generally a large crowd around the Wireless Society's stand eager to send souvenir telegrams to their friends in other parts of the building.

Mr. D. F. O'Dwyer, who has been acting as hon. secretary to the Society during the past year, has been elected chairman of the Transmitters' Section for 1931.

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A Coventry Listener.

"BRS 149," 181B, Albany Road, Earlsdon, Coventry, asks us to state that he listens for amateur telephony signals every Sunday from 12.00 to 14.00 G.M.T. on the 7 megacycle band and, on alternate Sundays, on the 3.5 megacycle band from 19.00 to 24.00 G.M.T., for C.W. or 'phone. He is willing to stand by for tests on any of the amateur wavebands at week-ends, and will send full reports.

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NEW CALL-SIGNS AND CHANGES OF ADDRESS.

G2AX (ex 2AJB), N. Blackburne, 11, Sea Rd., Bexhill-on-Sea, Sussex. Transmitting on 7 mC., 11.00 to 13.00 G.M.T. on Sundays, and will welcome reports.
G2HZ N. I. Bower, Court End, Adderbury, Near Banbury.
G2PF N. Huggett, 6, Alexandra Rd., Chichester, Sussex.
G2PH (Portable.) N. Huggett, 6, Alexandra Rd., Chichester, Sussex.
G2QG Ebbw Vale and District Radio Society (Operator, H. J. Gwillim, The Mount, West Hill, Tredegar, Mon.).
G2QI D. Briggs, 24, Gaer Park Cres., Newport, Mon. (Change of address.)
G2QT Lieut. F. S. Benney, Wykeham Hall, Lee-on-Solent.
G2RU H. C. Hall, 351, Ecclesall Rd., Sheffield.
G2UB A. Boffey, Newtown, Westbury, Wilts.
G5BS C. S. Bradley, 8, St. Margaret's Terr., St. Leonards-on-Sea. (Mr. Bradley's other call, G2AX, is cancelled.)
G6BS B. M. Scudamore, 39, Owlstone Rd., Newham, Cambridge.
G6IS H. Higson, 99, Ashton Terr., Stopes Brow, Lower Darwen, Blackburn.
2AAY J. R. Baker, 133, Trafalgar St., Gillingham, Kent.
2ACD W. O. Took, 46, The Hornet, Chichester, Sussex.

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A Correction.

Mr. F. W. J. B. Pigott tells us that the address of his station G2WA is 71, Nutfield Road, Thornton Heath, Surrey, and not 180, Franciscan Road, S.W.17, as given in our issue of December 10th. Incidentally, we mis-spelt his name, for which we offer our apologies, though he very kindly does not upbraid us for this. He will shortly be working on 1,875 and 7,150 kC.

G 5SN. Owned and operated by Mr. N. Skinner at 296, London Road, Westcliff-on-Sea. The photograph shows, from left to right, the modulation amplifier, crystal oscillator, frequency doubler, power amplifier and short- and long-wave receiver.

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CURRENT TOPICS

News of the Week in Brief Review.

THE EARLIEST WORM?

The early birds must rise very early indeed if they hope to catch the first morning broadcast from Posen (Poland), which opens transmission at 5.15 a.m. Wavelength: 335 metres.

oooo

'PLANE BOOKING BY WIRELESS.

By special arrangement between Imperial Airways and the White Star Line, Atlantic passengers approaching Europe can now book accommodation on air expresses by wireless. Ships' pursers act as booking agents.

oooo

MOUNTAINEERING WITH A MICROPHONE.

Listeners to Vienna are to hear a running commentary on a mountain climb. The microphone will be taken to the summit of the Arlberg (9,750ft.), the climbers describing their thrills by means of a portable short-wave transmitter.

oooo

PARIS SHOW IN MAY.

The 1931 Paris Wireless Salon is to be held in May next to coincide with the International Colonial Exhibition. A special Radio Fortnight will also be held in October, and will correspond with the usual Radio Manufacturers' Exhibition.

oooo

TELEVISION: SUCCESSFUL AND ELEGANT.

Our Paris correspondent states that February will witness the opening in the French capital of a television theatre using the new Barthélemy system "which has solved the problem of synchronisation with success and elegance."

oooo

LECTURES ON TELEVISION.

The first of a series of six lectures and demonstrations on Television will be given to-morrow (Thursday) at 8 p.m. at the Borough Polytechnic, Borough Road, London, S.E.1, by Mr. J. J. Denton, A.M.I.E.E., Hon. Sec. of the Television Society. Full particulars of the course can be obtained on application to the Principal at the above address.

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SURPRISE FOR FRENCH LISTENERS.

French broadcasting prospects are taking a turn for the better, according to our Paris correspondent, who reports that the Parliamentary Finance Committee, which is preparing the 1931 Budget, has voted substantial credits for the operation of future broadcasting services. The committee recommends the borrowing of a sum of 65 million francs for the completion of a national broadcasting system.

oooo

INDIRECTLY HEATED D.C. VALVES.

We are asked by the manufacturers to explain that the Mazda Indirectly Heated D.C. mains valves reviewed in our issue of January 7th will not be available to the public for four or five weeks. The manufacturers have had many enquiries for the valves, as a result of our review, and we wish to make it clear that it is always our endeavour to give information to our readers as early as possible concerning new products, but it sometimes happens that these are not generally available until some time after our description has appeared.

THE "MUSH" MAKER.

". . . the powerful new wireless transmitter at Mushlacker."—Sunday Paper.

Few misprints could show less tact.

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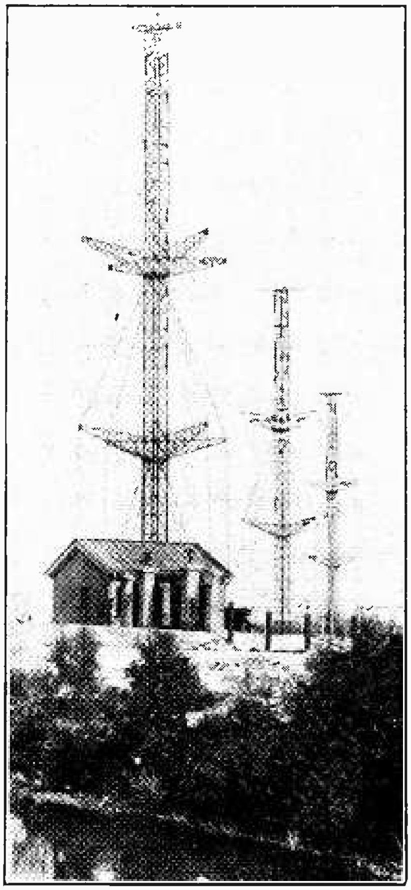
OMITS SODA FOUNTAIN.

The Visionola, combining radio, gramophone and home talkie apparatus in a single console no larger than the ordinary radio type will shortly make its appearance on the New York market.



NEW MODES IN MASTS. Chinese influences seem to have played a part in the design of these masts, which sustain the aerials of the new Shanghai radio station, built for communication with America, France and Germany.

GERMANY SAYS "NO."

After serious consideration the German Post Office has declined to sanction the distribution of broadcast programmes to telephone subscribers.

oooo

GERMAN TONGUE-TWISTERS.

Fired by the B.B.C.'s enterprise in publishing pronunciation booklets, the German Reichs - Rundfunk - Gesellschaft has entrusted the preparation of a similar work for German announcers to Prof. Siebs, of Breslau University.

oooo

STATE WIRELESS CONTROL IN GERMANY.

The famous station at Nauen, near Berlin, will come under State control on January 1st, 1932, as a result of the Reichpost's decision to acquire the complete plant of the Trans-Radio Company for Overseas Wireless Communication.

oooo

THE VILLAGE CLOCK: 1931 MODEL.

The village of Hythe, near Southampton, owns the first public radio clock in the country. Standing in the village square, the clock is connected to a wireless receiver, and is periodically synchronised with Big Ben. A loud speaker is incorporated in the clock so that villagers can hear the chimes from Westminster as well as the six "dots" from Greenwich.

The clock is the handiwork of Mr. Wallace Maton.

oooo

WHISKY-MADE STATIC.

The following advertisement, culled by our New York correspondent from a recent issue of *The Lassen Advocate* (California), speaks for itself:—

"There is one bootlegger in Susanville who is known to this committee and who has a whisky ageing machine. This machine is a nuisance to radio enthusiasts of Susanville, and unless this bootlegger, who is known, removes his machine from Susanville, warrants will be sworn to for his arrest for violation of the prohibition law and for violation of the city ordinance covering radio disturbance.

"Signed, COMMITTEE."

oooo

THE STENODE RECEIVER

Dr. James Robinson has called our attention to the wording of our Editorial on the above subject in the issue of January 7th, in which we state that Dr. Robinson "proceeds to attack the sideband theory of a modulated carrier."

Dr. Robinson denies that he attacks the sideband theory. In the full text of his paper, of which we gave an abstract in the same number, he states that "the application of the Fourier analysis to the complete radio equipment is not quite simple, and that when new facts are brought forward, as in the case of the Stenode, the application of the Fourier analysis must be made in a manner to include the whole of the phenomena."

oooo

RIALTON RADIO PRODUCTS.

We learn that Rialton products are in future to be marketed by a new company incorporating Rialton Radio with the title Benenson Radio Co., Ltd. The company's address is 10, White Lion Street, Bishopsgate, E.C.2.

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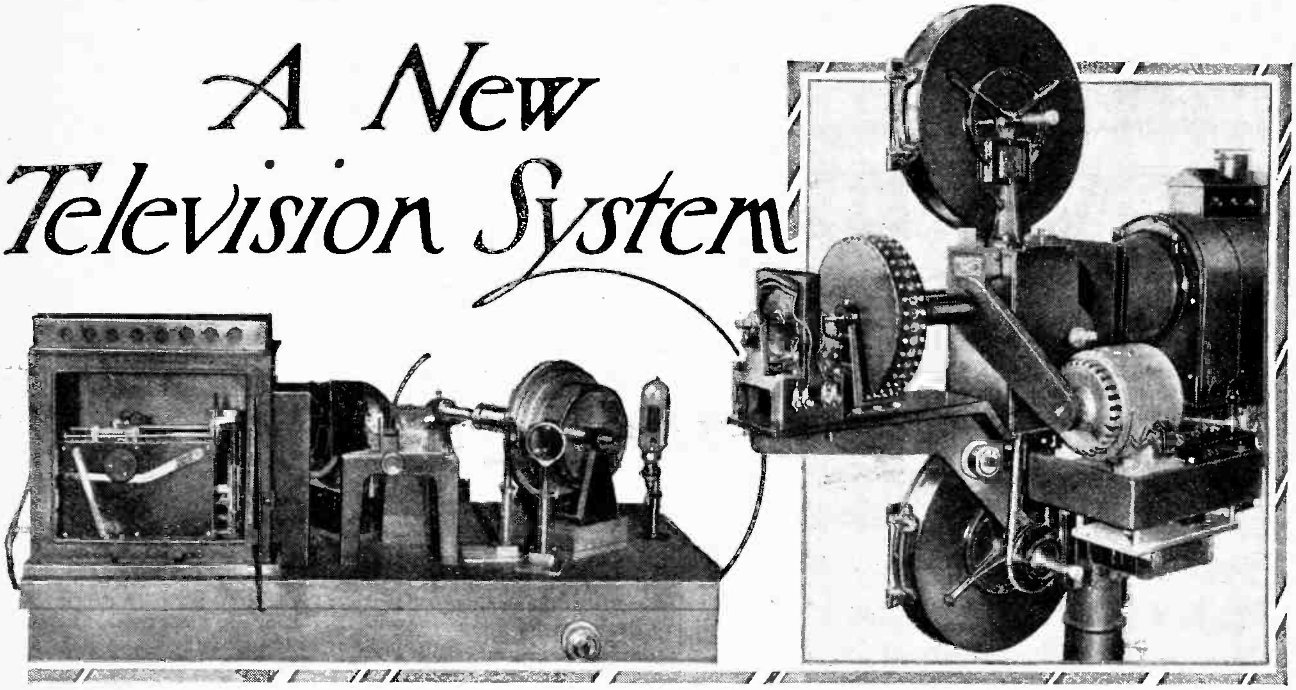
A New Television System



Promising Results of Recent Work in the H.M.V. Research Laboratories.

THE entry into the field of television research and development of the Gramophone Co., Ltd., will no doubt come as a surprise to many of our readers. A section of the Research Laboratories at Hayes, Middlesex, has been engaged now for some months on this fascinating problem, and a demonstration of the results so far obtained was given at the Exhibition of the Physical and Optical Societies at South Kensington last week.

It is made quite clear that the Gramophone Company have no intention at the present moment of producing television apparatus on a commercial basis. The work has been undertaken as an advanced laboratory experiment, in the course of which may be expected to emerge data of direct value in the company's principal business of sound reproduction. For instance, the standard of definition in the projected image which the H.M.V. engineers have set for themselves requires a frequency range in the amplifiers from 20 to approximately 20,000 cycles. Such an amplifier has been produced with a deviation of not more than 2 decibels over this range. Similarly, this particular research has resulted in a distinct advance in the technique of construction of photo-electric and Kerr cells.

Definition Comparable with the Cinema.

In order fully to appreciate the significance of the present research, it is essential to understand the point of view of the H.M.V. engineers. It is well known that the greatest difficulties in the development of any television system are associated with the link between transmitter and receiver. Where wide bands of frequencies associated with the image modulation and synchronising currents have to be transmitted, the link, whether wire or wireless, imposes certain limitations. Hitherto, research workers have accepted these restrictions, and have set to work to produce the best possible definition which present circumstances permit. The Gramophone Company, on the other hand, holds the view that television cannot hope to hold public interest until the definition of the image is at least comparable with that of the cinema.

Five Scanning Channels.

To achieve this object the image, which is projected on a ground-glass screen 24in. x 20in., is divided into 15,000 elements. Standard-size cinematograph films taken at the minimum speed of 12½ pictures per second are being used in present demonstrations. These are scanned by a revolving lens drum, and the light is passed over five equidistant photoelectric cell apertures which divide the light simultaneously into five vertical sections. According to figures published by the Gramophone Company, the maximum frequency which each section may be called upon to deal with is 23,750 cycles, and each of the five amplifiers associated with the photo-electric cells is capable of dealing with this frequency. It will be seen from the sketch showing the layout of the apparatus that the amplifiers are divided into two banks. Each bank contains two stages per section. There are five channels of communication between transmitter and receiver, and a sixth channel for synchronising, which will be dealt with later. At present armoured cables are used, and radio communication has not so far been attempted.

At the receiver end the modulated image frequencies

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A New Television System.—
are further amplified by a bank of five amplifiers, giving a stable overall amplification of more than a million—a notable achievement in view of the wide range of frequencies covered.

The output from the receiver amplifiers is impressed on a bank of five Kerr cells complete with crossed Nicol prisms which modulate the light from a powerful arc lamp. Reconstruction of the picture from the five fluctuating pencils of light is accomplished by a revolving drum fitted with polished steel mirrors corresponding to the arrangement of lenses at the transmitting end.

Synchronising is carried out by coupling a 1,200-cycle generator of the phonic wheel type mounted on the lens drum spindle of the transmitter to a motor of similar design on the receiver mirror drum. Phase adjustment is made by viewing a predetermined mark on the mirror drum in the light of a neon lamp, which is excited once every revolution of the lens drum on the transmitter.

It is essential that the speed of the lens drum on the projector at the transmitting end should be kept constant. In order to isolate it from the jerkiness inherent in the drive to the film gate, a mechanical filter has been incorporated in the drum spindle. This takes the form of a cush drive heavily damped with thick grease. To preserve symmetry at the receiving end a similar filter is used to couple the mirror drum to the driving motor.

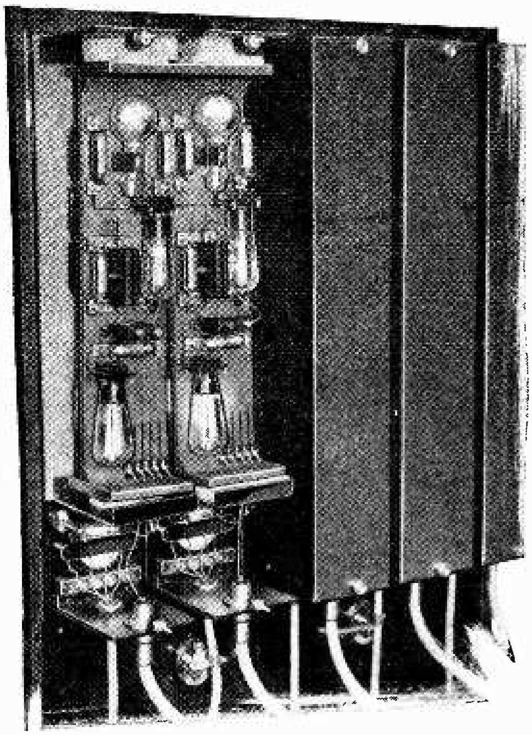
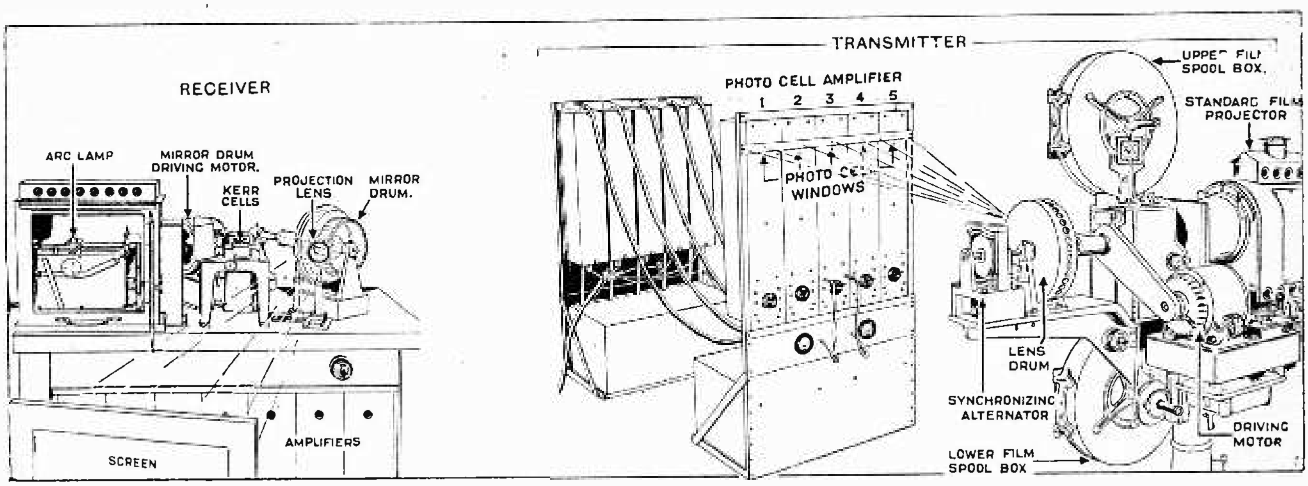


Photo cell amplifier with covers removed from two sections. The frequency response is level from 20 to 20,000 cycles.

We have had an opportunity of examining the apparatus and witnessing demonstrations of the new system both at Hayes and at the Physical Society Exhibition. In the first place, we would take this opportunity of congratulating the H.M.V. staff on the high standard of workmanship and technique, both optical and electrical, displayed in the construction of the apparatus. In judging the quality of the image we have in mind the standard which the Gramophone Company have set for themselves, namely, a degree of definition which will satisfy a public accustomed to the cinema. The brilliance of the image is excellent and quite equal to that of the small home ciné projectors now available. The size of the picture and the definition locally is also equal to this standard. For instance, the revolving spokes of vehicles in a street scene are clearly visible. But, viewing the picture as a whole, a certain irregularity is apparent, particularly at the boundaries of the five vertical sections. The solution of this difficulty would appear to be merely a matter of time and further mechanical refinement.

To sum up, a distinct advance has been made in the brilliance, size and definition of the image, but further work is necessary to achieve homogeneity in the general effect. The results are definitely good—for television—and if no fundamentally new principle has been introduced, at any rate the possibility of the establishment of television as a public service has been brought one step nearer to practical realisation.



Schematic diagram, showing layout of apparatus at both transmitting and receiving ends of the six channel land lines.

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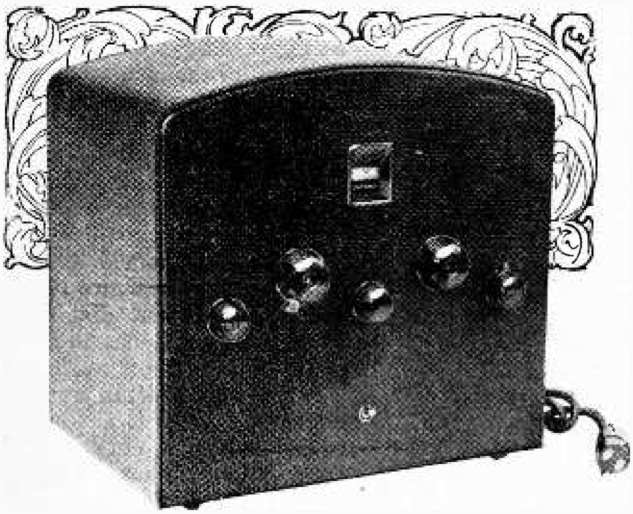
Ferranti A.C. Receiver



MODEL 32

A Carefully Designed Three-valve Receiver with an Exceptionally Wide Audio-frequency Response.

IT is difficult to call to mind a single great firm—in any branch of industry—whose publicity matter is characterised by quite the same sober and dispassionate tone as that emanating from the Ferranti organisation. Their components have never been sold as "perfect," although there are many misguided individuals among their prospective customers who would be ready to believe that perfection is attainable in the radio art. In the same way they point out quite frankly that compromises have been necessary in the design of the Ferranti receivers.

In whatever direction these compromises may have been made, it will not be news to those in touch with wireless developments that no sacrifice of quality has been tolerated. Almost every receiver has a good output in the middle register, but few sets combine good low-note reproduction with almost proportional response to high frequencies, which is so desirable for really pleasing reproduction.

Externally, the appearance of the particular model with which we are now dealing is plain and workmanlike. Its container is of metal, covered in blue, brown, or neutral grey Rexine. Controls are grouped on the front panel, and the mains connection, with sockets for aerial, earth, gramophone pick-up, and loud speaker pass through the back cover, which is removable, and carries plugs and fuses so arranged that the mains circuit is interrupted for safety when it is taken off.

With regard to the circuit arrangement, double-wound H.F. transformers with medium- and long-wave windings connected in series are used as aerial-grid and intervalve couplings. Bias for the H.F. valve (an indirectly heated Osram M.S.4) is obtained by interposing a resistance in its cathode lead. The detector, a M.H.L.4, works normally with a zero grid, but bias is provided in the same way when this valve is used as an amplifier for gramophone reproduction; the bias resistance is short-circuited on withdrawal of the pick-up jack.

A small reaction coil, rotatable through 180 degrees by a Bowden wire mechanism, is mounted between the medium- and long-wave H.F. transformers, and can be set either to reduce the normal damping of the detector grid circuit in the usual way, or feed-back may be introduced in the reverse sense to broaden tuning and thus to improve high-note reproduction. A very small fixed condenser is joined between plate and cathode of the detector to minimise stray reaction due to capacity effects, particularly at the lower end of the tuning scale.

The detector is coupled through an AF.6 transformer, with the high step-up ratio of 1 : 7, to a directly heated P.625 output valve. Negative bias for this valve is developed across a resistance connected between the centre tap of the filament transformer and the earthed negative H.T. bus bar in the conventional manner.

SPECIFICATION.

CIRCUIT: Screen-grid H.F. amplifying valve, coupled by tuned transformer to a grid detector. Forward and reverse magnetic reaction. High-ratio L.F. transformer coupling to directly heated output triode. Valve power rectifier.

CONTROLS: (1) Single-control tuning with corrector for input circuit. (2) Wave-range switch. (3) Reaction. (4) Input volume control. (5) Mains switch.

GENERAL: All-mains operation with outside or inside aerial. Reversed reaction to ensure good high-note response. Double-ratio output transformer for high- or low-resistance loud speakers.

Price: £25 0 0. Makers: Ferranti, Ltd., Hollinwood, Lancs.

An output transformer is fitted, with tappings providing a step-down ratio of 15 : 1 for use with a low-resistance moving-coil loud speaker, and also a 1 : 1 ratio to suit a high-resistance instrument. It may be pointed out that loud speakers of these different types may be operated simultaneously in different rooms without noticeably affecting the reproduction afforded by either. This application of a tapped output transformer seems to offer a solution to many domestic problems.

Anode current is obtained through a double-wave valve rectifier, and it will be observed that resistance smoothing is used throughout except for the output valve. As there is no common smoothing circuit, it follows that "decoupling" of the anode-feed system is unusually complete

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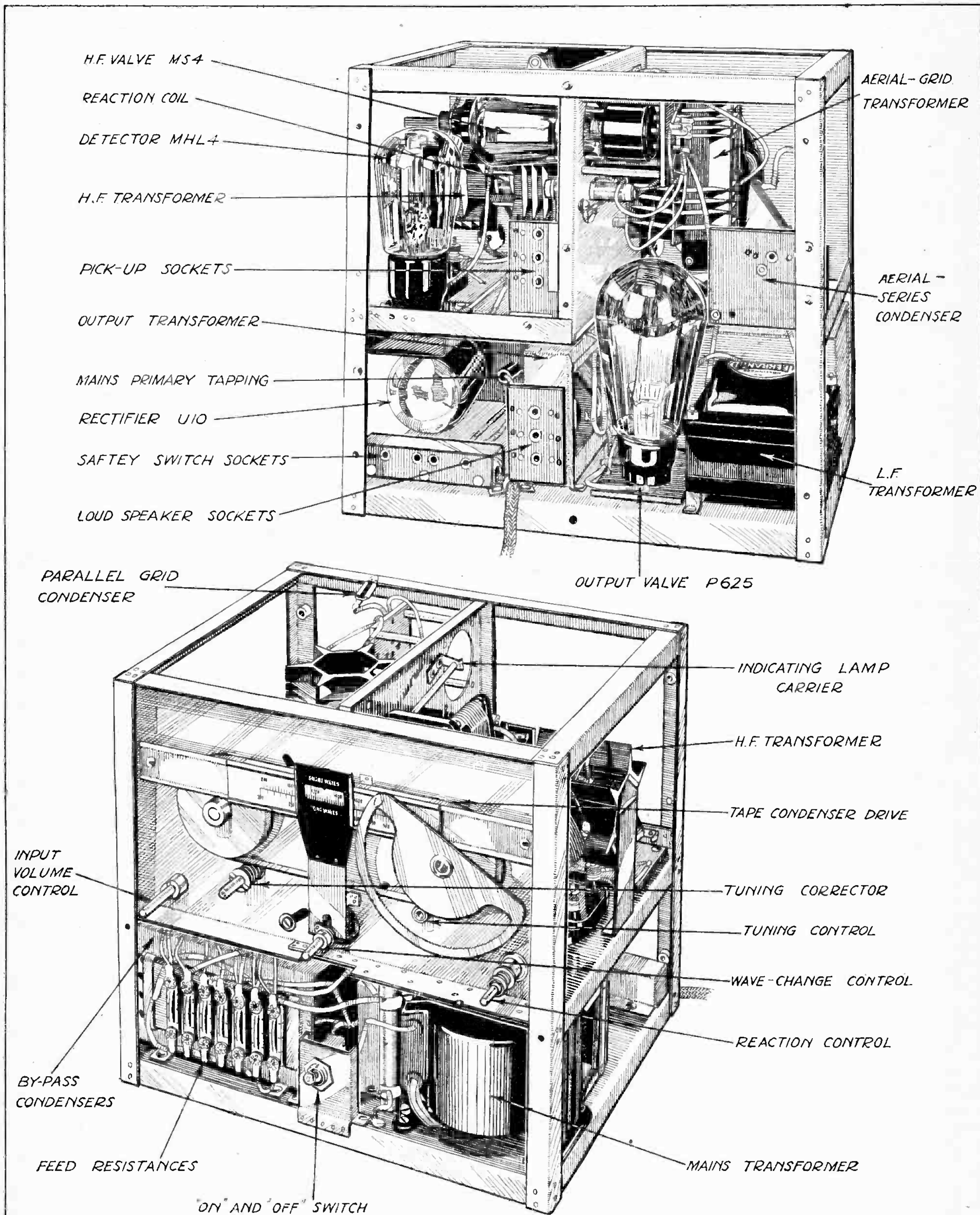

The Ferranti Model 32 Chassis as seen from front and back. Screening plates have been removed from the H.F. amplifier compartment.

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Ferranti A.C. Receiver—Model 32.—

Grid circuits are also decoupled where necessary, and it is interesting to see that the principles of what is generally called "scientific wiring" have been observed.

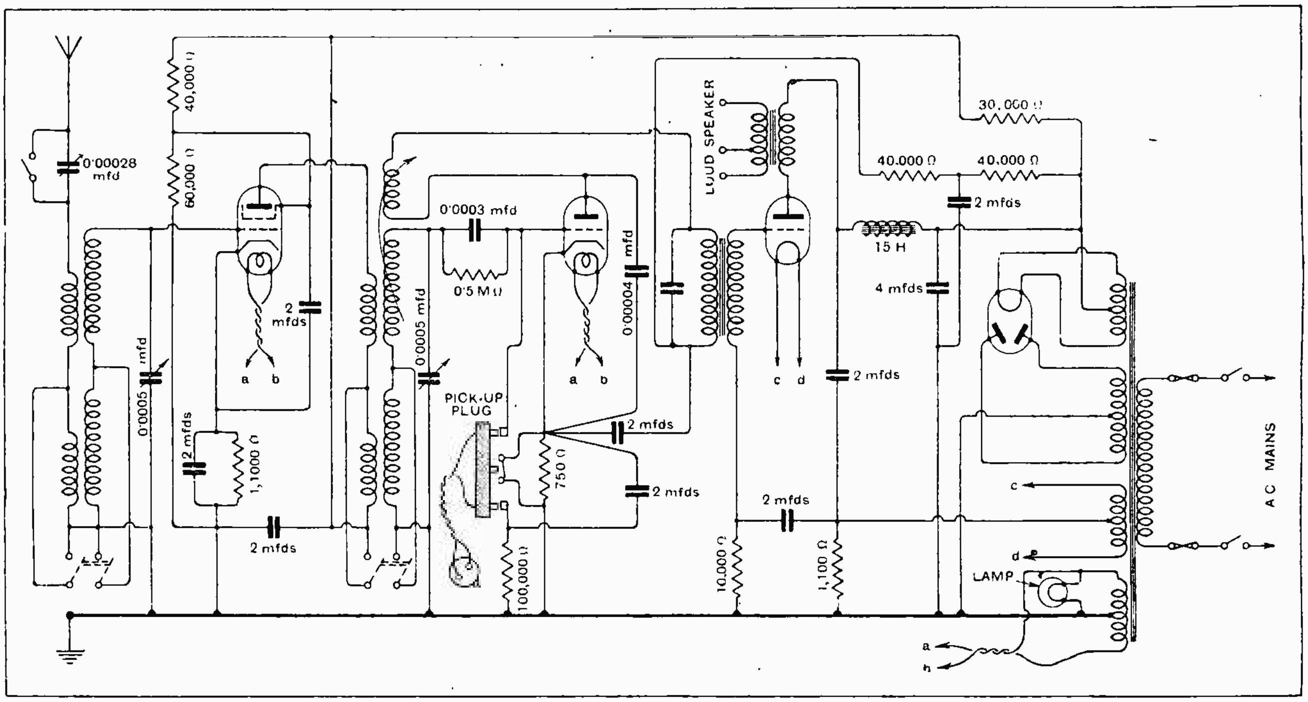
The apparatus is supported in a strong metal framework with spot-welded joints, and a completely screened compartment is provided for the components associated with the H.F. anode and the detector-grid circuit.

A metal band drive is fitted to provide simultaneous operation of both tuning condensers, and the stator of one of them (that in the aerial-grid circuit) may be rocked through a few degrees as a trimming control.

There is a horizontal tuning scale, directly calibrated in wavelengths and illuminated by a lamp which is mounted on a carrier rod, so that replacements may easily be made when necessary. A shutter, operated automatically by the wave-range switch, is arranged to obscure the particular scale that is not in use at the moment. The remaining control is in the form of a series aerial condenser which serves to regulate aerial input, and is, indeed, the only volume control fitted. A metal blade is provided, so that a short-circuit is introduced across this condenser when it is set at maximum capacity.

Voltages of 140 and 75 are applied respectively to anode and screen of the H.F. valve, while the detector anode works at 45 volts. This may appear to be on the low side, but it must be remembered that this valve is followed by a high-ratio L.F. transformer, which feeds into a power valve needing but a moderate grid swing for full loading; in consequence, the detector is not required to handle large inputs. According to the makers, the detector output at 6,000 cycles is only 10 per cent. below that at 500 cycles. Further, it is stated that a curve deviating from straightness by only a few per cent. is obtained when detector output is plotted against modulation percentages from 6½ up to 70. The L.F. magnification from detector grid to output is given as 334 times.

Other graphs show high and particularly uniform overall sensitivity on both medium and long waves. This is confirmed on test, and one gains the impression that the receiver, though primarily intended for high-quality reproduction at medium ranges, is much more sensitive than the average. Indeed, frequent use has to be made of the input volume control, and the only complaint to be registered is that the aerial series condenser which performs this function has not a lower minimum capacity.



Complete circuit diagram of the Ferranti Receiver. Ends of the power transformer secondaries are joined to valve filament terminals bearing corresponding lettering.

On the score of quality it was impossible to find any points for criticism, and the set is worthy of the very best loud speaker. The maximum undistorted output, which amounts to well over half a watt, is quite adequate for domestic requirements.

Some compromise has been made in the matter of selectivity, and the use of extremely sharply tuned circuits has been deliberately avoided in order that the exceptional high-note performance already mentioned may be obtained. In spite of this it was found that operation of the aerial series condenser conferred a reasonable immunity from interference. Thanks to the large reserve of sensitivity, it is possible to use this selectivity control without undue loss of signal strength.

Manipulation of the controls gives a pleasing impression of complete stability; everything seems to work "according to plan," and mains hum is practically non-existent. There is an ample margin of safety everywhere, and the design is on unusually generous lines.

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THE TIMING of WIRELESS ECHOES

The Use of Television and Picture Transmission.

By PROFESSOR E. V. APPLETON.

(Concluded from page 4 of previous issue.)

IN the first part of this article I dealt with the scientific methods which have been used in this country and in America for the timing of wireless echoes due to signals which have been reflected by the upper atmosphere. Using these methods it has been found that echo-times of the order of one millisecond (i.e., $\frac{1}{1000}$ second) are usual, and also that the relative strengths of the direct signal received and its subsequent echo, produced by reflection, depend in a very marked way on the wavelength employed, and also on the distance between the sending station and the receiving station. For example, in receiving 100-metre waves at a distance of ten miles, the echo signal at night is often many times as strong as the direct signal, while with 400-metre waves at the same distance the echo-intensity is only a very small fraction of the ground signal intensity. Also, for a given wavelength, the strength of the echo signal relative to that of the ground signal increases with increase of distance from the sending station.

Since the echoes in such cases arrive so very soon after the first direct signal is received, it is not possible to recognise their separate existence by ear when morse signals are being received, and in such cases the strength of the received signals depends on the combined strength of both direct and echo signals. In order to distinguish between them it is necessary to use some form of high-speed recording. It is also convenient to make the transmitter send out very short dot signals for such observations, so that the two signals do not overlap.

Now it happens that, in the transmission of pictures, either as a reproduction on paper, or as a televised image, we are dealing with a case of the high-speed recording of short signals so that we might expect the effects of echoes to be noticeable. In such circumstances we should expect the echo-signal to produce an echo-image which, if the speed of recording is sufficiently high, will be distinguishable from the image due to the direct signal because of its later arrival.

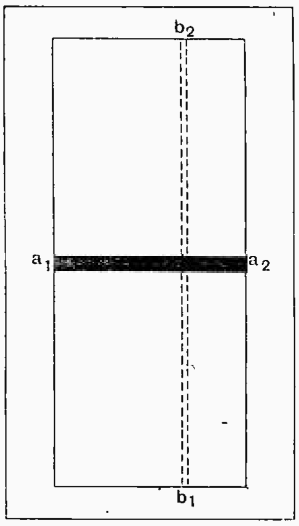

Fig. 1.—Demonstrating the principle of picture transmission.

To make this clear to the reader who is unfamiliar with the principles of picture transmission, let us suppose that it is proposed to transmit a picture consisting of a horizontal black line, a_1, a_2, on a white background (see Fig. 1). This is usually done in the following manner. A spot of light is made to "scan" or look over the picture in a certain way. We will suppose that the spot travels up a strip of the picture such as b_1, b_2, and then up an adjoining strip to the left of b_1, b_2, and so on until the whole picture has been "looked over" in this way. By means of a photo-electric cell the light scattered or reflected from the illuminated portion is made to control the amplitude of a wireless transmitter so that, in effect, a message is sent out each instant indicating whether the particular spot on the picture which is then being illuminated is light or dark.

The Echo Image.

At the receiving station another spot of light is used for the reproduction of the image. In the case of the transmission of still pictures the spot is kept fixed while the paper on which the image is reproduced is made to move. The strength of the modulation of the wireless signal which is received is made to control the intensity of the spot of light so that the "messages" sent out by the transmitter concerning the lightness or darkness of the particular part of the picture being illuminated are translated at the receiver into the lightness or darkness of the reproduced image.

The effect of an echo will now be easily understood. Let us suppose that we consider the state of affairs when the scanning spot at the transmitter is traversing the strip b_1, b_2 in Fig. 1, and that the spot is just illuminating the black line. The transmitter sends out a "message" indicating that the particular spot being illuminated at that instant is black. Because of the echo, however, this "message" is received twice, and the result on the received picture is that there are reproduced two black spots instead of one. When the picture is completed this means that two black lines appear instead of one, the echo line appearing above the direct signal line. In order to calculate the echo-time we require

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The Timing of Wireless Echoes.—

to know the speed at which the spot of light at the receiver is moving. This is technically known as the "scanning velocity." The distance between the two images on the received picture divided by the scanning velocity will then give the echo time.

The possibility of using picture transmission for measuring echo-times was, I think, first discussed by Dr. E. W. F. Alexanderson, the well-known American radio-engineer, at the meeting of the International Scientific Radio Union at Washington in 1927. At that time he had already observed examples of multiple echo-images in picture transmission. More recently the Marconi Company have met with the same phenomenon in the use of their method of facsimile transmission when working between America and this country. In such transmissions echo-times of, for example, 0.77, 1.55, 2.67 and 3.82 milliseconds have been simultaneously observed on a 22.2 metres circuit working between New York and Somerton. Mr. T. L. Eckersley, of the Marconi Company, has been able to account for these multiple images as being due to separate groups of waves which have been reflected twice, thrice, etc., by the ionised layer.

The theory underlying the transmission of television is very similar to that discussed above for the case of picture transmission. The chief difference is that the scanning spot in television has to "look over" the image in a very small fraction of a second, whereas there is no such limitation in the case of picture transmission. The image is scanned in strips, the spot moving from bottom to top and from right to left. We should, therefore, expect the effect of an echo to be shown as another image situated *above* the main one.

Some time ago I was able, through the medium of this journal, to ask amateurs receiving television from Brookmans Park to look out for echo-images and to inform me how the distance between the direct and echo-images was related to the size of the frame. Three replies were received to this request. Two of them were from observers who were situated so far from the transmitter at Brookmans Park that it is doubtful whether a simple theory of ground signal and reflected signal would apply, so that the interpretation of their results is not easy. From one observer, Mr. W. B. Weber, of Bristol, observations were received which may be compared with the results obtained by other methods. This arises from the fact that Bristol is sufficiently near London for an appreciable ground signal to be received. Mr. Weber informed me:

(1) That he had observed echo-images only at night and not during the daytime;

(2) That the echo-image was always situated above the main one; and

(3) That, so far as he could measure, the shift upwards was about one-seventh of a whole strip length.

He also sent me a rather delightful sketch, which is reproduced in Fig. 2.

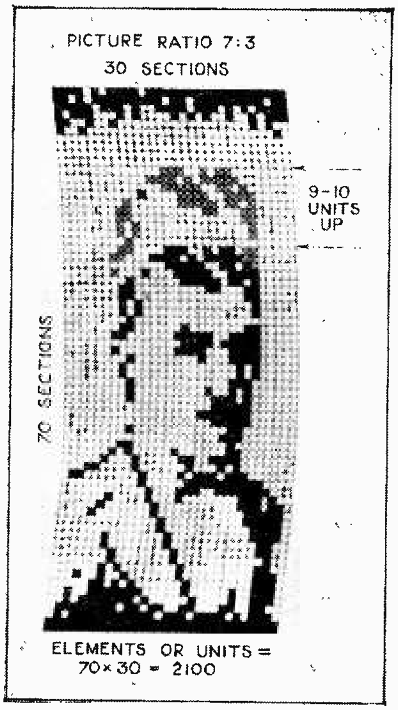

Fig. 2.—The displacement of the image represents the interval between the arrival of the direct and reflected waves.

Now, Mr. Weber's observations (1) and (2) given above are just what we should expect, for we know that the ionised layer is a better reflector for broadcasting wavelengths by night than by day. We also know that since the scanning spot travels upwards, the echo image would, because of its later arrival, be situated above the direct or main image. To interpret his observation (3) we need to know the time taken for the scanning spot to run up a strip. Now, the scanning disc had thirty holes, so that the image is scanned in thirty strips, and as the disc rotates 12½ times per second, it requires simple arithmetic to show that the time required for the spot to run up one strip is 1/375th of a second, or 2.7 milliseconds.

The value of 2.7 milliseconds, however, requires a slight correction. Synchronisation is brought about by the use of a break in the signal every time a new strip is started, so that no separate synchronising signal is necessary. The duration of this break signal, or "gate," as it is termed, relative to the strip-traverse time, can be varied as occasion demands, but a common state of affairs is for about 16 per cent. of the strip-traverse time to be utilised as the synchronising signal in this way. Reducing the figure of 2.7 milliseconds by 16 per cent. because of this, we arrive at a corrected figure of 2.2 milliseconds, or the time for the spot to traverse a strip of the picture produced. The echo-time in Mr. Weber's experiments must, therefore, be of the order of 0.31 millisecond, indicating an echo-path 93 kilometres greater than the ground path. This indicates a height of the echo-producing layer of the order of 100 kilometres, which is the same as the value found by other methods.

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BOOKS RECEIVED.

Television for All, by C. G. Philp. A simple explanation for the general public, including Noctovision, Television in Colour, and Stereoscopic Television. Pp. 82, with frontispiece and 8 diagrams. Published by Percival Marshall and Co., Ltd., London, price 1s. net.

Photograms of the Year 1930, edited by F. J. Mortimer, F.R.P.S. In addition to the reproductions of the work of leaders in camera art in all countries, this popular Annual contains articles dealing with the present position of photography in various parts of the world and gives particulars of over 400 Photographic Societies. Published by Iliffe and Sons Ltd., London, price 5s. in paper covers, or 7s. 6d. cloth bound.

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Broadcast Brevities

By Our Special Correspondent.

Pamphlets for Welshmen.

Minorities are proverbially noisy and thus are often able to effect changes at the expense of the lethargic majority. Wales is a small country, but she has been creating quite a stir lately in quest of a broadcasting station of her own, with the result that the B.B.C. has felt it necessary to publish two pamphlets—one in English and one in Welsh—explaining just why the Principality must share Western Regional with the denizens of Devon and Cornwall.

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Few Licences.

The writer of the booklet holds his trump card till the end. First he enumerates the distressing reasons for the scarcity of wavelengths in Europe; he then gives an ample description of the Regional scheme and the compromise which it aims at effecting in pleasing as many people as possible with the wavelengths available. Not till page 13 (there are 15 in all) does he mention the significant fact that the total number of licensees in Wales is 94,673, i.e., 3.2 per cent. of the total for the British Isles!

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Straight Words.

Copies of the pamphlet, I learn, should now be in the hands of every public person in Wales. They have been sent to corporations, borough councils, urban and rural district councils, besides to many individuals whose names adorn Welsh books of reference. No effort has been spared to put the case as clearly as possible, and Savoy Hill is hopeful that even the warmest of Welsh patriots will see that one exclusively national station is outside the realm of practical politics.

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Rebuilding 5XX.

The importance to Wales of the long-wave transmission from 5XX is fully emphasised, and in this connection I am interested to hear that, immediately upon the completion of the Regional scheme, the Daventry long-wave station is to be redesigned and largely rebuilt.

This should ensure that every corner of Great Britain will be covered by at least one programme.

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Why Oscillation Declines.

Less oscillation, but more electrical interference, took place during 1930, according to a survey of the technical correspondence received at Savoy Hill during the past twelve months.

The fact that there are fewer "oscillating Oscars" is ascribed, first, to the great increase in transmitting power since the inauguration of the Brookmans Park station, and, secondly, to the extended adoption of screen-grid H.F. stages.

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The Noble Listener.

The B.B.C. has never believed that many people oscillated with malice aforethought, and the reduction of oscillation due to improvement in technical conditions goes to sustain the official belief in the fundamental goodness of human nature.

Electrical Interference.

Producers of "man-made static" are credited with the same moral excellence, but the fact remains that electrical interference with broadcast reception is gravely on the increase. Complaints during 1930 were double those received during 1928 and considerably in excess of those for 1929.

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Another Pamphlet.

Savoy Hill has decided on the next step, which will be to prepare a special anti-interference pamphlet in the near future for distribution both to static producers and their victims.

While, however, the greatest care will be taken to instruct the parties concerned, the B.B.C. are not too hopeful regarding the future outlook.

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Is the Manufacturer to Blame?

It is felt that much of the blame lies at the door of the manufacturers of offending apparatus—gentlemen who are not likely to alter the design of their machinery until public opinion is reflected in diminished sales!

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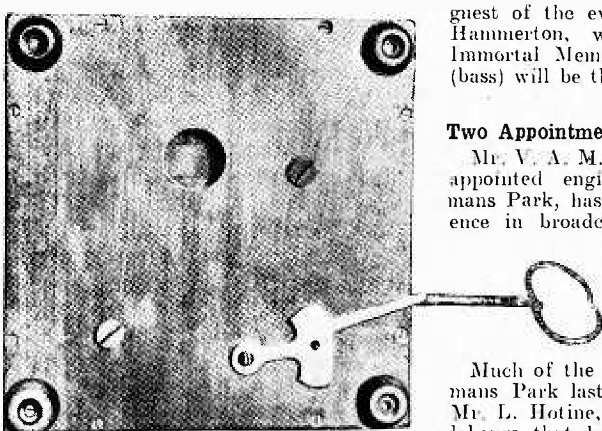
Landlords and Crackles.

To bring this about it will be necessary for the man-in-the-street to show decided preference for localities which are least troubled by electrical interference.

Electrical manufacturers may open their eyes when landlords begin to report difficulty in obtaining tenants in certain districts where the crackles outweigh the amenities.



ILLUSIONS SHATTERED. The B.B.C.'s clock tick interval signal has been compared unfavourably with the warbles of the tame nightingale at Radio Turin. This portrait of the "nightingale" will interest well-wishers who have been sending gifts of bird seed.

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Revolution in Sight?

"The nations will not wait until the International Wireless Conference at Madrid in 1932. If something is not done very soon to ease the European wavelength problem, the countries subscribing to the Prague Plan will break away from the Bureau International de Radiofusion and begin seizing wavelengths of their own."

Almost in his own words I give the considered opinion of an official expert with whom I discussed the wavelength problem a few days ago. Constantly checking the broadcast wavelengths and being in frequent touch with Geneva, he has no delusions concerning the trend of events in European broadcasting.

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Prague Plan Criticised.

He considers that the formulators of the Prague Plan should have anticipated the urge for power by providing for a considerably larger kilocycle separation between transmitters. My friend plumps for a separation of at least 15 kc. and would like it extended to 18.

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A Speech by "Q."

Sir Arthur Quiller-Couch's speech at the Dickens Fellowship dinner on February 7th will be relayed in the National programme.

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Scots Programme from Wales.

Burns Night celebrations will be relayed from the Cardiff Caledonian Society's dinner at the City Hall, Cardiff, on January 26th. The Earl of Dumfries, president of the society, will propose the "Health of His Majesty the King and Members of the Royal Family," and the guest of the evening will be Mr. J. A. Hammerton, who will propose "The Immortal Memory." Tom Kinniburgh (bass) will be the vocalist.

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Two Appointments.

Mr. V. A. M. Bulow, who has just been appointed engineer-in-charge at Brookmans Park, has seen much varied experience in broadcasting. He was chief engineer of the Indian Broadcasting Company in 1926, and superintended the erection of the Calcutta transmitter.

Much of the "spade work" at Brookmans Park last year was carried out by Mr. L. Hotine, and it is a tribute to his labours that he has now received the important appointment of Assistant Technical Superintendent at the Northern Regional Station, which, by the way, has not yet begun testing, despite rumours to the contrary.

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Unbiased by Free Grid

My Museum.

I HAVE recently started a small radio museum in which I am placing various obsolete pieces of apparatus which I have used at one time or another in the course of my radio career. One of my principal exhibits is a simple spark transmitter and crystal receiver which I constructed several years before the War at the instigation of a certain journal which is still catering for the youth of the land. The apparatus functioned after a fashion, and it has only recently occurred to me that as the journal in question never mentioned anything about a transmitting licence, and I never thought of it myself, I must have rendered myself liable to all the pains and penalties prescribed by the Wireless Telegraphy Act of 1904; indeed, for aught I know, I may still be liable, although I have held a transmitting licence for some years now, and I may yet give the opportunity to one of our judges to earn undying fame by asking: "What *is* band-pass tuning?"

What *is* band-pass tuning?

In my museum is another piece of apparatus embodying a coherer which successfully actuated an electric bell every time a motor car—they were comparatively few and far between in those days—passed the door of the ancestral home. Needless to say, the ignition system of the car was the transmitter. I suppose that really this arrangement infringed the P.M.G.'s telegraphic monopoly, as it conveyed to me an intelligent message, namely, that a car or motor bike was passing my door. I have also included an early model of a British loud speaker and an American one; the latter instrument I bought for five dollars in the States about a decade ago. It consists of an ordinary telephone earpiece attached to a cardboard horn, both being mounted on quite a massive base; its quality is atrocious, yet I well remember proudly summoning my friends to listen to its anything-but-dulcet tones. Speech was so bad that only the trained ear could distinguish between English and American, which to my mind was its most valuable asset, as you could so easily palm off the local station on to unsuspecting friends as being a long-distance foreigner, and so win their admiration at your skill in handling the multi-knobbed receiver.

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Uncharacteristic Curves.

It is refreshing to note that more and more manufacturers are supplying us with reliable and accurate data concerning their components, and are now emphasising the merits of their wares by exhibiting performance "curves" prepared by the N.P.L. and similar bodies. This practice is almost universal nowadays, and is in marked contrast to the state of affairs three or four years ago when merit was claimed for certain components because they had been boiled in oil for several years without showing outward signs of deterioration. In my opinion, the wireless enthusiast would have benefited more if the makers of some of these atrocious components I have in mind had been boiled in oil themselves. As it is, there is still a great deal of loose talk about characteristic curves, some of which are very misleading, owing to the fact that they are not plotted on an appropriate scale. It seems a great pity that there is not more standardisation in this respect. We cannot, for instance, compare the merits of certain L.F. transformers with others, as in some cases a logarithmic scale is used and in others the scale is of the "fishy" variety.

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Pardonable Misapprehension.

A friend and I had a curious experience the other night when we were "touring Europe" with my

A horrible suspicion entered my mind.

latest all-mains band-pass superheterodyne receiver. It so happened that he was twiddling the dials, and finally brought them to rest in the middle of an item which suited his somewhat depraved musical tastes. Judging from the sound emanating from the loud speaker it seemed quite evident that he had tuned in one of those ultra-modern symphonies which one gets so much of these days from certain broadcasting stations. He sat back enraptured, and I patiently endured it for a few moments, but at length a horrible suspicion entered my mind, and I hastily rose and went to the receiver. It was just as I had suspected, namely, the noise which had so entranced my friend was due to nothing more or less than two stations transmitting programmes only a few kilocycles apart. I can well understand, however, my friend being deceived into thinking that he was listening to an ultra-modern symphony.

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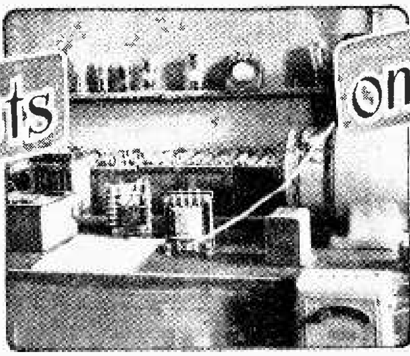
Wireless World Laboratory Tests on New Apparatus



FERRANTI TESTING LEADS.

These leads should make a useful addition to the experimenter's and service agent's equipment. They consist of two metal prongs fitted respectively into red and black bakelite handles, to each of which is attached a length of good quality flex terminating in a spade connector.

The metal prods are made of Eureka, a good form of acid-resisting material, and in addition all but the extreme points are coated with anti-sulphuric paint to prevent corrosion when used to test accumulators.

Ferranti acid-resisting testing prods with insulated handles.

The makers are Ferranti, Ltd., Hollinwood, Lancashire, and the price is 5s. per pair.

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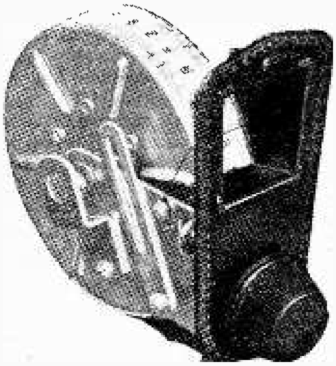
NEW "POLAR" DRUM DRIVE.

Made by Wingrove and Rogers, Ltd., Arundel Chambers, 188-189, Strand, London, W.C.2, this drum drive affords a reduction of 15 : 1—that is to say, 7$\frac{1}{2}$ complete revolutions of the driving knob are required to move the dial through 180 degrees. It will fit any condenser provided with a $\frac{1}{4}$in. spindle, and, furthermore, enable condensers to be mounted on either side of the drum.



Polar slow-motion drum drive.

The drive is by friction, but since considerable force is required to cause slip, the dial will drive four or five condensers in gang form in a satisfactory manner. A neat escutcheon plate is provided, the 180-degree dial appearing through an inclined window, traversing which is a hair-line pointer. The price is 8s. 6d.

NEAT PANEL INSTRUMENTS.

A receiver designed for quality reproduction and incorporating the best components procurable might well prove disappointing unless the valves are operated at the correct voltages or working within their capacity. Occasional overloading due to deeply modulated passages is probably the most prevalent cause of distortion, but this defect is readily discernible by the aid of suitable anode circuit milliammeters.

A range of meters of a convenient size for panel mounting has been introduced recently by the Central Manufacturing Co., Crown Works, Birmingham Road, Walsall. The overall diameter is 2$\frac{9}{16}$in. and the length of the scale 1$\frac{11}{16}$in. They are of the moving-coil type with dead beat movements.

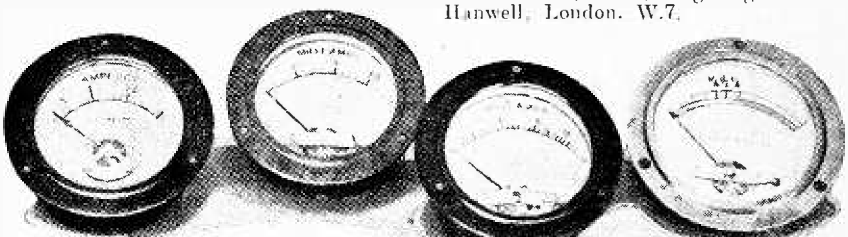
C.M. Co. Meter Scale.	Actual Current.	C.M. Co. Meter Scale.	Actual Current.
1 mA.	1.05 mA.	6 mA.	5.95 mA.
2 ,,	2.02 ,,	7 ,,	6.85 ,,
3 ,,	2.98 ,,	8 ,,	7.87 ,,
4 ,,	3.95 ,,	9 ,,	8.9 ,,
5 ,,	4.93 ,,	10 ,,	9.85 ,,

The range includes instruments reading 0-2 mA., 0-10 mA., and 0-15 mA. as standard, but higher readings can be obtained if required.

A 0-2 mA. sample tested showed a very small error, being very little more than the thickness of the pointer, which incidentally is of the knife-edge type. The error on a 0-10 mA. sample was only very slightly greater, the actual reading being as tabulated in the previous column.

These instruments are mounted in bakelite cases which can be obtained finished in various colours to match the panel scheme. All types are priced at 24s. each.

Mounted in a similar case is a spring-controlled moving-iron ammeter reading 0-2 amp., and suitable either for D.C. or A.C. measurement. This is priced at 7s 6d. Tests on D.C. and standard 50-cycle A.C. showed that the reading was uninfluenced by the nature of the current. This meter exhibited a high order of accuracy having regard to its cost.



Central Manufacturing Co.'s milliammeters and universal ammeter, 0-2 amp.: also battery charge indicator priced at 30/-.

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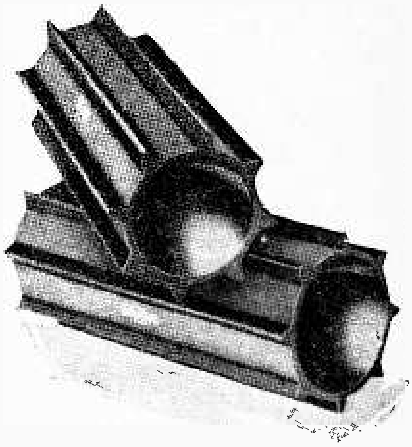
NEW BECOL FORMERS.

Hitherto Becol coil formers have been provided with 6 or 9 ribs, but the new style have 8 wings. Two kinds are available, the one with an overall diameter of 2$\frac{1}{4}$in., and measuring 1$\frac{7}{8}$in. inside, and the other 2$\frac{5}{8}$in. outside and 2in. inside. The mouldings are perfectly clean, being absolutely free from surface impurities, and we can confidently recommend them. In 6in. lengths these formers cost 2s. 1d. each, and the makers are The British Ebonite Co., Ltd., Nightingale Road, Hanwell, London, W.7.



Coil formers having 8 ribs.

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CORRESPONDENCE

The Editor does not hold himself responsible for the opinions of his correspondents.

Correspondence should be addressed to the Editor, "The Wireless World," Dorset House, Tudor Street, E.C.4, and must be accompanied by the writer's name and address.

BROADCAST RELAY SERVICES.

Sir,—The Postmaster General's attention has been called to the leading article in your issue of December 31, dealing with broadcast relay services, and he desires me to point out that each subscriber to a wireless exchange is required to take out a wireless receiving licence at the same rate (10s. per annum) as is applicable to a listener obtaining direct reception on his own receiving set.

Wireless exchanges apparently meet a demand from persons who are unwilling or unable to provide and maintain separate wireless receiving sets, and who would otherwise not obtain reception of broadcast programmes; and the experience of this department is that the establishment of such exchanges is followed by a local increase in the number of licence holders and, consequently, of the revenue of the B.B.C.

I am to add that in some cases a choice of two programmes is afforded. F. W. PHILLIPS.

G.P.O., London.

Sir,—You conclude your editorial on the subject of broadcast relay services by saying that "it would be interesting to know the views of the B.B.C." I am hoping that it would be more interesting to hear the facts from one who is actively interested in the broadcast relay services.

Let me dispose of certain misconceptions generally held and detailed in your editorial.

(1) The Post Office licence is granted to the exploiters of systems of rediffusion only upon the express understanding that every listener pays a licence. This licence is treated in exactly the same way as an ordinary licence.

(2) The class of people who subscribe to a rediffusion service largely contains those who could not afford the capital cost and maintenance charge of a battery operated receiver. Thus, in discouraging the scheme you are attempting to rob a large number of poor persons of the possibility of listening *via* loud-speakers to a quality which can be superior to any manufactured receiving set of average price.

(3) There is no technical reason why eventually subscribers to a rediffusion service should not have alternative programmes.

I do not believe that in any case the whole of the licensed population will give up purchasing receivers in favour of a rediffusion service, the point that I make is that rediffusion is touching a class of person hitherto condemned to headphone listening or to no listening at all.

London, W.3. P. P. ECKERSLEY.

THE BAND-PASS SUPERHETERODYNE.

Sir,—Having been a continuous reader of your valuable paper since 1920, I feel that I should like to record my appreciation of all the extremely helpful articles which have appeared during that period, many of them on subjects about which no information was obtainable from other sources, and, in particular, to say how pleased I am with one of your recent designs for a long-range receiver, namely, the "Band-Pass Superheterodyne," which I have just completed.

I have built it as an all-A.C. set, and though I have handled a good many powerful receivers, I do not think I have ever met one that could come anywhere near this for extreme sensitivity, combined with ease, and, above all, quietness of operation. For six valves the amount of background noise is very small indeed, better, in fact, than many well-known three-valve sets. As regards sensitivity, a 12in. frame aerial is about as much as the set can cope with, and enables even 2kW. Continental stations to be received at full loud speaker strength, with plenty of the volume-control still in hand.

In case you should think it to be of interest to any of your readers, I find that the following valves work very well: First H.F., Mazda AC/SG; first detector, Osram MS4; oscillator, Mullard 164V; intermediate H.F., Mullard S4VA; second detector, Mazda AC/HL and Mazda AC/PEN. A Mullard S4VA was also tried in the first detector stage, but was found to be far too "good." It was always on the verge of oscillation and the set was almost unmanageable, while the background noise quite drowned any signals. It was also found that it was advantageous to wrap tinfoil round the oscillator valve, and earth it. This cured a tendency for speech to be modulated by a ripple which, on a strong signal, often developed into genuine motor-boating.

I anticipated that having to carry one side of the heater wiring for the second, fourth, and fifth valves through the two screening boxes, without being able to twist it with its opposite number, would be sure to introduce a certain amount of hum, but this is certainly not the case.

I found one small error in the practical wiring diagram, i.e.. that the lead shown coming through hole No. 12 in the baseboard should be connected to the bottom right-hand contact of the four-pole switch, not the top right-hand contact. This is easily verified by reference to the theoretical diagram.

In conclusion, I can only say that your contributors, Mr. Sowerby and Mr. Dent, are to be congratulated on having produced a really outstanding receiver which goes far towards solving the interference problem. N. HENDRY (G6FG).

Newcastle-upon-Tyne.

BROADCASTING GRAMOPHONE RECORDS.

Sir,—My interest has been aroused by the correspondence in your columns re above. The argument that "*re*-canned canned music" is intolerable does not appear to hold water. Providing the records are as good as the best now obtainable, and the transmission up to the B.B.C.'s best standard, I can see no reason against records and many for them.

The best argument for them was given by the B.B.C. on Christmas Day, when for three hours they transmitted what I consider was the best programme they have ever put out, and this was entirely gramophone records, most ably selected and played by Mr. Christopher Stone. Of my household and visitors, totalling 11 persons, only three knew that records were to be played, and I faded out all announcements between records (listening with 'phones myself, so as to fade in at the right moment), and not one of the eight other listeners could tell that they were being given records, until it began to dawn on them that the studio could not possibly give such a variety of good music, etc., in so short a time. I then "let the cat out of the bag" and the non-wireless ones were amazed to find they had been *all* records.

May I ask those who are against the broadcasting of records which they prefer? Direct performances by the usual stock B.B.C. artistes, small orchestras, etc., few of whom can be classed as in the first rank, or record recitals by absolutely the world's (not England's only) finest artistes. Is not a record of the Philadelphia Symphony Orchestra better than a direct transmission of "somebody's Quintette," when both are transmitted by radio? Or would we not rather hear Chaliapin on a record occasionally than some second-rate small concert-hall artiste? Certainly we want the latter sometimes, but we also ought to have the former for a change.

From the point of view of quality, is there any difference between the two methods from the majority of our relay and some main stations, with their long land lines, wireless link, etc.? Ask Newcastle listeners if they could tell any difference!

Besides, record transmission is far cheaper.

London, E.C.2. L. PHILLIPS.

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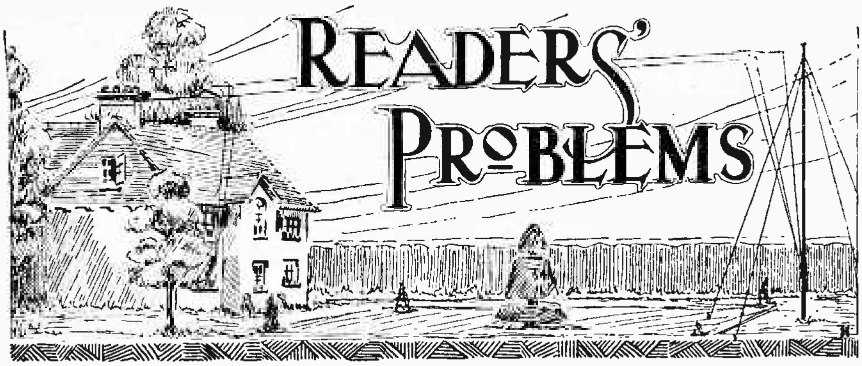

Replies to Readers' Questions of General Interest.

Technical enquiries addressed to our Information Department are used as the basis of the replies which we publish in these pages, a selection being made from amongst those questions which are of general interest.

Matched Coils.

It is noticed that the majority of coils for the ganged-control receivers described in your journal are wound on ribbed bakelite or ebonite formers. As an alternative, would it be permissible to wind them with enamelled wire in grooves cut in ebonite tubes with the help of a screw-cutting lathe?

Provided that reasonably good ebonite is used, there is no reason why coils should not be wound in this manner; indeed, it seems probable that it would confer certain advantages, as accurate matching of inductances could easily be ensured.

Efficiency of Filter Coils.

In a case where interference from a near-by station of high power is a really serious problem, is there any advantage in using "good" coils in a band-pass filter? It is realised that the separation between the peaks of the resonance curve will be determined by coupling, but I am wondering whether the width of the "skirt" or base of the curve can be decreased by using windings of lower H.F. resistance than those usually specified.

Although coils of high efficiency do not confer the same advantage in a filter as in a simple tuned circuit, it is a fact that the base of the resonance curve becomes

tion (depending, of course, on the voltage range covered). This current is low in comparison with that passed by an output valve, a power grid detector, or a low-impedance L.F. amplifier, and so the instrument will give sensibly accurate readings when used for measuring eliminator outputs which feed valves performing these functions. But a considerable error will arise when measuring the voltage applied to, say, an anode bend detector or an H.F. valve screening grid, where the current normally consumed is comparable with, or less than, that taken by the meter.

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Too Much Magnification?

My A.C. mains set, with resistance- and transformer-coupled low-frequency stages, works very satisfactorily, except when the post-detection volume control is "full on." Instability and L.F. oscillation is produced when an attempt is made to obtain full magnification.

Will you please make some suggestions as to how a cure may be effected?

We expect that your trouble is really due to excess of magnification; it is extremely difficult to handle the maximum gain obtainable from two stages with modern A.C. valves.

More effective decoupling devices—feed resistances of higher value, larger by-pass condensers, etc.—would help, but, unless surplus H.T. voltage is available, you may find it impossible to put this suggestion into practice. Probably it will be best to reduce magnification.

THE WIRELESS WORLD FOUR.

THE interest which the publication of the design of THE WIRELESS WORLD FOUR has created amongst our readers has resulted in an overwhelming volume of correspondence on this receiver. In the course of replying to questions an analysis was made of readers' requirements and the article "Hints on Building THE WIRELESS WORLD FOUR" which appeared in the issue of December 10th, 1930, was prepared to meet readers' needs and difficulties, practically all of which are covered by this article, with the exception of requests for modifications to the original design.

We take this opportunity of pointing out that we are not prepared to give suggestions for the modification of all-mains receivers, since often quite small departures from the original plan necessitate a complete revision of the design.

Readers who are now building the Battery Model WIRELESS WORLD FOUR are reminded that additional information on construction is contained in the article which appeared in the issue of December 10th, and they should also refer to the original articles on the all-mains operated set which appeared in the issues of October 15th and 22nd, 1930.

However willing we may be to assist our readers by replying individually to their enquiries, we now find that the enormous volume of correspondence makes it no longer possible even to contemplate sending replies through the post. We wish to point out, also, to those readers who are contemplating the construction of the set, that our experience is that difficulties met with have invariably been traced to modifications in the design or the substitution of different valves or components. We have overwhelming evidence from our correspondence to show that those who have followed precisely the instructions given have had the utmost satisfaction from the receiver.

Whilst being obliged to decline to reply individually through the post to enquiries we may receive, we shall do our utmost to give general assistance to constructors through the pages of this Journal.

A Source of Inter-stage Coupling.

Is it possible that H.F instability might be caused by induction between the conductors of a multi-strand battery cable? I have just added a second H.F. stage to my receiver, and so far have been unable to prevent self-oscillation, although all the usual preventive measures have been tried.

It is just conceivable that instability might be due to this cause, but if the battery circuits are properly decoupled—as they should be in a two-stage H.F. amplifier—harmful interaction cannot take place.

narrower as coil resistance is decreased. But the gain in this direction is generally considered to be insufficient to compensate for such drawbacks as tuning difficulties and lack of compactness.

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Eliminator Voltage Measurement.

I am thinking of obtaining a voltmeter having a resistance of 1,000 ohms per volt. Can it be assumed that this instrument will give a sufficiently accurate reading of eliminator output voltages?

A voltmeter of this type will consume about 1 milliampere for full-scale deflec-

Inductance and Periodicity.

With regard to the L.F. choke described in your issue of October 29th, 1930, will you please tell me how it should be modified for use on a 25-cycle mains supply?

It should be made clear that the design of a choke is not directly affected by the periodicity of the mains supply with which it is to be used. You do not give any particulars as to the purpose to be served by this component to help us in advising you, but it may be quite adequate for smoothing if the capacity of the associated condensers is increased.

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Band-pass Detector Unit.

If it is practicable, I should like to make up a detector unit—for local-station reception—to be operated in conjunction with the "Independent Gramophone Amplifier" described in your issue of December 24th. I already have the "Band Pass Unit" ("The Wireless World," August 27th, 1930), and propose to use the tuning system of that unit. Will you please give me a circuit diagram, with suggested values?

The amplifier in question is quite suitable for operation with a detector unit. We give a diagram of connections in Fig. 1, from which you will see that extra terminals must be added to the amplifier for feeding L.T. to the detector heater and H.T. supply for its anode.

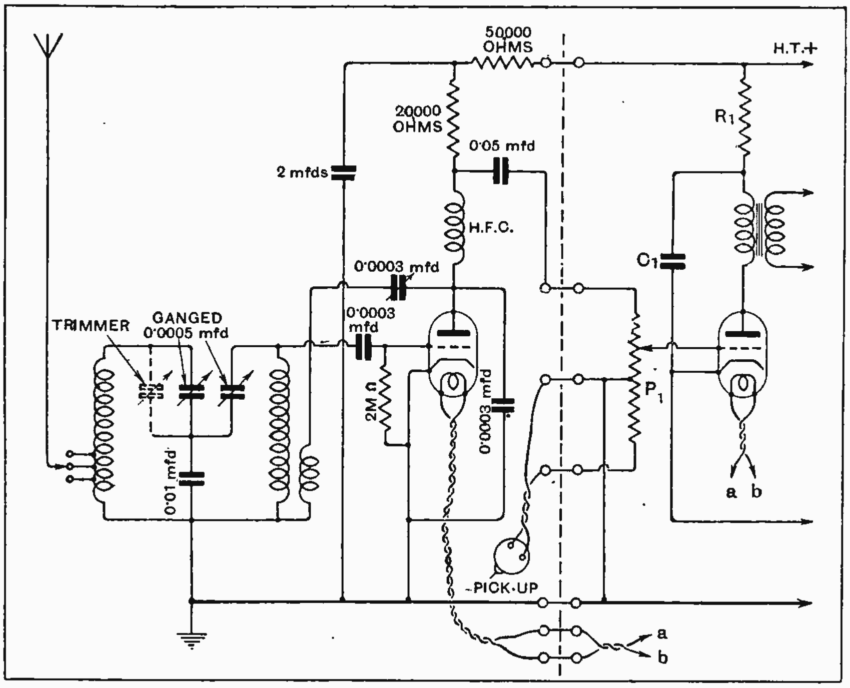

Fig. 1.—The "Independent Gramophone Amplifier" combined with a band-pass tuning and detector unit.

The potentiometer P_1 will serve as a switch for changing over from radio to gramophone reproduction and vice versa.

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Long-wave Inductances.

As it is desired to ensure the best possible reception of long-wave signals, would it be worth while to wind the tuning coils for this band in the form of single-layer coils? The tuning condensers of my new receiver are to be ganged, and I should imagine that perfect matching of inductance values and self-capacity would be more certain than if the coils were wound in sections in the usual way.

Your assumption is correct enough, but we do not consider that the matter is of any great importance. Possibly hand-made coils could be more evenly wound as single-layer solenoids, but machine-made sectional coils have proved very satisfactory in practice.

Tapped Coupling Inductance.

I have just constructed an H.F.-det.-L.F. set with an inductively coupled aerial input filter. As I had rather anticipated after reading your article dealing with this method of coupling it is found that tuning is unduly broad at the lower end of the tuning scale, and I have decided to make provision for using a smaller common inductance for reception below 350 metres.

Will it be satisfactory if a tapping is made on the present coupling coil, or do you advise me to use an entirely separate winding?

A tapped connection will be quite adequate for this purpose. Your idea of providing for alternative values of coupling is a good one, but a complication will arise if the tuning condenser for the H.F. stage is "ganged" with the filter tuning system; in this case some form of compensation will be necessary.

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Improving High-note Response.

The output of my loud speaker seems to be deficient in the upper register, and I am thinking of replacing the existing triode output valve by a pentode. A tapped filter choke will be used in conjunction with a tone corrector consisting of a resistance and condenser, as included in several receivers described in your journal. Will it be in order to use conventional values (25,000 ohms and 0.01 mfd.) for the correcting circuit?

As it is desired to over-emphasise the higher frequencies, a smaller capacity than that usually specified is indicated in your case. We suggest a capacity of 0.005 mfd.

Input Volume Control.

I am about to fit an input volume control, consisting of a differential condenser with a compensating capacity to reduce change of tuning brought about by operation of the control. Would it be better to employ a condenser with "straight line capacity" or "logarithmic" vanes for this purpose?

A differential condenser with semi-circular moving vanes will be the most generally satisfactory type for regulating input from the aerial.

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Mains Feed for Short-wave Reception.

Would it be possible to supply anode current for the two valves of the "Short-wave Superheterodyne Adaptor" ("The Wireless World," April 23rd, 1930) from the same eliminator which is normally used to feed the four-valve receiver with which the adaptor is operated?

If the eliminator output is adequately smoothed, it would be suitable for feeding the detector valve of the adaptor, but we do not recommend this source of supply for the oscillator valve. Any trace of ripple will modulate the oscillations generated by it, and will produce hum.

FOREIGN BROADCAST GUIDE.

BARCELONA (EAJ 1)

(Spain).

Geographical position: 41° 22′ N. 2° 11′ E.

Approximate air line from London: 720 miles.

Wavelength: 349 m. Frequency: 860 kc. Power: 8 kw.

Time: Greenwich Mean Time.

Standard Daily Transmissions.

11.00 G.M.T., chimes (Sun.); 13.00, concert; 15.00, broadcast to hospitals and prisons; 17.30, dance music; 18.00, relay of opera from *Teatro del Liceo* (Sun.); 20.15, main evening programme; 21.00 - 24.00, gramophone records (Sun.); chimes; relay of opera (Tues., Thurs.), or outside broadcast. Regularly relays Madrid (EAJ 7) on Saturdays.

Opening signal:

No interval signal.

Male announcer. Call: (phon.) *Akky esta-see-own-ayc oon-aye-own rah-dee-owe Barth-ell-owna* (Here is station EAJ 1 Union Radio Barcelona).

Closes down with Spanish National Anthem and the words *Buenas Noches, Senoras y Caballeros; hasta mañana si Dios quiere* (until to-morrow if God so wills it).

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AND RADIO REVIEW
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As many of the circuits and apparatus described in these pages are covered by patents, readers are advised, before making use of them, to satisfy themselves that they would not be infringing patents.

Editorial Comment

Identification Signals.

AFTER contemplating the matter with becoming deliberation for some three years, the B.B.C. has at last adopted an interval signal to serve as an indication between the items that the transmitter is still operative, and to assist in station identification.

Some three years ago a good deal of space was devoted in *The Wireless World* urging that identification of signals should be adopted by the B.B.C. in common with most of the transmitters on the Continent, but a variety of excuses were put forward by the Corporation in the attempt to justify themselves for not adopting an interval signal of any kind.

It would almost seem as if the surest way to prevent the B.B.C. from adopting some new scheme is to urge them to do it. The same attitude has, we know, been taken over Empire broadcasting; one cannot but be tempted to think that if the idea of Empire broadcasting had been put forward by the Corporation themselves instead of from an independent source, much more rapid progress would have been made. However, now that an interval signal has been adopted, are we to welcome it and congratulate the B.B.C. or not? Personally, we think that the time had almost come when the absence of an interval signal with the British transmitters was, in itself, sufficient as a means of identification, since practically every other station in Europe has long since adopted a distinctive signal of some kind as a means of identification.

We do not think that the present signal chosen by the B.B.C. is quite a happy one; something less obtrusive might be adopted, as the complaints which we hear with regard to the present signal are that it is apt to become an irritation to the listener, especially when prolonged intervals occur.

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Distant Reception.

LISTENING in company with an experienced American engineer a few days ago we were surprised to find that our American friend expressed himself amazed at the ether congestion in Europe, which he found, in general, to represent a far worse state of affairs than he was accustomed to experience in most parts of the States. He thought that if the allocation of wavelengths to European transmitters has been made on sound lines providing, say, a 10-kilocycle separation between stations, then the majority of these transmitters must be failing miserably to keep within the band allotted. Only the smallest margin of shift is tolerated in the United States, and a station which causes trouble in this way is almost certain to lose its licence and have its place taken by one of the many applicants now on the waiting list hoping for a transgressing licencee's wavelength to be allotted to them.

In This Issue

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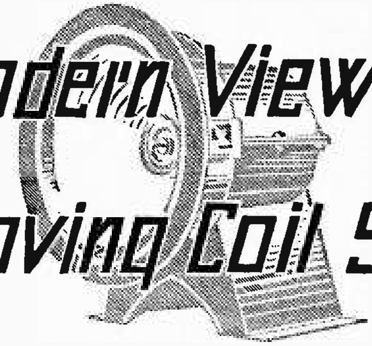

Modern Views on the Moving Coil Speaker

The Important Part Played by Resonances.

By N. W. McLACHLAN, D.Sc., M.I.E.E., F.Inst.P.

A FEW years ago the moving-coil loud speaker was regarded as an extremely simple piece of apparatus. Anyone could make one, provided he were supplied with a suitable circular magnet. The results were at first rather bewildering after the strange mutterings of horns two feet long whose variety of shape and tone was legion. With time we grew more and more critical—partly because nothing can be perfect—until it was recognised that no two moving-coil loud speakers sounded alike. The truth slowly dawned upon us that the device contained something in addition to that which met the naked eye; in fact, the more we studied the contraption the greater became our amazement as to its complexity. To take a simple example: some years ago I sat down to write out the various forms of electrical, mechanical and acoustical distortion pertaining to a moving-coil speaker, and gave it up at the *sixteenth*—almost round the course. In fact, as the items piled up one after another, there seemed to be little but evil in one's reproducing agent. Thanks to the accommodating propensities of the human ear, the effect of the inherent distortion is not quite so dreadful in practice as would appear from theory.

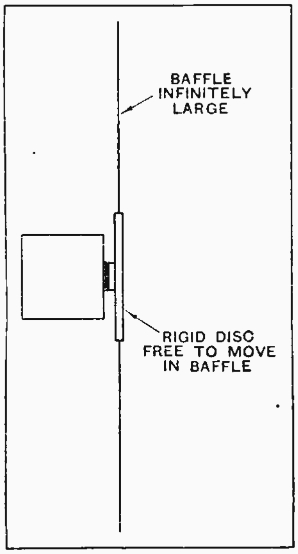

Fig. 1.—Illustrating coil-driven rigid disc in baffle of infinite extent.

It is usually accepted that resonances are undesirable, but I hope to show that without them the moving-coil loud speaker would be an absolute failure. To do this it is necessary to consider the effect of using a coil and a circular disc which moves as an absolutely rigid structure at all frequencies. It is realised that with the dimensions and masses of coils and diaphragms to which we are accustomed, a structure of this nature cannot be a practical reality at present! If such a structure were available, it would emit no sound when tapped by hand, because the natural frequency of vibration would be outside the audible register. Personally, I could never quite understand why in the beginning—say 1925—so many people imagined that cones moved like pistons, i.e., as a whole, because they always emit a sound when tapped.

The Problem of interference.

Fig. 1 shows diagrammatically a rigid disc coil-driven system with a baffle of infinite dimensions. What we have to do is to deduce mathematically the sound output on, say, one side of the disc over the frequency band 50 to 8,000 cycles per second. I solved this problem[1] early in 1926, and some of the results—minus the

[1] See *Phil. Mag. Supplement*, pp. 1011-1038, June, 1929, for complete solution.

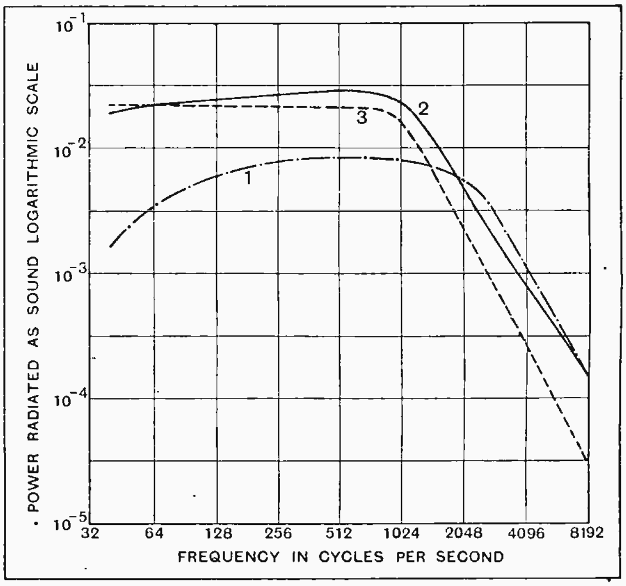

Fig. 2.—Curves illustrating power radiated by coil-driven rigid discs at various frequencies. Curve 1 shows a disc 5 cm. radius (4in. diameter); curve 2 a disc 10 cm., radius (8in. diameter); and curve 3 a disc 15 cm., radius (12in. diameter).

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Modern Views on the Moving Coil Speaker.—

mathematical formulæ—were published in *The Wireless World*, March 30th and April 13th, 1927. The total power radiated as sound from both sides of the device at various frequencies is shown graphically in Fig. 2 for discs of different diameters. With a disc 4in. in diameter (curve 1), the output is small over the frequency band 50 to 8,000 cycles. It is greater for discs 8in. (curve 2) and 12in. in diameter (curve 3), but in all cases the power falls away very rapidly above 1,000 cycles per second. In fact, this frequency can be regarded as a cut-off point. At 8,000 cycles the energy is only 1-100th that at 50 cycles when the disc is 8in. in diameter. The query immediately springs to mind, why does the output decay so rapidly above 1,000 cycles?

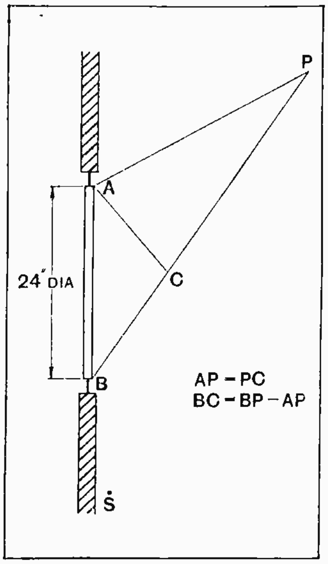

Fig. 3. — Showing that an appreciable difference exists between the distances from a point P in space to diametrically opposite edges of a large disc. When BC = half a wavelength the radiation from opposite sides of the disc will practically cancel out at P.

This was explained fully in *The Wireless World* some time ago,[2] but it may be well to refresh the reader's mind on the subject. If we have a vibrating disc, as in Fig. 3, the sound from A reaches P before that from B. Since sound is propagated as a series of waves, and as waves have troughs and crests, if the crest of a wave from A and a trough from B reach P simultaneously, they will annul each other. The sound at P will, therefore, be zero. This effect is known as "interference," and it is due to this that the energy at high audio-frequencies is confined to a narrow beam, as shown in Fig. 4. Actually, the sound energy in the space at the sides of the disc annihilates itself, due to the differences in phase or time of arrival of the sound (at any point) from the various elemental areas which constitute the surface of the disc.

The Breaking-up of Conical Diaphragms.

The fact remains, moreover, that the academic or hypothetical coil drive, i.e., the rigid-disc type, has no upper register, excepting at points on or near the axis of the disc where the reproduction would be all but perfect. Now, the reader knows from actual experience that coil-driven cones sometimes have a very powerful upper register. In general, the coil-drive speaker has a strong resonance which usually lies between 2,000 and 3,500 cycles, although it (or another type of resonance) is sometimes higher, and causes the "esses" to whistle. Obviously, here is a little freak of nature, because it was firmly believed in certain quarters that coil-driven diaphragms moved as a whole and had no resonances. The problem in designing coil-driven diaphragms is to fix the resonances in appropriate places and to reduce their magnitude so that no perceptible accentuation of any frequency or band of frequencies occurs.

The "breaking-up," or resonating, of conical diaphragms was discussed in this journal some time ago (*The Wireless World*, July 10th, 17th, 1929, also Patent 288713), but we can again refer to the subject in greater detail. With fairly flat cones of rough paper, the break-up phenomenon can be demonstrated with the aid of lycopodium powder, which lies on the nodes—on either side of which the diaphragm moves in opposite directions.[3] With the average diaphragm other means have to be adopted. By using a neon lamp—of respectable length—driven at nearly half[4] the frequency of the diaphragm the latter can be "seen to move." The frequency to either the lamp or to the diaphragm is increased or decreased until the latter is seen in slow motion—stroboscopcially. To get results easily, a flexible diaphragm structure should be used, e.g., a thin cardboard disc or

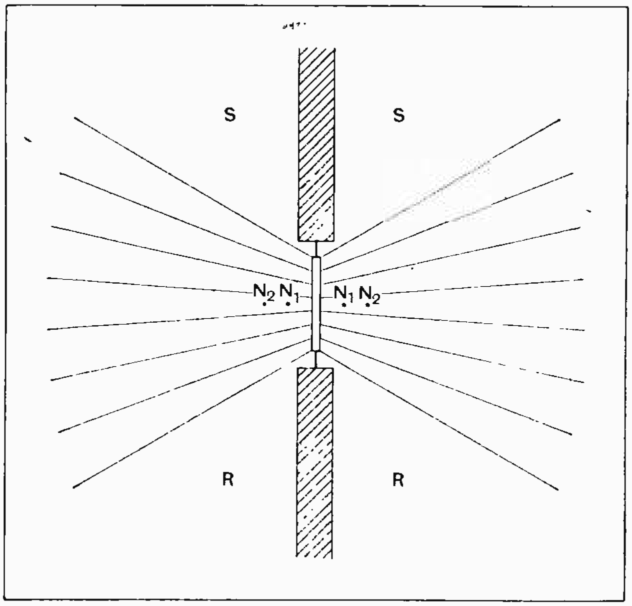

Fig. 4.—Beam of focusing effect at high frequencies due to interference in the regions R and S. Nodes, or points, of zero pressure are represented by N_1N_2.

a fairly flat paper cone with a free edge, so that the latter bends easily. At low frequencies (30 to 100 cycles) the amplitude of the diaphragm at the edge is quite large, provided the input to the driving mechanism is adequate and the paper fairly thin. Eddy currents are created at the antinodes (places of maximum motion at the edge of the diaphragm) and there is sufficient draught

[2] *The Wireless World*, p. 345, March 23rd, 1927, p. 357, Sept. 21st, 1927, and Proc. Roy. Soc. A. 122, pp. 604-609, 1929, for mathematical analysis underlying axial pressure (also *Phil. Mag., loc. cit.*, Fig. 8) and pressure distribution in space round rigid disc.

[3] It should be observed that where cones are concerned the term "node" does not mean a point of absolute rest. It means that the motion in a certain direction is zero.

[4] Results can also be obtained when the frequencies are almost equal or greater than the diaphragm frequency, but the above method is better.

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Modern Views on the Moving Coil Speaker.—
to extinguish a lighted match. This little stunt is quite fascinating, and can be tried by any experimenter who is able to produce from 30 to 100 cycles or can use the A.C. mains direct, *via,* of course, a suitable regulating resistance or reactance.

It is impossible to describe all the methods of producing the desired effect, but the following may be of some assistance to those wishing to make draughts. If 50-cycle mains are available this will operate one neon lamp, or several in parallel to get more illumination. The diaphragm can be driven at nearly 100 cycles per second from a pick-up and standard frequency record *via* the amplifier. By varying the speed of the turntable the slow motion picture can be obtained. This latter arrangement can also be usefully employed to find the resonance frequency of a diaphragm on its surround, when the amplitude will be very large. If the pick-up refuses to stay on the record, use one of higher frequency (smaller grooves) and reduce the speed of the turntable.

Personally, I run the neon lamps from one variable frequency oscillator with amplifier, whilst supplying the driving current for the diaphragm from another oscillator-amplifier run at nearly double the frequency of the former.

When the cone is seen in slow motion and two or more parts of the edge are moving inwards and outwards, say, half an inch, the draught can be felt with the hand, more particularly if it is wetted by petrol, eau de Cologne, or methylated spirit. For those who have no neon tube the eddies (and the nodes on the diaphragm) can be explored with either a gas jet or a lighted match. If the flame is moved round the edge of the diaphragm it will be blown most violently at the antinodes or points of maximum amplitude, whilst at the nodes there will be comparative calm.[5]

[5] The input to the speaker must be large to cause a strong draught.

(To be concluded.)

PRINCIPAL TIME SIGNALS OF THE WORLD.

Particulars of Signals from Other Important Stations are Included from Time to Time.

See also our issues of September 17th and December 17th, 1930.

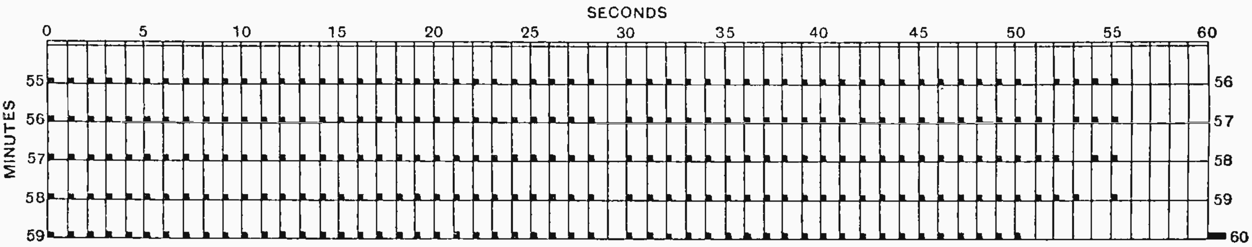
HONOLULU—PEARL HARBOUR, NPM (HAWAII).

Wavelength : 26.1 kilocycle (11,490 metres), and 106 kC. (2,828 m.).
Time of Transmission : 23.57–00.00 G.M.T.
U.S.A. Time Signals (last three minutes only of new code).

Signals also transmitted from :

WASHINGTON—ANNAPOLIS, NSS (U.S.A.).

Wavelengths : 17.8 kC. (16,840 metres), 12,045 kC. (24.9 m.), and 16,060 kC. (18.67 m.).
Times of Transmission : 02.57–03.00 on 12,045 and 17.8 kC. 07.57–08.00 on 17.8 kC. 16.57–17.00 on 16,060 and 17.8 kC. (G.M.T.)



U.S.A. Time Signals (New Code).

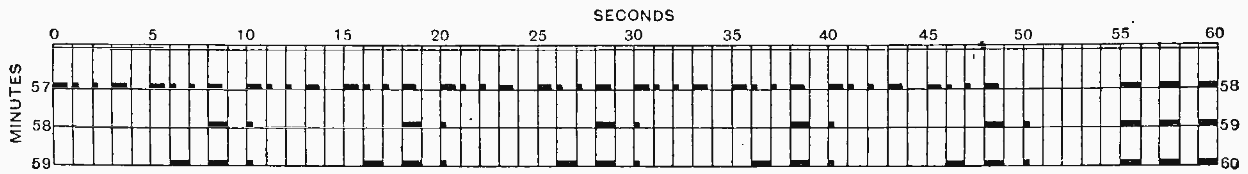
WASHINGTON—ARLINGTON, NAA (U.S.A.).

Wavelengths : 12,045 kC. (24.9 m.), 8,870 kC. (33.82 m.), 4,015 kC. (74.7 m.), 690 kC. (434.5 m.), and 113 kC. (2,653 m.).
Times of Transmission : 02.57–03.00 on all above wavelengths, except 12,045 kC. 07.57–08.00 on 8,870 kC. and 113 kC. 16.57–17.00 on all above wavelengths; and also on 16,060 kC. (18.68 metres). (G.M.T.)
U.S.A. Time Signals (last three minutes only of New Code) **(from Naval Observatory, Washington)**

In the event of Arlington being out of action, signals are transmitted from New York, NAH (on 2,939 metres), Charleston SC, NAO. Norfolk, Va., NAM, and Great Lakes, NAJ, all on 2,458 metres at 17.00 G.M.T. (last three minutes only of U.S. System, New Code).

CADIZ, EBC (SPAIN).

Wavelength : 430 kilocycles (700 metres).
Times of Transmission : 12.56–13.00 G.M.T.
Preliminary Signal : A series of O's – – – .
International (Onogo) Time Signal (from San Fernando Marine Observatory).



Old International (Onogo) System adopted at the Conference Internationale de l'Heure, 1912-1913.

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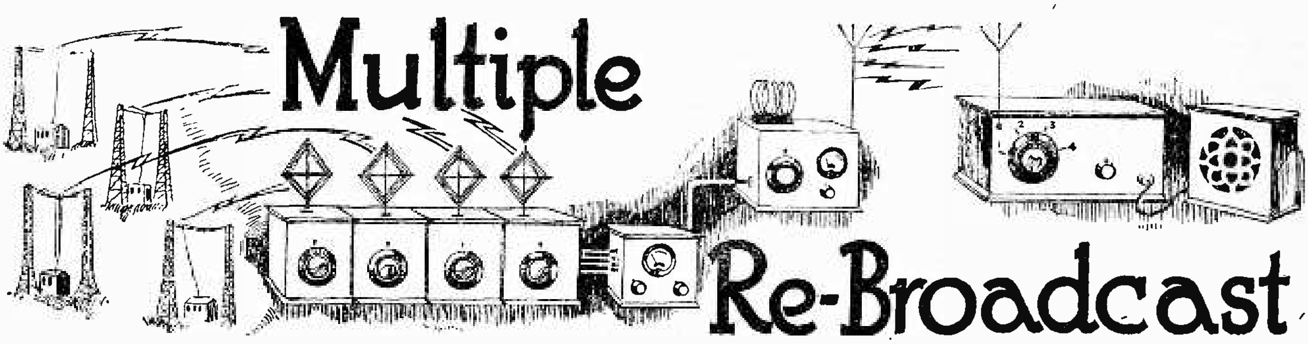

Multiple Re-Broadcast

An Interesting Scheme for Long-distance Reception in Cities.

IN *The Wireless World* for December 3rd, E. Schwandt described an interesting project of Manfred von Ardenne's in which a central receiving station in the quiet of the country, equipped with all the latest refinements—anti-fading devices and so on—was to receive, amplify and hand on the complex mixture of radio-frequencies representing five or six programmes received from foreign stations, to a corresponding number of small-power relay transmitters grouped round the city's local station; each of these relay transmitters would pick out the band representing its allotted station, and would relay that band at full power. The central receiving station would transmit the mixed radio-frequencies to the city transmitters either by a line or by an ultra-short wave link.

At a meeting at which von Ardenne's paper on this scheme was read, a number of rather severe criticisms were expressed. The critics doubted whether the 300-500-watt relay transmitters would be effective in view of the simultaneous working of the big local station; and, anyhow (said these critics), how about ructions with other countries if our relay stations start re-radiating *their* particular wavelengths? And how about zones of interference (as is often experienced in common-wave broadcasting) between relayed and direct signals? And what about the expense of numerous relay transmitters? and so on.

As a result of this healthy criticism, von Ardenne has thought again, and has speedily brought out a modified form of the scheme. In an article in the issue of *E.T.Z.* for November 20th, he describes it as avoiding the points subjected to criticism in his first scheme, and also the weak points of Esau's plan for ultra-short wave broadcasting—which one of his critics had exalted. Esau apparently, has only got as far as thinking of one programme, one ultra-short wavelength; to convey a number of programmes, therefore, he would have to use a number of ultra-short wave channels—which would be extravagant in ether and would lead to trouble in separation at the receivers.

So von Ardenne, wishing to adopt Esau's ultra-short wave broadcasting for his new scheme of long-distance reception, first of all revolutionises it so as to get over this difficulty. This he does by treating his ultra-short waves with what really seems to approach disrespect. He proceeds to take a single ultra-short carrier wave and modulates this, not with audio-frequencies representing a programme, but with several radio-frequencies in the broadcast region of 200-300 metres. Each of these radio-frequencies is modulated with the audio-frequencies of one programme. The one ultra-short wave therefore carries four or five broadcast-frequency bands each representing one programme—and here, straight away, apart from special applications, you have the possibility of multiple broadcasting on a single ultra-short wave.

Now to adapt this to his long-distance reception scheme, von Ardenne proposes to have his ultra-short transmitter (fed by his interference-free central receiving station) at a short distance from a densely populated area, radiating a rather broad beam over the latter. The idea of relay stations re-radiating on the original wavelengths of the distant stations is completely washed out. Each listener has an ultra-short wave receiving set with detector (see Fig. 1). After rectification, what is left is the group of several broadcast-region frequency bands which originally modulated the short-wave carrier, and these can be dealt with by the ordinary broadcast receiver just as if they came direct from their respective foreign stations.

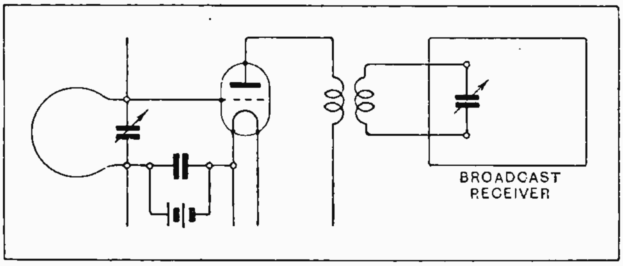

Fig. 1.—Each listener would require a simple ultra-short wave adaptor to be coupled to the ordinary broadcast receiver.

Fig. 2 shows the whole scheme. On the left you see the four separate receivers at the central receiving station, each having its own frame aerial, its own fading-compensator, and its own H.F. amplifier and band filter. Each receiver passes on the partly amplified radio-frequency band received from its particular distant station to the common, aperiodic H.F. power amplifier (3), which still further amplifies the mixture and passes it on by line (4) to the ultra-short transmitter (7); losses on the way are made up for by the aperiodic repeater at (5). The apparatus marked (6) is a complication

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Multiple Re-Broadcast.—
which only comes in to enlarge the possibilities of the scheme so that instead of only re-broadcasting foreign programmes, several programmes originating locally or received at (6) by telephone line or cable can be simultaneously broadcast instead. To do this, the received audio - frequencies must be made to modulate a broadcast - frequency wave or waves, so that these in their turn may be impressed on the single ultra-short carrier; hence (6) is a local radio - frequency generator complete with modulator and aperiodic amplifier.

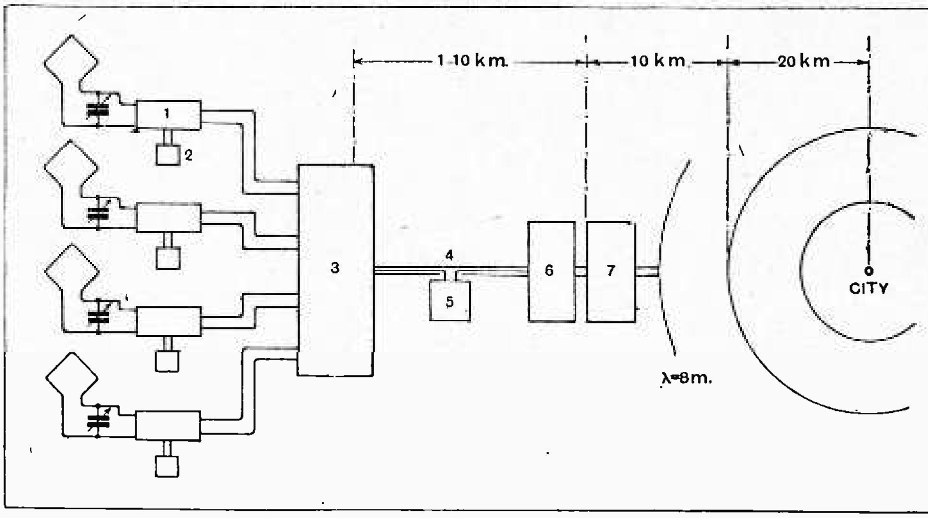

Fig. 2.—Schematic diagram of multiple rebroadcast arrangement. On the left are four separate receivers at the central receiving station which feed into an aperiodic H.F. power amplifier 3. This is followed by a repeater 5 and an ultra-short-wave transmitter 7.

In his article, von Ardenne goes into a few details as to the quantitative aspect of the scheme—the width of the side-bands, the necessary proportions of power, and so on. Thus he points out that the modulation of an eight-metre carrier by the shortest broadcast frequency, 200 m., causes only a four per cent. displacement from the carrier frequency; and that the half-amplitude breath on the resonance curve of an average ultra-short wave receiver circuit, with detector, is many times that. After rectification, therefore, all the broadcast-frequency waves will appear in their original proportions of amplitude. He ends by remarking that his tests have already shown that no serious difficulties exist either in transmitting or in receiving, and that the time seems ripe for a test on a large scale.

D'O. B.

CLUB NEWS.

All About Magnetos.
How rotary transformers and converters are made was explained with lantern illustrations by Mr. Woodall, of the M.L. Magneto Syndicate, at a recent meeting of the Tottenham Wireless Society. The lecturer showed the manufacturing processes from first to last, and described the strides which had been made in recent years in reducing overall size and increasing the efficiency of magneto machines.

The Society has a number of vacancies for new members. All interested are asked to communicate with the Hon. Secretary, Mr. W. B. Bodemeaid, 29, Pendennis Road, Tottenham, N.17.

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Members as Specialists.
An innovation was introduced at a recent meeting of Slade Radio (Birmingham), when members were able to help each other on three perplexing problems.

Questions on the first topic—rectifiers—were answered by Mr. G. T. Peck. Problems connected with the choice of an L.F. transformer were answered by Mr A. F. Poynton, while Mr R. Heaton dealt with the subject of instability in receivers.

Full particulars of membership of the Society can be obtained from the Hon. Secretary, 110, Hillaries Road, Gravelly Hill, Birmingham.

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Programmes on Request.
The Wembley Wireless Society, probably one of the oldest in the country, resumed its weekly meetings on Friday last, with a discussion on recent receiving sets.

An interesting programme has been prepared for the second half of the winter session, and copies can be had on application to the Hon. Secretary, Mr. H. Comben, B.Sc., 24, Park Lane, Wembley.

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Is Wireless a Curse?
That wireless is a curse to any home was the surprising opinion put forward by a participator in a debate held by the South Croydon and District Radio Society at a recent meeting. The speaker contended that either the programme chosen displeased at least one of the household, or the loud speaker was too loud or too soft!

Other speakers championed the claims of wireless, and the condemnatory speaker found himself in a minority.

The Society has opened a New Year campaign for new members. Full particulars will be gladly supplied by the Hon. Secretary, Mr. E. L. Cumbers, 14, Campden Road, S. Croydon.

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All About Public Address Systems.
High power public address equipment was described at a recent meeting of the Tottenham Wireless Society when a representative of the Marconiphone Company delivered a lantern lecture dealing with all phases of public address amplification. Pictures were thrown on the screen showing giant moving-coil speakers, a mobile amplifier for use in public places, and permanent equipment installed in the House of Lords and Bath Abbey. Interesting details were given of the technical difficulties encountered when installing equipment in public places.

Hon. Secretary, Mr. W. B. Bodemeaid, 29, Pendennis Road, N.17.

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FORTHCOMING EVENTS.

WEDNESDAY, JANUARY 21st.
Muswell Hill and District Radio Society.—At 8 p.m. At Tollington School, Tetherdown, N.10. Lecture: "Microphones and Sound Amplifying Apparatus," by Mr. L. Paddle (Igranic Electric Co., Ltd.). Also a demonstration of "Ekco" products.

THURSDAY, JANUARY 22nd.
Golders Green and Hendon Radio Society.—At 8.15 p.m. At 30, Temple Fortune Parade, N.W.11. Lecture: "How to Detect and Remedy Faults in Radio Receivers (with constructional hints)," by Mr. Scott Sessions.
Slade Radio (Birmingham).—At 8 p.m. At the Parochial Hall, Broomfield Road, Erdington. "Junk Sale." Members are asked to bring surplus apparatus (and cash!).

MONDAY, JANUARY 26th.
Cambridge University Radio Society.—Lecture: "Rectification, with Special Reference to Westinghouse Metal Rectifiers," by a representative of the Westinghouse Brake and Saxby Signal Co., Ltd.

TUESDAY, JANUARY 27th.
Birmingham University Radio Society.—Lecture: "Westinghouse Metal Rectifiers."

Next Summer's D.F. Schemes.
Amongst the recent activities of the Golders Green and Hendon Radio Society was an interesting debate on Direction Finding schemes. Representatives from the North Middlesex, Western Postal Radio Societies were present, and took an active part in the meeting.

It was unanimously agreed that the schemes should be continued, but that, instead of a fixed transmitting station and mobile D.F. groups, the transmitting station should be mobile and the groups, working in pairs, should be fixed.

The Society's meetings are now held at "Ark," 30, Temple Fortune Parade, N.W.11. Hon. Secretary, Lt.-Col. H. A. Scarlett, D.S.O., 60, Pattison Road, N.W.2.

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Talking Pictures.
The last two or three years have seen a great merging, as it were, of the radio science with that of the gramophone. One of the most important developments of this has been the advent of the sound film, and if only on this account the recent lecture before the Muswell Hill and District Radio Society given on the subject of Talking Motion Pictures by Mr. Hind, of the Western Electric Company, was of particular interest. It was enhanced to no small degree by the showing of a comprehensive series of lantern slides depicting many of the stages in the making and reproduction of a talkie. Portable equipments came in for quite a considerable amount of discussion.

Hon. Secretary: Mr. C. J. Witt, 39, Coniston Road, N.10.

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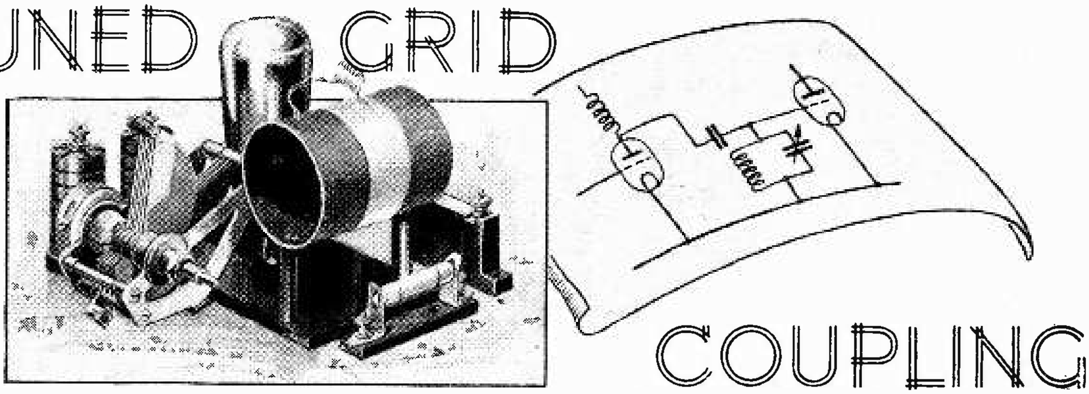
The TUNED GRID COUPLING



The Influence of the High-Frequency Choke.

By S. O. PEARSON, B.Sc., A.M.I.E.E.

IN dealing with the tuned anode coupling it was explained that all the components comprising the intervalve circuit are virtually in parallel with each other, the coupling condenser being the only exception. Owing to the fact that the reactance of the coupling condenser is in normal circumstances small compared with the impedances of the other components, it was shown that this condenser could be omitted from the equivalent A.C. circuit without introducing any appreciable error into the calculation of the stage gain and the selectivity. Thus, the tuning coil, the tuning condenser, the grid leak and the inter-electrode capacities of the valves could be treated as though they were all truly in parallel.

The tuning coil and condenser, of course, constitute the most important part of the circuit, the grid leak and bias battery being included merely for the purpose of maintaining the grid of the second valve at a suitable mean potential, whilst at the same time allowing it to follow the required signal variations.

Suppose now that the positions of the tuned circuit and the grid-leak resistance are interchanged. The resistance R_1 would then be in the anode circuit of the first valve and the tuned circuit LC would be connected between the grid of the second valve and the negative terminal of the grid-bias battery, the circuit then being as shown in Fig. 1. In spite of this change the various components are still virtually in parallel, only their positions having been interchanged, and therefore the circuit is fundamentally the same as the orthodox tuned anode coupling, the method of calculating the stage gain being identically the same. But an examination of Fig. 1 will show that the high-tension feed current to the first valve now has to flow through the high resistance R_1, and if this resistance had a value of a megohm or more, the voltage drop in it would be so large that the anode itself would only be a few volts positive with respect to the cathode of the valve, which would therefore cease to function properly.

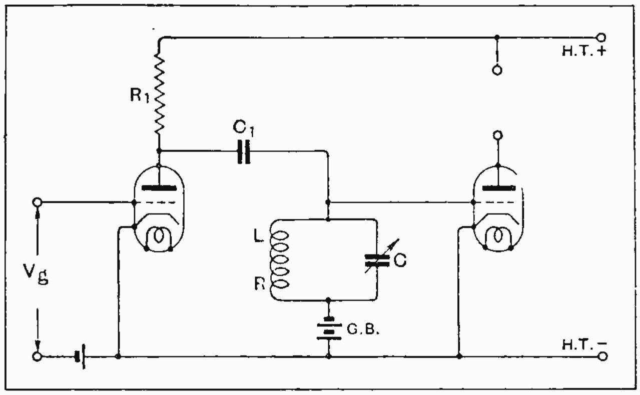


Fig. 1.—A circuit which results when the grid leak resistance and the tuned circuit of the tuned-anode coupling are interchanged. The arrangement is not very practical on account of the voltage drop in the resistance R_1.

In the tuned anode arrangement the high-tension current flows through the tuning coil, which has only a few ohms resistance, so that the anode is very nearly at the same potential as the positive terminal of the high-tension source.

Separation of H.F. and D.C. Components.

The voltage drop in the anode resistance R_1 of Fig. 1 could, of course, be reduced by decreasing the value of R_1, but it must be remembered that this resistance is virtually in parallel with the tuned circuit itself, and therefore goes to diminish the dynamic resistance of the latter. For instance, if R_1 were made equal to the dynamic resistance of the tuned circuit alone then the dynamic resistance of both would be just half that of the tuned circuit. On the other hand, if R_1 were kept sufficiently high to prevent excessive damping, the high-tension voltage supply would have to be made abnormally high from the economic and practical points of view, to ensure that the first valve would function properly.

It is clear that the circuit of Fig. 1 is unpractical solely on account of the voltage drop occurring in the anode resistance R_1. Thus the obvious thing to do is to replace R_1 by a component which will offer a low resistance to the passage of the high-tension current, whilst at the same time offering as high an impedance

The Tuned Grid Coupling.—

as possible to all high frequencies over the range of wavelengths to be received; that is to say, the resistance R_1 must be replaced by a high-frequency choke. When this is done the circuit becomes as shown in Fig. 2.

Here we have an arrangement very similar to the choke-capacity coupling already dealt with, but where the grid-leak resistance is replaced by a tuned circuit; and since the tuned circuit itself behaves, as regards the relationship to the other parts of the circuit, like a non-inductive resistance of L/CR ohms at the resonant frequency, the method of calculating stage gain would appear to be very similar to that for choke-capacity coupling.

The simple equivalent A.C. circuit corresponding to the choke-capacity-tuned grid coupling is indicated in Fig. 3 (a), where R_a represents the A.C. resistance of the first valve, Z_c the impedance of the choke in its anode circuit, and LRC the tuned grid circuit itself. In this equivalent circuit the coupling condenser C_1 in Fig. 2 would normally have to be included at the point marked Y in Fig. 3 (a). But as the capacity value of this condenser is chosen so that its reactance at all operating frequencies is small compared with the dynamic resistance of the tuned circuit, the condenser may be omitted from the equivalent circuit without making any appreciable difference to the calculated value of the voltage amplification obtained, whilst at the same time greatly simplifying the calculation.

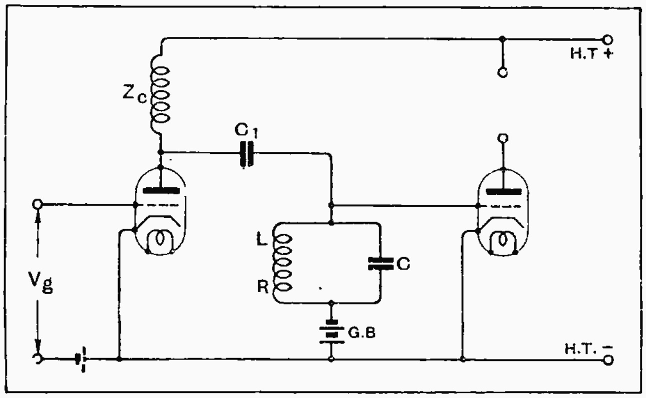


Fig. 2.—The orthodox tuned-grid coupling. The resistance R_1 of Fig. 1 is replaced by a high-frequency choke Z_c.

As in the case of the tuned anode circuit, the inter-electrode capacities of the valves, between the anode and cathode of the first, and between the grid and cathode of the second, are virtually in parallel with the tuned circuit, so that the sum of the tuning capacity C and the stray capacities, together with the inductance of the coil, determine the resonant frequency. Consequently, it will be assumed that the capacity C in Fig. 3 (a) represents the total capacity across the ends of the tuning coil L, including the self-capacity of the latter. It is the product of the inductance and the total capacity that determines the resonant frequency.

The H.F. Choke.

The high-frequency choke Z_c in the anode circuit of the first valve is designed to have a high ratio of reactance to resistance at radio-frequencies and a high value of total impedance. The resistance offered to the D.C. component of current is small compared with the effective anode-to-cathode resistance of the valve itself, and therefore the voltage drop is very slight, the positive potential of the anode being very nearly equal to that of the positive terminal of the source of H.T. current.

The main tuned circuit LRC of Fig. 3 (a) behaves like a simple resistance whose value is $R_d = L/CR$ ohms when the frequency is $f = \frac{1}{2\pi\sqrt{LC}}$ cycles per second, and therefore at this frequency the equivalent A.C. circuit could be still further modified as shown by Fig. 3 (b), the intervalve circuit being then equivalent to a choke in parallel with a resistance. If V is the alternating voltage developed across the tuned circuit, and therefore across the choke also, the current passing *via* the tuned circuit would be $A_1 = V/R_d$ amps., and that through the choke, whose impedance is denoted by Z_c ohms, would be $A_2 = V/Z_c$ amps. Now the current passed by the tuned circuit is exactly in phase with the voltage across it, because, at the frequency $\frac{1}{2\pi\sqrt{LC}}$, the reactance of the coil and that of the total capacity are balanced. But in the case of the choke the current lags by a large angle because the impedance is equivalent to a resistance and reactance in series, where the reactance is by far the larger component. In fact, under normal conditions the reactance of the choke is so large compared with the high-frequency resistance that the current is out of phase with respect to the voltage by very nearly a quarter of a cycle, unless, of course, the frequency happens to be near the value to which the choke is tuned by its own self-capacity.

Under the circumstances, in most cases it is possible to ignore the resistance of the high-frequency choke altogether and treat the latter as a pure reactance which takes a current a quarter of a cycle out of step with respect to the voltage. But in the present instance the choke is in parallel with a tuned circuit, and therefore, unless the impedance is very high compared with the dynamic resistance of the tuned circuit, the resistance of the choke will introduce extra damping and its reactance *will alter the tuning of the circuit as a whole.* These effects are not usually small enough to be neglected, and therefore the frequency $\frac{1}{2\pi\sqrt{LC}}$ is not the resonant frequency of the complete intervalve coupling. Consequently, the circuit of Fig. 3 (b) does not apply at the true resonant frequency of the combined circuit.

It can be shown fairly simply that a coil of resistance R and reactance X ohms (its impedance being $Z = \sqrt{R^2 + X^2}$ ohms) can be replaced by a non-inductive resistance R′ and a pure reactance X′ *in parallel,* where $R' = Z^2/R$ ohms and $X' = Z^2/X$ ohms.

The effect of the reactance of the H.F. choke on the tuning and of its resistance on the damping of the main tuned circuit can only be taken into account in a moderately easy way if both the tuning coil LR and

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The Tuned Grid Coupling.—

the choke Z_c are resolved into their respective equivalent pure reactances and pure resistances in parallel. Now for each of these coils the inductive reactance is very large compared with the resistance, and therefore in both cases the respective impedances and reactances are very nearly equal. Consequently, in numerical calculations the impedance and reactance of any one coil can be interchanged.

The tuning coil LR of Fig. 3 (a) can be replaced by a pure reactance Z^2/X ohms, or simply X (since Z and X are practically equal), in parallel with a pure resistance Z^2/R or X^2/R ohms. Similarly, the choke coil Z_c may be replaced by a reactance X_c (equal to Z_c) in parallel with a resistance $Z^2{}_c/R_c$ or $X^2{}_c/R_c$ ohms, where R_c is the actual high-frequency resistance of the coil. When these changes are made the equivalent A.C. circuit becomes as shown by Fig. 4, in which we have two pure resistances, two purely inductive reactances, and a condenser, all in parallel.

The two reactances X_c and X in parallel can be represented by a single reactance whose reciprocal is equal to the sum of the reciprocals of the individual reactances, its value being therefore $\frac{X.X_c}{X+X_c}$ ohms, which, when divided by 2π, gives the resultant effective inductance due to both coils in parallel. The tuning conditions are therefore determined by the inductances of both coils.

The equivalent circuit of Fig. 4 enables the stage gain to be calculated much more easily than a casual glance at the diagram is likely to indicate. The definition of dynamic resistance provides the necessary clue. This definition is as follows: "The dynamic resistance of a parallel-tuned circuit is the value of the resistance measured between the ends of the circuit when accurately tuned to resonance." Now since the coils and condensers of Fig. 4 are free from resistance, their currents balance out at the resonant frequency, and these alone would therefore constitute an infinitely great impedance, so that the current passed is simply that through the two resistances $X^2{}_c/R_c$ and X^2/R. Consequently, the com-

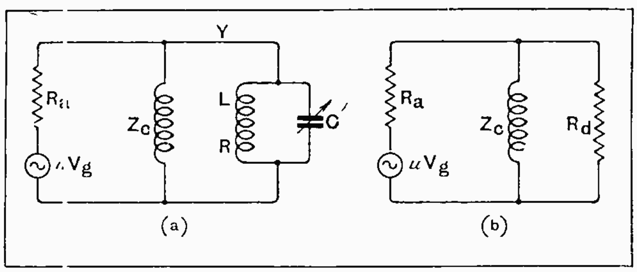

Fig 3.—(a) Equivalent A.C. circuit for choke-capacity-tuned grid coupling, applicable at any frequency. (b) Equivalent circuit when the frequency $f=\frac{1}{2\pi\sqrt{LC}}$ cycles. This, however, is not the resonant frequency of the combined circuit.

bination of these two resistances in parallel gives the dynamic resistance of the complete intervalve coupling. Denoting them by R'_c and R' respectively, the dynamic resistance of the combined circuit is

$$R'_d=\frac{R'R'_c}{R'+R'_c}\text{ ohms} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

and the voltage amplification is therefore $n=\frac{\mu R'_d}{R_a+R'_d}$, where μ is the amplification factor of the valve and R_a its A.C. resistance.

Numerical Example.

The practicability of the method will best be indicated by numerical calculation for an actual circuit. Suppose the tuning coil to have an inductance value of 200 microhenrys and a high-frequency resistance of

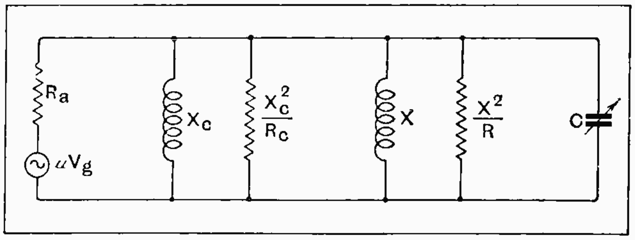

Fig. 4.—A.C. circuit in which the coils Z_c and LR of Fig. 3 (a) are resolved into equivalent parallel reactances and resistances.

10 ohms at a frequency of 1,000 kilocycles per second, and let the H.F. choke have an impedance of 10,000 ohms at this frequency, its resistance being 200 ohms.

The reactance of the tuning coil will be $X=2\pi fL=$ 1,257 ohms. The equivalent parallel resistance R′ is therefore $\frac{X^2}{R}=\frac{1{,}257^2}{10}=158{,}000$ ohms, or 0.158 megohm. (Note that this is the dynamic resistance as found previously for the tuned circuit alone.) Similarly for the high-frequency choke, the equivalent parallel resistance R'_c is $\frac{Z^2{}_c}{R_c}=\frac{10{,}000^2}{200}=500{,}000$ ohms, or 0.5 megohm. Thus from equation (1) the dynamic resistance of the complete coupling is $R'_d=\frac{0.158\times0.5}{0.158+0.5}=0.12$ megohm. from which the voltage amplification can be calculated in the ordinary way, knowing the amplification constant μ and the A.C. resistance R_a of the valve.

It may possibly appear to the reader that the 10,000 ohms impedance of the H.F. choke given in the example is unduly small compared with the dynamic resistance of the tuned circuit itself, and likely to reduce the dynamic resistance of the combination to an impossibly low figure. This, however, is not the case, for it must be remembered that the high-frequency choke actually constitutes part of the tuned circuit. After all, the impedance of the tuning coil itself is only 1,257 ohms. Also, the resistance of the choke has the same effect on the damping and selectivity as the presence of resistance in the tuning coil itself. It is to be inferred from these facts that the choke should be one in which the inductance is as high as possible consistent with low resistance. Also, when a high-frequency choke is used in parallel with a tuned circuit, the self-capacity does not act as a by-pass for high-frequency currents, but takes part in the tuning, as it is virtually in parallel with the main tuning condenser.

The reactance of the H.F. choke causes a reduction in the effective inductance of the complete intervalve coupling below that of the tuning coil. For instance,

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The Tuned Grid Coupling.—
in the example the equivalent parallel reactances of the tuning coil and of the choke are 1,257 ohms and 10,000 ohms respectively at 1,000 kilocycles per second. Since these are in parallel the resultant reactance is $\frac{1,257 \times 10,000}{1,257 + 10,000} = 1,113$ ohms. If L' is the effective inductance of the combination, $2\pi f L' = 1,113$ ohms, from which $L' = 117\mu H$, since $f = 10^6$ cycles per second. This should be compared with $200\mu H$ for the coil alone.

The lowered value of the effective inductance calls for a higher setting of the tuning condenser, whereas the stray capacities necessitate a reduction in the main tuning capacity at a given frequency. It is therefore evident that the valve capacities and the inductance of the H.F. choke have opposite effects, and under certain conditions may cancel each other out, in which case the main condenser would be set to the same value in the actual circuit as for the tuning coil alone. This is a point which may be worth while considering when arrangements are being made for the ganging of two or more tuning condensers in a receiver.

CURRENT TOPICS

Events of the Week in Brief Review.

THE POWER URGE IN MOROCCO.

The Rabat (Morocco) broadcasting station will shortly be transferred to Bouznika, with a power increase from 2.5 to 20 kilowatts.

oooo

A WELCOME VISITOR.

The Czecho-Slovakian Post Office has just welcomed the arrival of the three hundred thousandth applicant for a wireless licence. The country has 12,500,000 inhabitants.

oooo

THE SACRED EIGHTY.

Owing to the prevalence of alleged anti-Soviet wireless transmissions the Russian Government has issued orders, we understand, prohibiting the use of receiving sets within eighty miles of the Soviet frontier unless a special permit is obtained.

oooo

PHOTO-ELECTRIC CELL GUARDS PERSIAN TREASURES.

The photo-electric cell is being used to protect certain of the treasures at the Persian Exhibition in London. The device acts on the familiar burglar alarm principle; the interception of a ray of light on a photo-electric cell actuates a relay which rings a bell.

oooo

MONEY FOR IDEAS.

Prizes to the value of 25,000 francs are offered by the organisers of the International *Foire de Paris* for "new ideas in wireless publicity." The competition is open to all, and there is no entrance fee. Application for particulars should be made before March 15th to "Le Comité de la Foire," 23, rue Nôtre-Dames-des-Victories, Paris.

oooo

B.B.C. FOR CANADA?

Educationists, financiers, statesmen, churchmen, and women's leaders have stepped forward spontaneously to form the Canadian Radio League which has been formed with the object of urging the nationalisation of broadcasting in Canada at the earliest possible date. The proposed scheme (writes an Ottawa correspondent) would be financed by an increase in the existing licence fee of one dollar per annum and by provincial and federal grants.

GERMAN SHOW DATES.

Germany's 1931 Wireless Exhibition will be held in Berlin from August 21st to 30th.

oooo

I.E.E. REUNION.

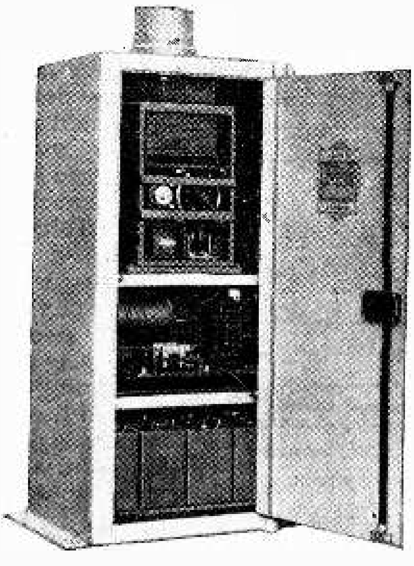
The annual dinner and reunion of the Institution of Electrical Engineers will be held at the Connaught Rooms, Great Queen Street, London, W.C., on Thursday, February 12th, under the presidency of Mr. Clifford C. Paterson.

oooo

"MOVE ON" BY LOUD SPEAKER.

Loud speakers for traffic control purposes are carried on the new police radio cars in use at Perth, Australia.

The wireless system includes a two-kilowatt transmitter at headquarters capable of communicating with any radio car in the police zone.



TO OUTWIT PIRATES. The Marconi ½kW. quenched spark set fitted into a safe for use by Chinese river craft exposed to piratical attacks. A switch operates an automatic distress call which continues after the safe is locked.

CANNY SCOTS.

Fifty additional schools in Scotland have installed wireless sets in the past month. The total now exceeds two hundred.

oooo

FRENCH VALVE EXPORTS.

Complaints of poor turnover in the French radio trade are not justified by the latest export figures for valves, writes our Paris correspondent. During 1930 valve exports attained a value of £64,128, as compared with £37,272 in 1929.

oooo

THE FIGHTING SPIRIT.

"If 5XX likes to . . . come to my house any morning between two and five o'clock and be prepared to give two pounds to the infirmary or a hospital if he hears America, I am prepared to give one pound to the same charity if I cannot get America."—Correspondent in a Bristol paper.

oooo

GOOD WORK WITH A PORTABLE.

"We are now 1,800 miles from London and some 2,640 miles from New York, and with the aid of a 56-foot aerial, I get perfect reception from all the large British stations, together with fifteen stations from the States," runs a letter received by Messrs. L. McMichael, Ltd., from a yachting customer who recently purchased a McMichael Super Range Portable Four.

oooo

A LEGAL RADIO JOURNAL.

"The Journal of Radio Law" is the title of a new American quarterly publication which will make its first appearance in April next, under the editorship of Mr. Louis G. Caldwell, a Washington attorney and former general counsel of the Federal Radio Commission. The journal will be published under the auspices of various American universities and law schools.

Such is the complexity of radio rules and regulations that the editor should experience little difficulty in filling his pages. It remains to be seen whether he can invest an alarmingly turgid subject with the gaiety and charm which would ensure a world sale.

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NAUGHTY!

"The St. Louis police department recently changed its broadcasting apparatus because officials suspected that ambulance-chasing lawyers were listening in and beating the radio patrol cars to accidents," says the *California Broadcaster*.

oooo

RADIO HINTS ON A RECORD.

Music dealers are being supplied with a special demonstration record to assist in marketing the new H.M.V. radio-gramophone, model 521. The record tells the prospective purchaser exactly what the instrument will do, how long- and short-wave transmissions are obtained, and how the instrument can be adjusted for radio reception or gramophone records at a volume to suit any room.

oooo

"ALL THE BIRDS OF THE AIR."

A grand reunion of the "old-timers" of American amateur radio was carried out during the first week of January under the auspices of the American Radio Relay League. To enable the "hams" to get together on the air and renew old friendships, the A.R.R.L. devised a special call, viz., "OT," which, when used, signified that the transmitter belonged to the pioneer species and wished to meet another of his kind. During the festal week group conversations were held on the ether, transmitters taking turns in contributing to the general discussion.

oooo

ANTICIPATING A RADIO ACT.

A tightening up of French wireless regulations is indicated by a new statement of the Postmaster-General on the subject of broadcasting permits.

Pending the passing of a new Wireless Act, no licence will be granted for the opening of any private broadcasting station, while permits for alterations to existing stations will be vouchsafed only after the most searching enquiries.

The Postmaster-General makes it clear that no permit will be granted which is not strictly in accordance with the terms of the Washington Convention.

oooo

SHORT WAVES FROM SOUTH POLE.

Sir Douglas Mawson's exploration ship "Discovery," which is now *en route* to the South Polar regions, has been fitted for the second occasion by Amalgamated Wireless of Australia, Ltd., writes a correspondent. This will permit of weekly broadcasts from the Antarctic, giving the public details of the progress of the expedition. Arrangements are being made for the words of the explorers to be re-broadcast by the Australian stations so that listeners may hear them on ordinary radio receivers.

The equipment includes the latest type of short-wave radio apparatus designed to withstand the severe climatic conditions.

oooo

ELECTRIC SILENCE FOR LISTENERS.

Madame Leriche, a resident of Douai, who was recently fined £4 and costs for using an electrically-operated gramophone which interfered with the radio reception of her neighbour, Dr. Vidal, contested the judgment before the local Appeal Court. Our Paris correspondent reports that Madame has lost her appeal, and that, in addition to being mulcted of double costs, has been accorded eight days in which to render her gramophone "electrically silent." French listeners greet this judgment as a final ruling on the subject of electrical interference.

oooo

TRIALS OF AMERICAN RADIO MANUFACTURERS.

"The most trying year in the history of the trade," is the description applied to 1930 by American radio manufacturers. The best estimates now available place sales of radio receivers during the year at 3,500,000. Many of these sets were produced in 1929—a year of gross over-production—and only now does it appear that the supply is becoming suitably related to the demand.

With the Department of Commerce's pre-census estimate that 13,500,000 sets are in use in the U.S. to-day, and with the average life of a receiver reckoned at four years, it is estimated (writes our Washington correspondent) that 3,000,000 sets will be needed in 1931 for replacements alone. In addition, the trade sees a market for at least 1,000,000 new sets in the development of the midgets, automobile sets, farm sets using the new low-drain battery valves, automatic record-changing gramophone combinations, combination radio-gramophone-home talkies, and other new sales.

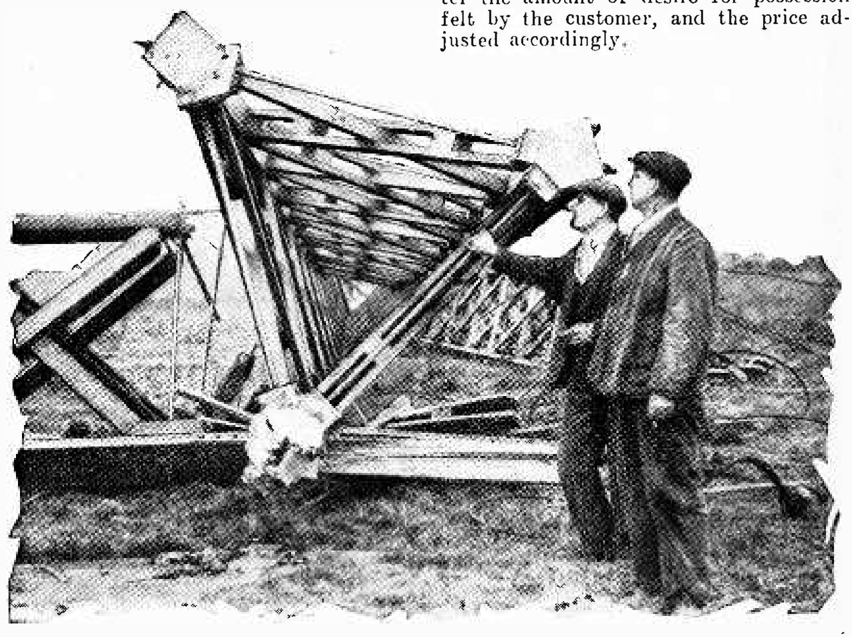
oooo

A HUNDRED YEARS HENCE.

The part that wireless will play in a well-conducted grocery business of A.D. 2031 is foretold by an imaginative correspondent in *The Grocers' Gazette*.

The sales room (he writes) would contain an elaborate set of wireless. . . . There would be a television transmitter and receiver, attached to either the wireless or telephone wires at will. . . . "Madam," if she wished, could order and see her goods while taking her morning bath. Each of the fleet of electrically driven vehicles would be in direct touch with headquarters by wireless. Fog would not affect delivery, because by using apparatus based on the recently discovered use of infra-red rays they could see through the fog.

Incoming goods, if conveyed by aeroplane, would be caught in a net, and eggs (one-day old) would come floating gracefully down on parachutes. Probably telepathy . . . would be used in conjunction with the televisor. A chart would register the amount of desire for possession felt by the customer, and the price adjusted accordingly.



A FALLEN GIANT. The masts of Northolt wireless station, famous as a Middlesex landmark, are being reduced in height in the interests of aircraft. The three 500ft. pylons and the steel pole, 300ft. high, are to be replaced by two masts only 150ft. in height.

TRADE NOTES.

Change of Address.

The Regent Radio Supply Co., Regentone House, Bartlett's Buildings, Holborn Circus, London, E.C.4, announce that their sales organisation has been transferred to a private limited company under the name of Regentone, Ltd., and trading from the same address.

oooo

The Bought Ledger Department of the Marconiphone Co., Ltd., has been transferred from 210-212, Tottenham Court Road, London, W.1. to 100, Blythe Road, Hayes, Middlesex. The telephone number is Southall 0180.

oooo

At least twenty-five wireless firms will exhibit at the British Industries Fair at Olympia, London, W.14. The Fair opens on February 16th, continuing until February 27th.

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Home Recording

The Brown Equipment. Making Records of Broadcast Items.

IN the days of the phonograph, with its cylindrical wax records, it was fairly commonplace to make one's own records. Unlike the modern gramophone the old phonograph was fitted with a lead screw for keeping the sound box, or, as it was then more commonly called, the reproducer, tracking correctly in the spiral groove of the soft cylinder. All that was necessary for recording was the substitution of a sharply pointed needle in place of the ball-ended reproducing needle, so that the diaphragm when thrown into vibration made a varying depth of cut. Cylindrical wax records reproduce sound by change in the depth of the groove, thus differing from the modern method of recording, in which the groove is in the form of a wavy line of uniform depth. Attempts at home record-making were discontinued with the coming of the flat disc and its transverse recording, and with the development of valve amplifiers and electrical reproducers the production of equipments for home recording is again receiving attention. This time, however, home recording will establish itself. While almost every radio set can now be used for the electrical reproduction of records the next adjunct likely to become standard is the provision of a recording cutter. This, developing side by side with the home cinematograph, is leading in the direction of the radio set with its valve amplifier becoming a complete home entertainer having many functions.

Several home record-making equipments have recently appeared on the market. While there is undoubtedly a need for this class of apparatus primarily for making records for broadcast transmissions, the development is likely to receive a setback unless the initial results are reasonably satisfactory. Tests reveal that home recording is now possible, resulting in a satisfactory degree of perfection.

Powerful Motor Drive Required.

The following is a description of the home recorder developed by Messrs. S. G. Brown, Ltd., and which was originally demonstrated by Mr. Sidney Brown at the Institution of Electrical Engineers, as this serves to illustrate the main problems of design and the results obtained. Those who have experimented with recording quickly appreciate that the first difficulty is that of obtaining sufficient power to rotate the record under the recording cutter. As the recorder is much heavier than a soundbox a powerful motor drive is required, and in addition the load on the motor is made greater by the sharp cutting point of the stylus, and the fact that its hold on the record is greatly increased as it vibrates. In the Brown equipment we find a very large type of double spring motor, normally capable of playing through a number of records. By the substitution of new pinions the rate of rotating the turn-table is unaltered, but the motor is discharged in the course of making a single one-side recording. In this way considerable power is rendered available. As resistance to rotation increases with the diameter of the record, its size has been reduced to 6in. across, giving normally about one to one and a half minutes' playing.

A particularly robust form of construction is employed for the arm which carries the recorder. A heavy casting mounted in centres provides for the traverse across the record. This is guided by a spring-loaded point travelling in a buttress spiral thread cut in the under-face of the turn-table. A hinged joint suspended from its centres allows the recorder to be lifted from the surface of the turn-table, and in so doing the guide pin is released from the thread on the underside. A trigger action lowers the recorder on to the record, at the same time engaging the pin on the underside as well as closing a contact which, brought out to terminals, provides for lighting an indicating lamp showing that the recorder is in action. A meter is also thrown into circuit.

The Recorder Tested.

In action the recorder operates the reverse way to a gramophone pick-up. Where, in the latter case, the vibrating armature generates a current, we have now a varying current actuating an armature. In design, therefore, the mechanism of a recorder resembles a loud speaker movement arranged to vibrate a pivoted cutter instead of a diaphragm. In this instance the design closely resembles the Brown "V" action loud speaker unit, arranged to impart movement to a sharply pointed diamond standing almost perpendicular to the face of the record. This point is adjustable and can be readily replaced, although owing to its hardness it shows no sign of wear.

Many materials may be used for recording upon, and that most generally adopted is aluminium. Soft materials like celluloid and bakelite are fairly suitable, but metal discs probably give better results. A mild steel disc, in fact, serves quite well, giving results superior to those obtained with bakelite. Examination of the spiral under the microscope reveals that the groove is made by turning up a burr on the metal as apart from actually paring the surface away. Bakelite, being brittle, is

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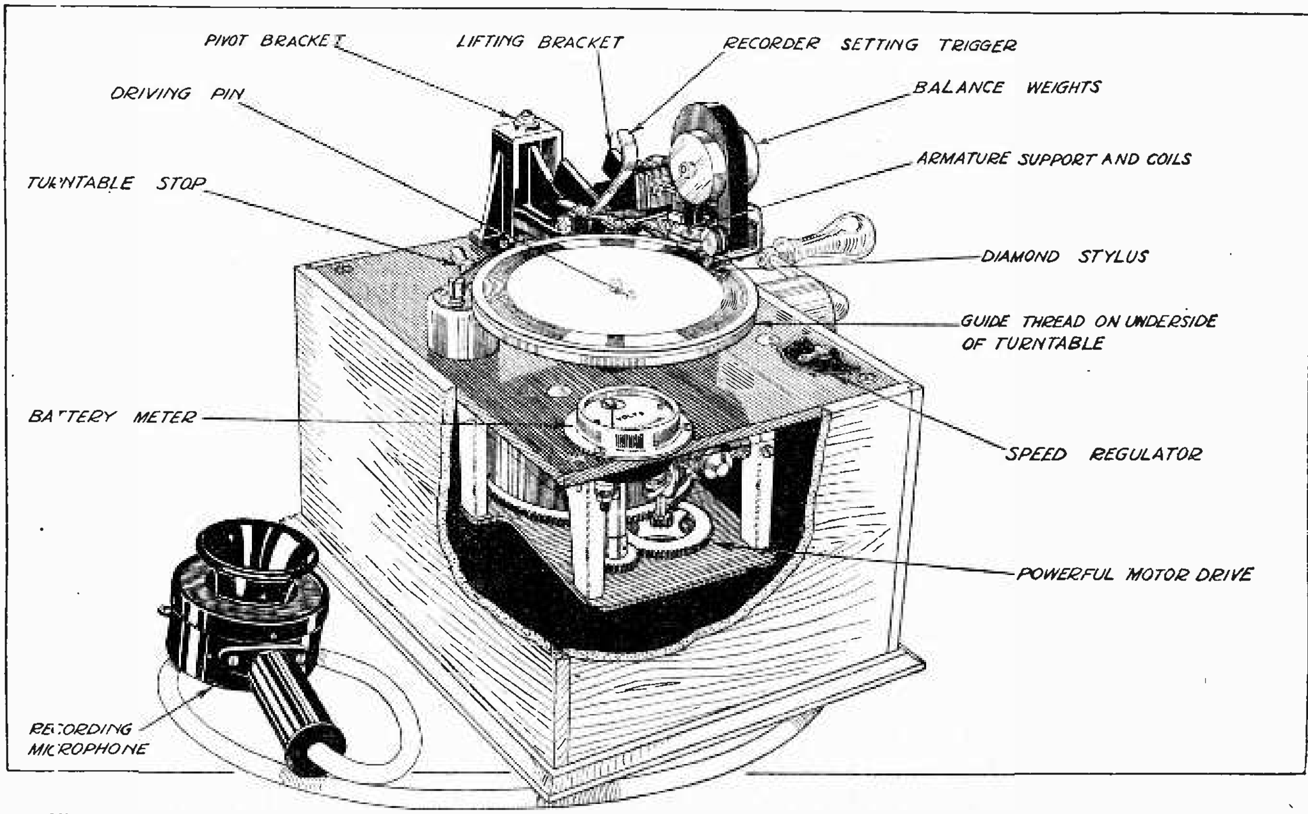
Home Recording.—
actually cut, the surface being removed as powder, and is less satisfactory. When reproducing from the surface of the aluminium record, however, a pointed steel needle sinks into the bottom of the groove, deepening the cut in the soft metal surface. It is better, therefore, to use either a needle with a rounded point or, preferably, a fibre needle. The Brown equipment examined was fitted with a recording microphone, which, being of a heavy-duty type, gave ample output. It should be noted, therefore, that with this equipment record making is effected without the aid of a valve amplifier. To operate the microphone circuit an 8-volt battery is required, and when speaking or singing close to the mouthpiece of the microphone a record is produced which plays with almost the average loudness of the ordinary gramophone record.

The quality of reproduction, while not being quite up to the standard of the ordinary record, is, nevertheless, pleasing, and particularly so when applied to the recording of broadcast transmissions. The range of frequencies covered is the same as that customarily handled by pick-up or loud speaker and its associated amplifier.

It is thought that the ultimate application of the home recorder will be that of making records from broadcast items. In this way records are obtained quite cheaply which, when played, give results comparable with the purchased record. The future, no doubt, will witness considerable development in the application of the home recorder to the broadcast receiver.



The Brown home record making equipment. It may be used with the microphone, or when connected to the output terminals of a receiver, for recording broadcast items.

CORRECT BIASING OF S.G. VALVES.

THE importance of correctly biasing the ordinary control grid of an S.G. valve appears to be too little realised among radio enthusiasts. If insufficient bias is used it is obvious that the same trouble occurs as in the case of a triode, namely, grid current flows with consequent loss of selectivity. Unfortunately, owing to the limited portion of "straight" in the grid volts-anode current curve of an S.G. valve it is just as easy to over-bias as to under-bias it, the result of this being equally as detrimental to the performance of the set. If the valve is over-biased such evils as rectification and cross-modulation creep in, with disastrous results to selectivity and sensitivity. It was in order to combat this that the special 0.9-volt grid cell was introduced by this journal. Unfortunately, many people have adopted this cell for biasing each and every kind of S.G. valve. It is never sufficient in the case of an indirectly heated S.G. valve, and often a somewhat higher biasing voltage can be used with good effect in the case of the battery-heated type. Since individual valves differ somewhat in the matter of optimum grid bias, it is always advisable to try various values of grid bias when a new valve is first put into use. Correct bias adjustment is still more important in the case of the second valve in a two-stage H.F. amplifier, since it is obvious that a larger input has to be handled, and there is, therefore, more risk of the grid voltage swinging off the straight portion of the characteristic.

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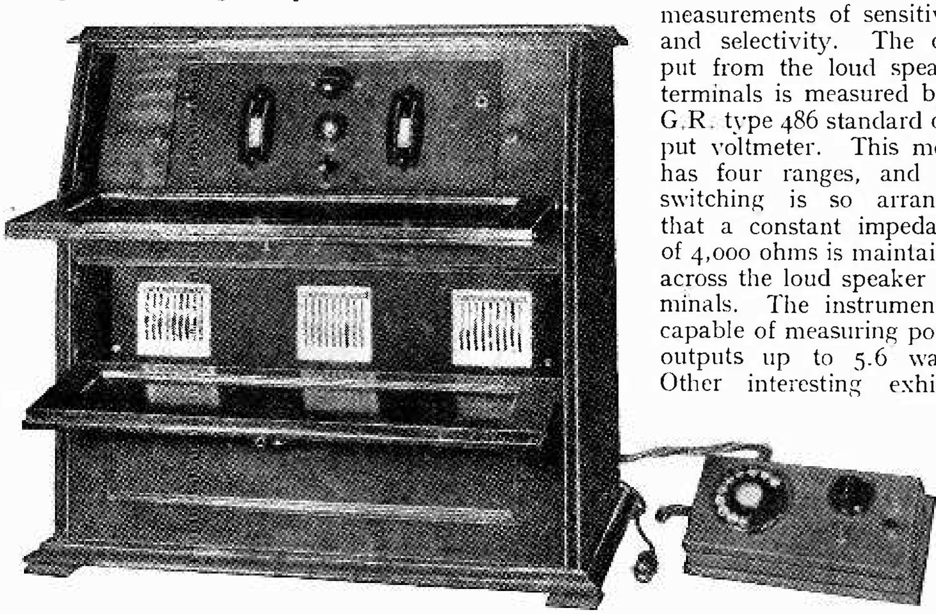
WIRELESS AT THE *Physical Society's Exhibition*

The Application of Scientific Measurement to the Problems of Broadcast Receiver Design.

THIS year the Annual Exhibition of the Physical and Optical Societies attained its majority, for the display of apparatus on view at the Imperial College of Science, South Kensington, on January 6th, 7th, and 8th, was the twenty-first of the series. Of recent years the proportion of wireless exhibits has shown a steady increase. The science of radio communication embraces every branch of physics, not excluding optics now that television is occupying the attention of research workers, and the results of recent work along diverse and novel lines were to be found in both trade and research sections of the Exhibition.

While most of the exhibits were of a highly technical nature there were several items of direct interest to the broadcast listener and home constructor. For instance, the Dubilier Condenser Co., Ltd., were showing a new range of "Auto Dial" receivers, in which remote control is effected by a standard telephone exchange relay and the now familiar automatic telephone dial. The system gives a choice of nine stations, each of which is pre-selected by a series of tuning circuits. Actually, there are three sets of condensers with edgewise disc dials for aerial, tuned H.F., and reaction circuits respectively.

The wide range of "Miniwatt" barretter lamps shown on the Philips stand are of special interest to constructors of D.C. mains receivers. These components consist of an iron wire filament in a glass bulb filled with hydrogen, and have the useful property of passing a constant current over a comparatively wide range of voltage variations. Thus it is possible to keep the filament current of 0.1 amp. valves, which are sometimes rather sensitive to changes of filament temperature, practically independent of fluctuations of voltage in the supply mains. The price of these units is 6s., and a wide variety of specifications is available.



Dubilier "Auto Dial" receiver with nine pre-set circuits operated by a standard automatic telephone relay.

When the physicist turns his attention to a new subject, one of the first things he does is to develop methods for precise measurement in order that he may be supplied with concrete data upon which to work. Consequently, we find that a large proportion of the radio exhibits are concerned with the measurement of the electrical constants met with in the design of wireless apparatus. In the United States apparatus for conducting radio frequency tests is now marketed on a commercial basis and Messrs. Claude Lyons, Ltd., were showing a comprehensive range of oscillators made by the General Radio Company of America. Probably the most interesting is the equipment for measuring the overall performance of receivers. This consists of a G.R. type 403-C. standard signal generator with a range of 200 to 600 and 750 to 2,250 metres. The radio-frequency output, which is variable from 1 to 200,000 micro-volts, is modulated at a fixed frequency of 400 cycles. Provision is made, however, for external modulation by the G.R. type 377-B. variable low-frequency oscillator, so that it is possible to take an overall low-frequency characteristic of the receiver under test in addition to measurements of sensitivity and selectivity. The output from the loud speaker terminals is measured by a G.R. type 486 standard output voltmeter. This meter has four ranges, and the switching is so arranged that a constant impedance of 4,000 ohms is maintained across the loud speaker terminals. The instrument is capable of measuring power outputs up to 5.6 watts. Other interesting exhibits on this stand were the Jenkins and Adair condenser microphone and a range of heavy-duty "B.A.T." moving-coil loud speaker units for attachment to exponential horns, and having power-handling capacities up to 30 watts.

An ingenious performance tester for recording the radio-frequency output of receiving sets was shown by the Gramophone Company, Ltd. This piece of apparatus was specially developed for testing the Model 560

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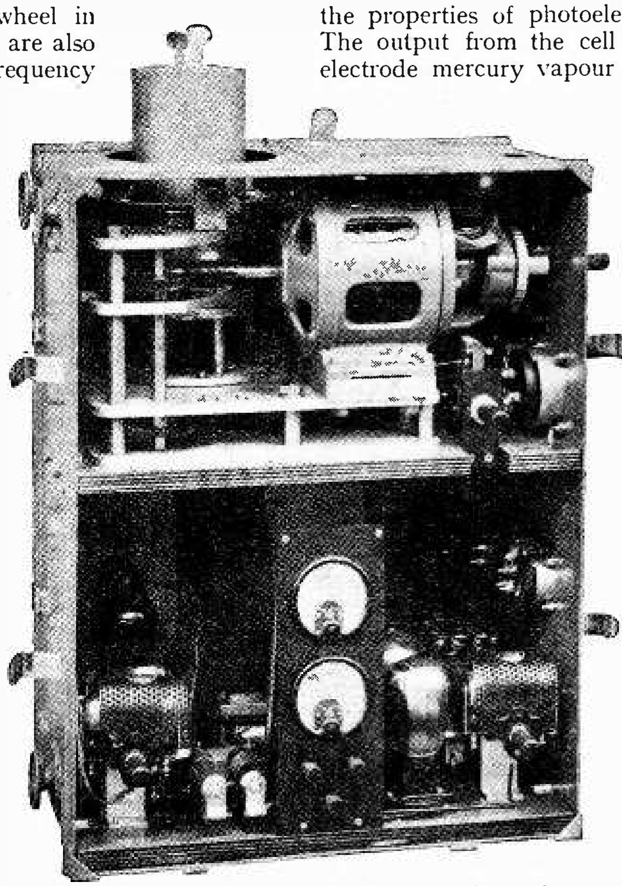
Wireless at the Physical Society's Exhibition.—

chassis, and consists of a modulated oscillator deriving its current entirely from the mains. The receiver chassis, which has previously been checked on the L.F. side, is placed in a jig, and the valves are automatically inserted by rotating a wheel in front of the test table. Meters are also connected to show the radio-frequency input and the low-frequency output, and the receiver is required to pass a standard performance on five wavelengths on each of the two-wave ranges. Since the low-frequency percentage modulation is adjusted to be the same on each of the test wavelengths, and since the L.F. part of the set has already been checked, the low-frequency output is a measure of the H.F (and detector) efficiency at different parts of the wavelength scale. Under production conditions the wavelength and percentage modulation at each position of the ten-way selector switch are tested daily.

On the stand of the Marconi Company an interesting instrument was shown for measuring level, gain and loss in amplifiers, filters and land-lines. The range for measurements of gains or losses is 0 to 70 decibels, and for levels from −70 to +20 decibels.

Laboratory instruments of general interest to research and development engineers included a precision-frequency meter by the Cambridge Instrument Co., Ltd., with a range of 12 to 12,000 cycles, and a standard variable condenser with a range of 0.1 micro-mfd. giving readings to 0.001 micro-mfd., by the General Electric Company, for measurements of inter-electrode capacity in screen-grid valves.



Marconi portable picture receiver for line sketches such as weather charts and maps.

H.M.V. Television Demonstration.

In the research section the demonstration of television by the Gramophone Company was one of the most popular items. A full description of the apparatus and comments on the results obtained were published in our previous issue. An allied subject, that of picture transmission, was represented by the Marconi portable picture apparatus. This instrument is designed primarily for the use of air and military authorities, and is capable of transmitting and receiving line drawings, such as weather charts, maps and rough sketches, but will not deal with half-tones. Compactness is the main feature, as may be judged by the accompanying photograph.

Television and the talking films have given a great impetus to research in photoelectricity, and all the important electrical concerns were showing examples of their latest types of photo cells. The B.T.H. research exhibit included a clever arrangement for demonstrating the properties of photoelectric cells of different types. The output from the cell is made to control a three-electrode mercury vapour valve supplied with current from A.C. mains, and the rectified output is made to drive a D.C. motor. The speed of the motor is thus proportional to the output from the photoelectric cell, and affords a striking demonstration of the relative sensitivity of different cells and their sensitiveness at various parts of the spectrum.

Another demonstration of the relative sensitivity of photo cells was shown in the H.M.V. exhibit. In this case the pick-up from a gramophone record is amplified and made to modulate the light generated by a crater neon lamp. The light is allowed to fall alternately on an ordinary potassium photo cell and the latest type of H.M.V. caesium cell. The latter gives the remarkably high output of 48.3 microamps. per lumen, and, of course, gives a much greater output in the loud speaker after amplification than the older type of potassium cell.

Other photoelectric cells of interest were the Philips small type 3511 and 3531 cells, which have been specially developed for talking-film work, and a novel copper oxide photo cell on the Westinghouse stand.

The N.P.L. exhibit, in addition to a display of short-wave apparatus, including a rotating beacon transmitter for 5 to 20 metres, was notable for a demonstration of the existence of sidebands by means of a sharply tuned exploring circuit in conjunction with a sensitive indicating galvanometer. A similar principle is involved in the B.T.H. noise analyser, in which the wave form is picked up on a microphone, and after amplification is caused to modulate a carrier frequency which can be varied from 11,000 to 16,000 cycles. The resultant sidebands are then analysed by a resonant circuit consisting of an electrically maintained steel bar.

Finally, mention should be made of the Supra electric motor in which speed variations are obtained by means of a variable air gap. This motor is being developed by Supra Electra Motors, Ltd., 48, Southwark Bridge Road, London, S.E.1, and has distinct possibilities as a drive for electric gramophones.

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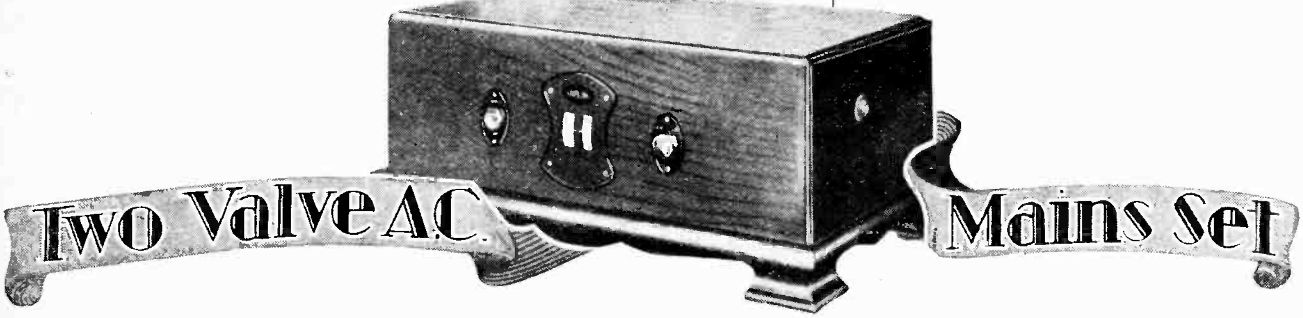
AMPLION



Two Valve A.C. Mains Set

A Simple but Effective Detector-Pentode Receiver.

IT is seldom so clear as it should be why two receivers of different make but basically of similar type should behave quite differently when tested under identical conditions. The simpler the receivers the more likely are they to show these inexplicable divergencies; this is probably because the designers have less scope for real originality, and minor differences in circuit arrangement are generally dismissed as being of no importance by those making a comparative test.

A case in point is that of the Amplion two-valve set under review. There is nothing particularly arresting in its design, and even the exceptional characteristics of the particular valves that are used can hardly be taken as explaining its unusually satisfactory performance. One must assume that results are due to careful attention to details.

With regard to the circuit arrangement, which is shown on the following page, it will be seen that somewhat elaborate precautions have been taken to secure the greatest immunity from interference that is practicable in a receiver of this type. On the medium-wave side there is the option of a direct connection, through a series condenser, or of auto-transformer coupling through a still smaller capacity when maximum selectivity is needed. For long-wave reception direct connection may also be made, and, to avoid the all-too-common trouble of interference from a nearby medium-wave transmitter, there is a separate long-wave primary winding in series with a loading coil which prevents aerial resonances in the medium band.

Separate series-connected reaction windings are provided for each of the tuned inductances, and feed-back is controlled by a small variable condenser. The presence of a detector anode by-pass condenser of relatively large capacity has an important bearing on the general operation of the reaction system. The values of the grid condenser and its leak are rather lower than usual.

Both the valves are heated from the same four-volt output of the power transformer, and the grid circuits are returned to the centre tapping of a low-resistance potentiometer shunted across the L.T. secondary.

Anode current is fed through a combined decoupling and voltage-absorbing resistance to the detector, which is linked to the pentode output valve by a transformer in the conventional way. The loud speaker is directly connected, and the pentode screening grid operates at the maximum H.T. voltage—about 135 volts. A pressure in the order of 85 volts is applied to the detector anode, and nearly 4 milliamps is consumed in this circuit.

High-tension supply is obtained through a metal rectifier connected in the well-known voltage-doubling circuit. Automatic grid bias for both the output valve and for the detector—when it is converted into an L.F. amplifier for gramophone reproduction—is obtained by inserting series resistances in the H.T. negative feed lead and taking the grid return leads, *via* decoupling resistances, to appropriate points.

The set was tested with an Amplion Type A.B.6 loud speaker, which was submitted by the makers as being specially suited for operation with this set; if desired, the loud speaker may be mounted on top of the receiver cabinet. Reproduction afforded by the combination was of a most pleasing character, although the bass response was not particularly well marked there was no objectionable resonance, and the upper register, thanks largely to the pentode, was particularly strong.

Naturally, the set is not really intended for consistent long-distance reception, but rather for those who expect to get satisfactory signals from two or three nearby stations. For its type, sensitivity is good, and the reception of distant transmissions can be depended upon under fair conditions. Again, the high magnification of the pentode is partly responsible. Reaction control is smooth, reasonably constant, and almost free from backlash, particularly on the medium band.

One must not expect the impossible as regards the selectivity of a detector-L.F. set, but in this respect the receiver works surprisingly well. As overall sensitivity is good it is possible to work with a very loose aerial coupling—or with a very short aerial. The receiver costs 15 guineas complete, and is manufactured by Graham Amplion, Ltd., 26, Savile Row, London, W.1.

SPECIFICATION.

***CIRCUIT**: Indirectly-heated grid detector, transformer coupled to a directly-heated pentode output valve. Capacity-controlled reaction. A.C. mains-feed through Westinghouse metal rectifier.*

***CONTROLS**: (1) Tuning. (2) Reaction. (3) Wave-range switch. (4) Mains switch.*

***GENERAL**: Jack for gramophone pick-up. Price: 15 guineas.*

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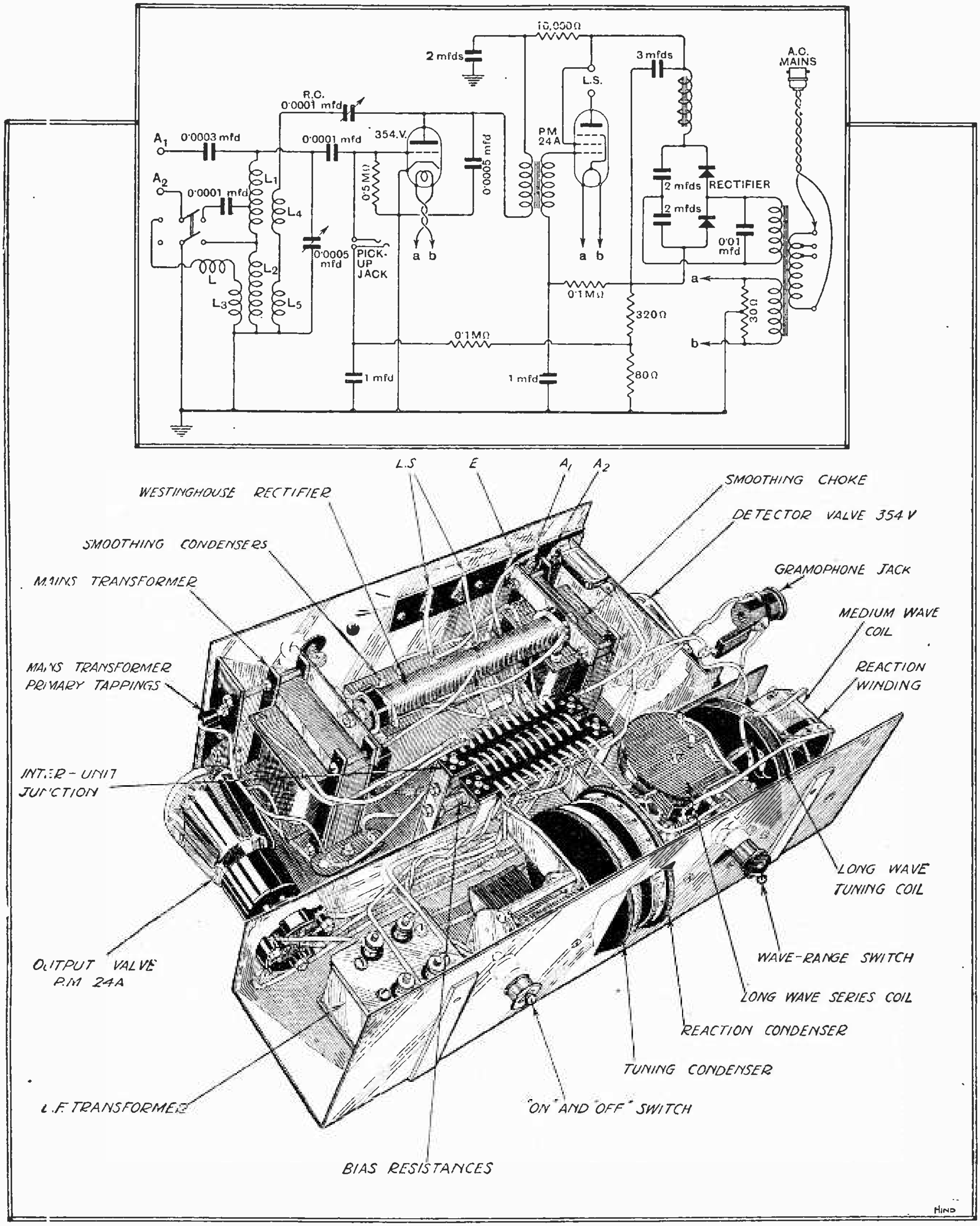

Amplion two-valve receiver removed from cabinet, showing two-unit chassis construction. Inset: complete circuit diagram; L, long-wave series coil; L_1, medium-wave grid coil; L_2, long-wave grid coil; L_4, L_5, reaction coils.

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UNBIASED * * *

By FREE GRID.

Music at Midnight.

I spent a few nights in Manchester recently, and I was lucky enough to get the "permanent loan" of a receiver to dispel the depressing effect of the morgue-like atmosphere of my hotel bedroom, as I happened across a man who had been a comrade-in-arms in War-time, and is now, I find, the Northern representative of a well-known radio firm. It was an extremely interesting experience for me to be able to listen in a radio locality with which I was totally unfamiliar. I found the Manchester station extremely troublesome to eliminate, as it certainly "spreads" rather badly, although not nearly so much as I had been led to believe by certain Mancunians. I was surprised to find that not only Brookmans Park but the much nearer 5GB was subject to bad fading. Altogether, my experience was a thorough revelation to me, and I became so engrossed that I did not realise that my reception might be

In unprintable language.

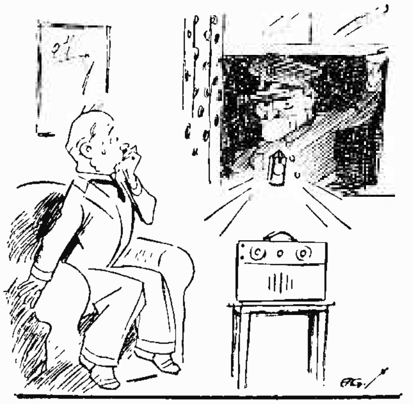
disturbing others until there was a knocking on the wall, and an irascible voice demanded in unprintable language what I thought I was playing at. Fortunately, I was supplied with headphones, and thus was able to continue my etheric ramblings until far into the night. My aerial wire consisted of a length of "flex" stretched across the room, whilst I earthed at first on to the cold-water tap, as the room was fitted with "h.c. all md. con.," but, strange to say, I found a much better "earth" later on in the iron framework of my bedstead. As a result of my "researches," I formed the resolution that all set designers should be made to take their perpetrations round to the vicinity of the various main broadcasting stations before foisting them upon an unsuspecting public.

A Slaithwaite Story.

By the way, I heard when up north the other day that the B.B.C. are so apprehensive of what will happen to the handful of licence holders and other listeners dwelling under the shadow of Slaithwaite's aerial that they propose to supply them with two programmes *via* land-line, provided that they have their houses linked up together, and bring the two necessary feeders to the edge of the B.B.C. property. I have this piece of information on unimpeachable authority as an aunt of mine has a charwoman—sorry, charlady—who has a cousin who is married to a man whose sister takes in Mr. Noel Ashbridge's washing, the very same individual, in fact, whose father, a railway porter, swept the snow from the troop trains at Folkestone after the Russian troops had passed through *via* Riga and Aberdeen in September, 1914.

What Would the P.M.G. Say?

I have just received a printed postcard from the Postmaster-General, or rather from one of his myrmidons, in which I am reminded that my licence money is due once more, and I am requested to pay up or state whether my apparatus and aerial have been dismantled. Since Christmas is now long past, and all New Year resolutions have long ago become badly warped, it occurs to me that there must be many a radiophobe unwittingly breaking the law by retaining an unused portable set which his more enlightened relatives have given him in order to try and induce him to link up with the greatest of all indoor pursuits. If the recipient does not intend to utilise his gift, what, I wonder, does the Postmaster-General expect him to do about it? Portable sets are usually supplied complete with jelly-acid accumulators, ready to switch on, and surely, therefore, he is infringing the law by having it in his possession, and ought, as a law-abiding citizen, immediately to proceed to dismantle it.



. . . Would not satisfy a marauding post-office inspector.

I presume that the mere fact of disconnecting the valves and batteries would not satisfy a marauding post-office inspector, since any pirate could get away with it by quickly removing these components before he answered the persistent knocking on the front door. Surely, however, it is not required that the thing be pulled to pieces, thus virtually destroying many pounds' worth of property. In all seriousness, however, I know of one portable-set owner who has not renewed his licence because other occupations take up all his time during the winter. He does not wish to sell the set as he intends to take out a licence again after Easter, when he will have time for listening, but, on the other hand, he does not see why he should pay up and look pleasant when he honestly does not intend to use the set during the winter. If it was a receiver which required an outdoor aerial he would presumably comply with the law by dismantling that. A letter to the local postmaster has not elicited any very helpful reply.

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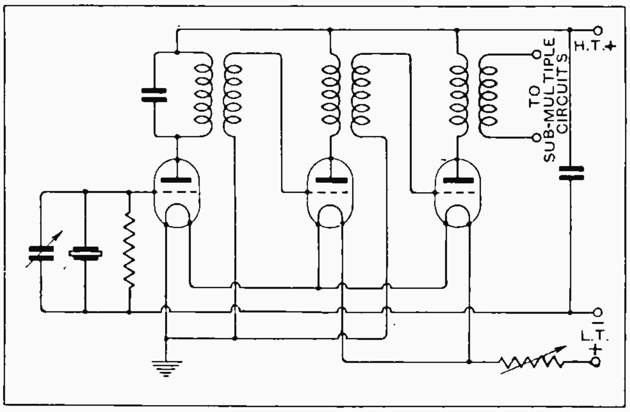
The CRYSTAL CLOCK

A Promising New Application of the Quartz Oscillator to the Measurement of Time.

THE accurate measurement of time intervals plays an important part in electrical standardisation work as well as in other branches of science. Probably the highest standard of accuracy so far achieved is to be found in the clocks in use in astronomical observatories, and absolute measurements of frequency are generally made in terms of the time intervals provided by such clocks.

Astronomical clocks are of the pendulum type, and much ingenuity has been displayed in rendering them independent of change of rate due to temperature and pressure variations. For instance, in the well-known Reifler clock the pendulum rod is made of "invar"—a nickel steel with a low temperature coefficient of expansion. Variations in atmospheric pressure change the effective weight of the pendulum due to the change in buoyancy of the air at different densities. This is compensated for by a small aneroid barometer attached to the pendulum, which automatically raises or lowers a small weight to keep the effective length of the pendulum constant. The drop of the driving weights is limited to a few inches to eliminate the increased gravitational attraction if the weights were allowed to fall to a position appreciably nearer the earth. Even these precautions are brought to nought, unless the site for the clock is carefully chosen away from machinery, magnetic fields, etc.

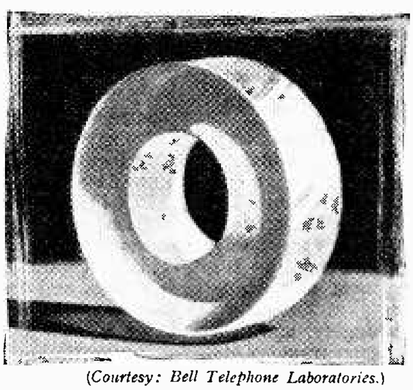
Many of these difficulties and inconveniences are eliminated in a new type of clock making use of an oscillating quartz crystal as a time basis. The accuracy of this new clock is comparable with that of the best astronomical clocks, for it is well known that the quartz crystal has unrivalled chemical and physical permanence under normal conditions, and its temperature coefficient is very low. Perhaps the most important advantage of the crystal clock, however, is its small size. It can be conveniently enclosed in a bell jar and kept under constant conditions of temperature and pressure. It is reasonably free from errors due to vibration and earth tremors, is easily transported, and can be worked satisfactorily in magnetic fields, while it is easily screened from electrostatic fields. Two or more clocks can also be worked in close proximity for inter-comparison without fear of the mutual interference which would occur with pendulum clocks.



Simplified circuit diagram of crystal oscillator circuit.

The clock illustrated was developed in the Bell Telephone Laboratories, and was intended primarily as a reference standard of frequency for the Bell System. It is described in a paper[1] read before the National Academy of Sciences, from which the following particulars are extracted.

The crystal is cut in the form of a ring with its optic and electric axes parallel to the plane of the ring. The crystal has several modes of vibration, for some of which the temperature coefficient is negative, and for others positive. By making the crystal in the form of a ring these coefficients can be made to cancel out. Nevertheless, as an extra precaution, the crystal is mounted in a hermetically sealed bell jar, and the temperature is kept under thermostatic control to within 0.01° C. The crystal is thereby also rendered immune from changes of atmospheric pressure. By these means it has been found possible to control the frequency of vibration to within one part in a hundred million.


(Courtesy: Bell Telephone Laboratories.)
The 100,000 cycle quartz crystal which is cut in the form of a ring to reduce the temperature coefficient.

The crystal is associated with a three-valve circuit in which the first valve functions as an oscillator, the anode circuit being tuned approximately to the frequency of the crystal (100,000 cycles). Small changes of frequency may be made by the variable condenser in parallel with the crystal; the capacity changes very slightly the *effective* elasticity of the crystal.

The second valve in the circuit acts as a buffer between the oscillator and output stages to prevent changes of load affecting the crystal circuit.

[1] *Proc. Nat. Acad. of Sciences*, Vol. 16, pp. 496-507, July, 1930.

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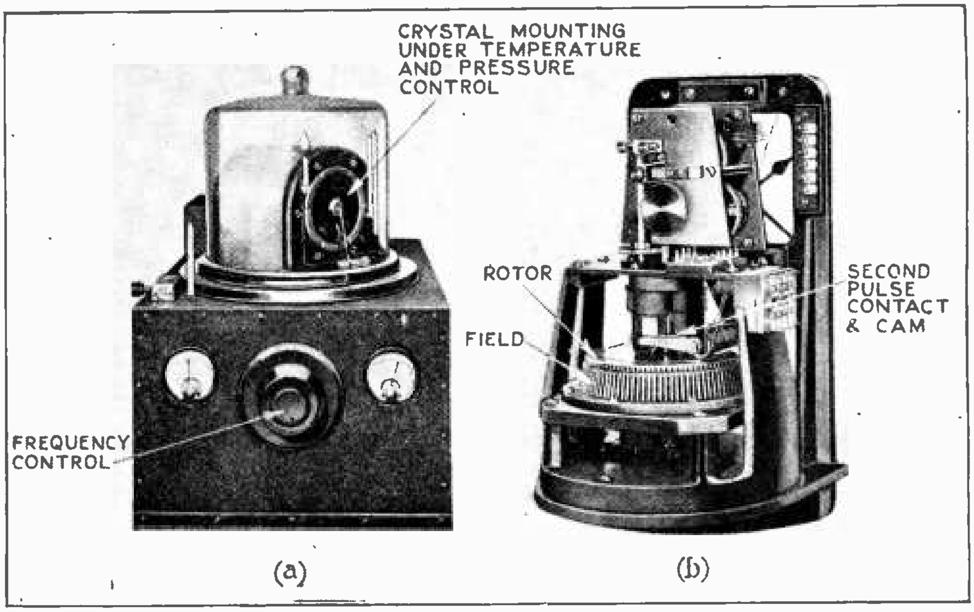
The Crystal Clock.—The 100,000-cycle output from the crystal circuit is then passed through two sub-multiple generator circuits, each of which divides the fundamental frequency by 10. The resulting 1,000-cycle current is then fed to the clock mechanism, the driving mechanism consisting of a phonic wheel synchronous motor. The rotor is provided with a mercury-damped flywheel to prevent hunting, and, in addition to the usual dial-hand mechanism, the spindle drives a cam-operated contact for giving second impulses for time-marking purposes, and two small generators delivering 100- and 10-cycle A.C. for research purposes. The gearing for the clock is so adjusted that the dial keeps accurate time when the crystal is adjusted to exactly 100,000 cycles per second.



(*Courtesy: Bell Telephone Laboratories.*)

(a) Crystal oscillator unit showing hermetically sealed crystal mounting. (b) The 1,000 cycle synchronous motor and clock mechanism.

Preliminary tests have shown that the variations in rate are of the order of one- or two-hundredths of a second per day, and work is now proceeding to determine whether the residual error is attributable to the crystal, the crystal mounting, or the associated circuit.

There can be no doubt that this new application of the quartz crystal shows great promise, and there is a strong probability that in the near future the crystal clock will displace the astronomical pendulum clock as a reference standard of time.

NEW BOOKS.

BOOK REVIEW.

Testing Radio Sets. By J. H. Reyner, B.Sc., A.C.G.I., D.I.C., A.M.I.E.E., M.Inst.R.E. Price 10s. 6d. net. Published by Chapman and Hall.

The testing of radio sets is such an important subject that the correlation into one volume of the more important methods of fault-finding is to be welcomed. The first section of the book deals with the location of faults in complete sets, which are assumed to be originally of good design, and the tracing of troubles due to bad design is not considered.

Emphasis is laid chiefly upon routine and careful point-to-point checking, with such simple instruments as a voltmeter, a milliammeter, and a battery. In the 124 pages which comprise Part I, high-frequency, detector, and low-frequency circuits are considered, together with mains apparatus, and the section concludes with a résumé of some curious faults. It is very wisely stressed throughout the book that one must take nothing for granted, and must not assume that any component is working efficiently until it is proved to be doing so.

All the more usual faults are dealt with thoroughly, and in a clear and concise manner, but a few not uncommon troubles are omitted. Two or more turns of a tuning coil may easily become short-circuited through the careless handling of a screwdriver; but such a fault would not be shown up by the simple continuity test recommended.

The second section of the book is devoted to a description of laboratory apparatus; some 30 pages are given to an outline of the methods of testing employed in the design of commercial receivers, among which a particularly interesting chapter is that headed "American Test Data." There is a useful Appendix of 20 pages describing the testing of components. Errors and omissions are few, but it should be mentioned that there is no coupling resistance or H.T. connection to the detector in the circuit of a beat frequency oscillator (Fig. 70) on page 142.

The book is well printed and bound, with a number of excellent illustrations, and it should prove a valuable addition to the bookshelves of those with little technical knowledge. W. C.

oooo

BOOKS RECEIVED.

Practical Testing Systems, by J. F. Rider, explaining the construction and use of simple apparatus for testing and calibrating wireless apparatus, receivers, valves, etc. Pp. 147+ix, with 99 diagrams. Published by Radio Treatise Company, Inc., New York, price $1.

The Cable and Wireless Communications of the World (2nd Edition revised), by F. J. Brown, C.B., C.B.E., M.A., B.Sc. A survey of present-day means of international communication by cable and wireless, including a chapter on State *versus* private enterprise and one on International Broadcasting. Pp. 153+24, with map and 20 illustrations and diagrams. Published by Sir Isaac Pitman and Sons, Ltd., London, price 7s. 6d. net.

Modern Radio Communication (3rd Edition), by J. H. Reyner, B.Sc., A.C.G.I., A.M.I.E.E., with a foreword by Prof. G. W. O. Howe. A textbook on the theory and practice of Radio Communication, covering the syllabus of City and Guilds Examination and suitable for candidates for the P.M.G. certificate. Pp. 260+xi, with 121 diagrams and illustrations. Published by Sir Isaac Pitman and Sons, Ltd., London, price 5s. net.

Les Postes de T.S.F. Alimentés par le Secteur, by E. Aisberg. A short textbook describing typical mains-operated sets and giving practical advice in their construction and operation. Pp. 101, with 45 illustrations and diagrams. Published by Etienne Chiron, Paris, price fcs. 7.50.

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Broadcast Brevities

By Our Special Correspondent.

Rumour Gets Busy.

Dame Rumour, after dogging the footsteps of the B.B.C. in such lofty localities as Moorside Edge, the Welsh Mountains, the Scottish Moors and the Quantock Hills, seems to be settling down in Portland Place. She is now proclaiming that the B.B.C. is anxious to use the large studio of Broadcasting House before the upper storeys are completed. I am officially informed that the story is untrue.

oooo

How the Story Started.

The canard probably owes its origin to grumbles among musicians concerning the depressing surroundings of No. 10 studio, the converted warehouse on the south side of Waterloo Bridge. How nice it would be, said the malcontents, if we could fly from these dreary vaults to the sunshine of Marylebone! Scarcely had the words been uttered when Rumour departed with her notebook.

oooo

No Need for Gloom.

Actually No. 10 studio is less depressing than any other studio used by the B.B.C. It possesses height, light, and smooth, undraped walls. On such occasions as the Sunday evening orchestral concerts it is positively cheerful, and those musicians who are worried by the proximity of wharves and empty barrels must be victims of an X-ray temperament.

oooo

A Three-decker Studio.

Savoy Hill confirms the report that the giant studio at Portland Place is to have two galleries. This modification of the original plan will help to accommodate a still larger audience. Lest theatre and concert interests should take alarm at this news, the B.B.C. again affirms that there will be no question of competition with the entertainment industry.

oooo

Free Admission to Public.

No charge will be made for admission to the studios, members of the public being welcomed on the same terms as at present, i.e., by presentation of privilege tickets obtainable on application.

The only difference will be, it is hoped, a shorter waiting list. Nowadays an applicant is fortunate if he waits no longer than six months.

oooo

Plea for a "Stunt."

An interesting "stunt" programme could be devised by giving us a selection of gramophone records interspersed with records made on the Stille machine, which is due for delivery at Savoy Hill this week. Readers are probably aware that the Stille machine employs steel tape on which sounds are recorded by varying degrees of magnetisation. The device has been used for some time in Germany, principally in training students for the microphone.

oooo

As Others Hear Them.

The B.B.C. will use the instrument for a similar purpose. Rehearsals will be recorded so that artistes can check their own performances and correct small mistakes in diction.

I hear that there is a possibility that the instrument might be used for "bottling" programmes intended for transmission to the Dominions a few hours later and also for rebroadcasting in the evening important speeches or other outside events not available to the majority of listeners at the time they are recorded.

oooo

Flyweight Championship Broadcast.

A running commentary on the fight for the flyweight championship of Great Britain, between Bert Kirby and Jackie Brown, relayed from Belle Vue Stadium, Manchester, will be heard by National listeners on February 2nd.

oooo

Another G.B.S. Play.

A Shaw play can be relied on to survive the three tests: appearance in print, performance on the stage, and presentation at the microphone. I hear that Cecil Lewis is making preparations for the broadcast production of "You Never Can Tell" during the second week in March.

The play will take an hour and three-quarters to perform—a test of the listener's powers of concentration, even remembering that the writer is G.B.S.!

oooo

Morbidity at the Microphone.

Two hours of Shaw would be preferable to half an hour of the morbid type of play which has figured so often in recent programmes. I see that Mr. Val Gielgud, the B.B.C.'s dramatic director, has been defending the present policy on the grounds that Savoy Hill possesses no born radio dramatic comedian.

Apparently the microphone is kinder to groans than to laughter. Well, if we must have groans, let them steal forth earlier in the evening.

oooo

Grandfather's Night Life.

Harold Scott and Lance Sieveking are collaborating in a programme entitled "The Pursuit of Pleasure," which is to be produced in February.

This will be a bird's-eye view of three centuries of entertainment; and although in these days of broadcasting, talkies, midget golf, night clubs and dirt tracks, we may imagine that we leave grandfather and his ideas of night life and entertainment standing, his pursuit of pleasure was in reality not less exciting than ours.

oooo

All About the Census.

A good deal will be heard presently about the Census which is to be taken on April 26th next. On February 17th the Registrar-General, Mr. S. P. Vivian, will broadcast an introductory talk in the National programme, entitled "Numbering the People."

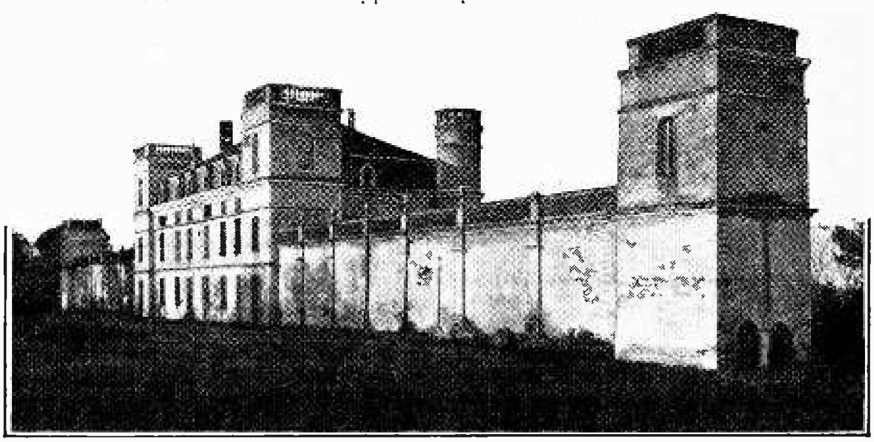
Following talks by several experts on census procedure, Mr. Vivian will wind up the series on March 24th.

oooo

Two Little Words.

Despite the clamorous appeals of its votaries, Esperanto still fails to get a hearing at Savoy Hill, but I wonder whether the B.B.C. is thinking of relaxing its adamantine attitude to artificial languages? The question is suggested by the fact that in his Grand Goodnight on New Year's Eve, Mr. J. C. Stobart included the salutation: "Selican Novjaros!"

While not unduly elated, the Esperantists consider that they have started the year well.



CHATEAU AS BROADCASTING STATION. At the end of March the transmissions of Radio Toulouse will radiate from a new 60 kW. station now being built at the picturesque Château de Saint-Agnan, 30 km. from Toulouse. The authorities state that Toulouse will soon have as large a circle of listeners as Daventry or Langenberg.

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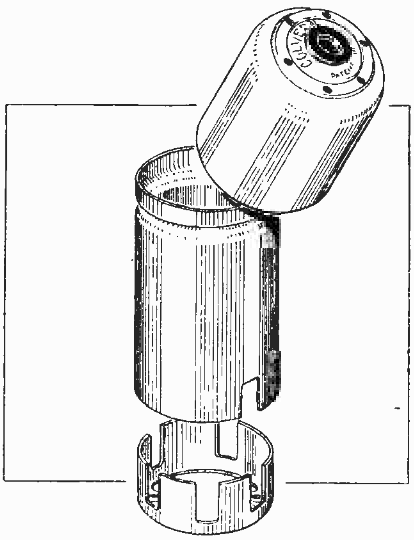
Laboratory Tests on New Apparatus.

A Review of Manufacturers' Recent Products.

VALVE SCREENS.

There is no question that total screening around screen-grid valves is essential, becoming of great importance when more than a single H.F. stage is employed. Circular screens around valves were first introduced in presenting the designs of the *Foreign Listeners* and *Wireless World Four* receivers, and it was necessary to procure spun aluminium covers to take the place of the temporary tin screens which were used when producing these sets. In this connection Colvern, Ltd., Mawneys Road, Romford, Essex, are now manufacturing covers possessing several advantages.

In the first place the tubular formation is obtained by pressing as an alternative to spinning. By this means all covers are identical and interchangeable while possessing a smooth well-finished appearance similar to that of the well-known Colvern coil covers which are produced by a similar method. Several novel features have been introduced, permitting the use of the screen with valves of any size and valve holders of any make. The base piece is completely cut away except for a rim, thus giving safe clearance for all terminals and screens. Side slots in the base piece allow of leads being taken directly to terminals when the wiring is to be carried out above the baseboard.



The new Colvern telescopic valve screen designed to fit all types of valves and valve holders.

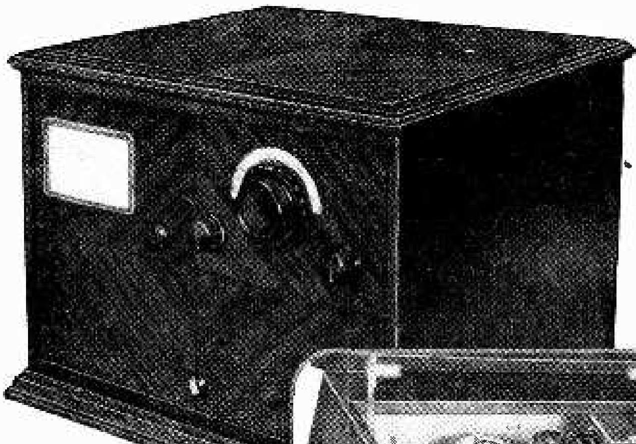
A telescopic adjustment of the valve cover results from the use of cylinder and cap, the latter sliding down on to the cylinder so as to allow of the correct height being obtained with the anode terminal just protruding. At one end of the tubular portion is a groove which in addition to giving a stiffening effect prevents contact between screen and outgoing wires when the connections are made to the valve holder above the surface of the baseboard. When using under baseboard wiring, as in the *Wireless World Four*, the central tube is reversed, thus covering the side slots. A gap is, however, arranged so that the grid wire, which is normally above the baseboard, may be carried through.

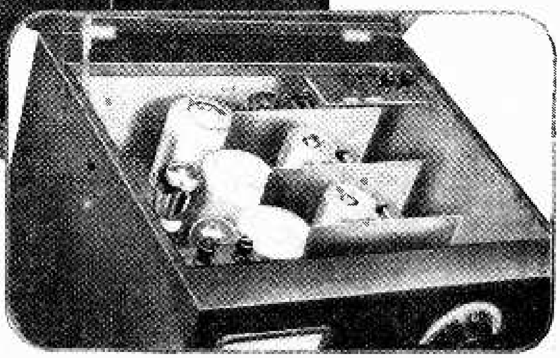
The screens are thick and rigid and the sections fit each other well. A durable and attractive finish is obtained by chemical etching, while ventilating holes are provided at the top. This screen is of sufficient diameter to accommodate all types of S.G. valves without looking unduly large. An insulating ring in the top prevents contact with the anode of the valve. The price of this new component is 2s. 9d.

oooo

CARRINGTON CABINET FOR THE WIRELESS WORLD FOUR.

An exceedingly well-finished cabinet is now obtainable for this receiver, permitting its use as a table-type set. The receiver chassis built in accordance with the specification fits the cabinet by sliding in from the back. Access to valves, condensers and coils is obtained through the hinged top lid. The accompanying illustration shows the method of fitting aerial and earth terminals as well as pick-up terminals and gramophone change-over switch. It will be noted that the aerial terminal is kept near the front of the set while the gramophone switch which is in the grid circuit of the detector is not brought forward beyond the edge of the third screen. These details are, of course, essential as is explained in the article describing the set in order to prevent unwanted couplings. A recess on the underside of the lid accommodates the terminals.





Carrington cabinet for the Wireless World Four, showing the method of fitting terminals and controls.

The cabinet is a really high class piece of furniture, the front and top panels being quartered. It is an easy matter to fit the set to the cabinet and a pleasing front layout is obtained by fitting a station indicator (such as that made by Bulgin) to balance the single dial control, while an on-and-off switch near the lower edge and in the centre controls the mains transformer, which is immediately behind.

The cabinet is made by the Carrington Manufacturing Co., Ltd., "Camco" Works, Sanderstead Road, South Croydon, Surrey, and is supplied in mahogany or oak selling at £4.

oooo

DOUBLE PUSH-PULL TRANSFORMER.

This is a Varley product and consists virtually of two transformers wound on a common core. There are two separate primaries and two secondaries, each affording a step-up ratio of 2.5 to 1. Since its principal application will be in a push-pull circuit, the magnetising effect of the two primary currents will cancel out, consequently the effective inductance will be that shown with no steady D.C. flowing.

Measured at 50 cycles under the above conditions, the inductance of each primary winding was found to be 89 henrys with 1.23 milliamps of A.C. flowing in the

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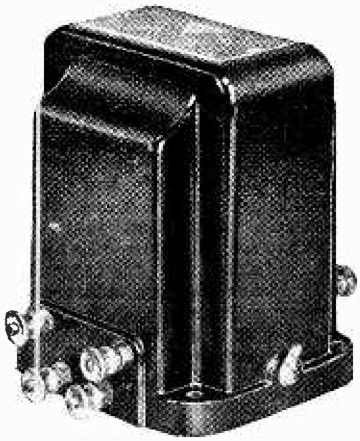
winding. The D.C. resistance of each half was 1,060 ohms.

For push-pull circuits the main advantage arising out of the separate secondary windings is that each of the valves following can be biased independently, thereby balancing the output stage and making for more stable working.



Varley double push-pull input transformer with two separate primary and secondary windings.

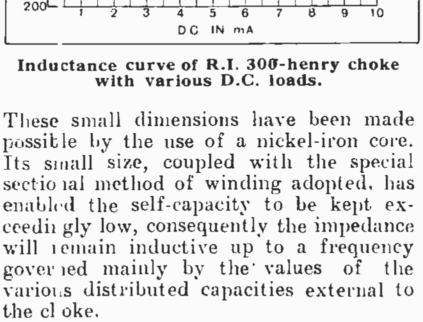
The many applications of this interesting and useful transformer are explained fully in an instructional booklet supplied with each component.

The makers are Varley, Kingsway House, 103, Kingsway, London, W.C.2, and the price is 27s. 6d., including royalty.

o o o o

R.I. 300-HENRY CHOKE.

One of the principal applications of this choke will be in conjunction with a power grid detector, where the available H.T. is of the order of 200 volts or possibly less. In spite of the very high order of inductance attained, the overall size of the component is only 2½in. × 2in. × 2in., and its weight is approximately 1 lb.



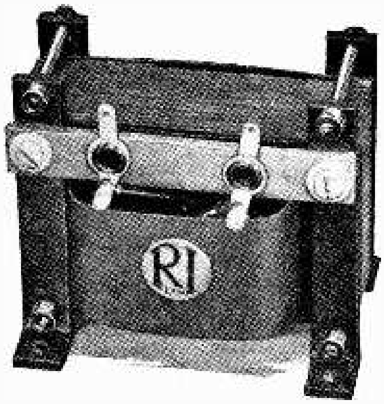
Inductance curve of R.I. 300-henry choke with various D.C. loads.

These small dimensions have been made possible by the use of a nickel-iron core. Its small size, coupled with the special sectional method of winding adopted, has enabled the self-capacity to be kept exceedingly low, consequently the impedance will remain inductive up to a frequency governed mainly by the values of the various distributed capacities external to the choke.

A sample was tested, and its inductance measured at 50 cycles with various values of D.C. flowing, and with an A.C. voltage of 10.5 applied to the ends of the choke. The current component of the A.C. varied from 0.1 mA. with no D.C. flowing to 0.165 mA. when 10 mA. of D.C. were passing.

The inductance is well maintained over the normal working range of the choke, as can be seen from the curves, as even when the A.C. type of valve is employed, the steady anode current will not normally exceed 8 mA. With a battery type valve this will drop to between 5 and 6 mA. The measured D.C. resistance of the winding is 2,870 ohms.

The makers are Radio Instruments, Ltd., Purley Way, Croydon, and the price is £1 1s.



R.I. 300-henry L.F. choke with nickel-iron core.

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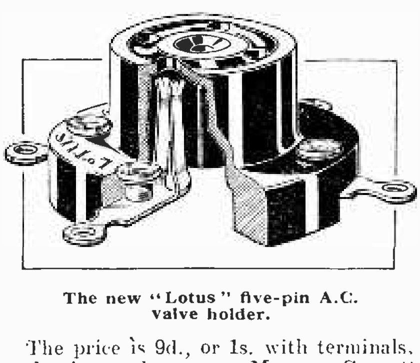
A NEW "LOTUS" VALVE HOLDER.

This valve holder is of the five-contact type, and is therefore suitable for modern indirectly-heated valves. The contact sockets and terminal tags are one-piece stampings from tinned hard-rolled brass, which is bent in the shape of a U and firmly grips opposite sides of the valve-pin. There can be no doubt that this is one of the most positive forms of contact that has yet appeared, and we recommend it without reserve.

The moulding is of good quality, and the guide holes for the valve-pins are sunk in an annular groove to facilitate easy insertion of the valve.

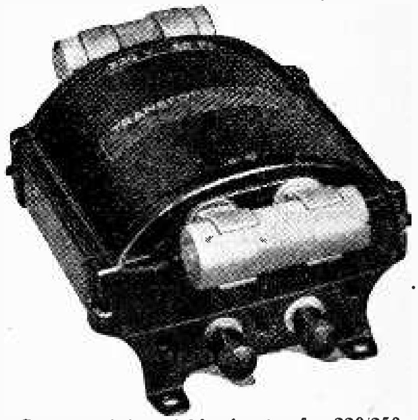


The new "Lotus" five-pin A.C. valve holder.

The price is 9d., or 1s. with terminals, and the makers are Messrs. Garnett Whiteley and Co., Ltd., Mill Lane, Liverpool

A COMPACT L.T. CHARGER.

This unit is intended for charging 4- and 6-volt accumulators from 220-volt 50-cycle mains, but it can be employed to perform a similar service for 2-volt cells if a small resistance is included in the charging circuit to limit the current to 0.5 amp. This resistance may be re-



Compact L.T. trickle charger for 220/250 volt 50-cycle A.C. mains.

quired, also, when 4-volt cells are charged, if the mains voltage is much in excess of 220.

A test carried out on a supply of 235 volts showed that without this limiting resistance a 4-volt cell charged at 0.53 amp., but a 6-volt accumulator received only 0.26 amp.

The charger consists of a step-down transformer with a small cartridge-type silver-oxide rectifier and an input fuse mounted on the case.

The price is 16s. 6d., and supplies can be obtained from M. Benoit, 4, Manor Gardens, Gunnersbury Lane, London, W.3.

o o o o

Change of Address.

The American Hard Rubber Co. (Britain), Ltd., 13a, Fore Street, London, E.C.2, announce that on December 25th, 1930, their offices and warehouses were removed to 95, Hatton Garden, London, E.C.1. The telephone number is Holborn 6037, and the telegraphic address "Eboniseth, Smith, London."

Catalogues Received.

The Gripso Co., 32, Victoria Street, London, S.W.1.—Illustrated folder dealing with accessories and new pattern indicating switches.

Rotor Electric, Ltd., 2-3, Upper Rathbone Place, London, W.1.—Leaflets dealing with a new range of gas-filled grid leak type resistances. These are rated to dissipate 0.25 watt, 1.5 watts, and 4 watts.

Philips Lamps, Ltd., 145, Charing Cross Road, London, W.C.2.—Illustrated catalogue describing the range of battery and all-electric receivers, also loud speakers, L.T. chargers and rectifiers.

Nivex Gauge, Ltd., Tipping Street, Ardwick, Manchester.—Descriptive folder explaining the various uses of the **Nivex pocket Detectorscope.**

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CORRESPONDENCE.

The Editor does not hold himself responsible for the opinions of his correspondents.

Correspondence should be addressed to the Editor, "The Wireless World," Dorset House, Tudor Street, E.C.4, and must be accompanied by the writer's name and address.

CAUSES OF HUM.

Sir,—"Ideas" refers, in your issue of January 7th, to the H.F. currents induced in the power rectifier valve of a H.T. eliminator. These H.F. currents are modulated at 50 or 100 cycles, and produce hum, even though smoothing may be perfect. I drew attention to this phenomenon in *Experimental Wireless*, November, 1928, p. 606, and pointed out that the oscillations could be suppressed by a method substantially identical with that given by "Ideas."

Although I had then been employing this method for at least a year, I did not imagine that it could be novel. It was not, however, until some time later that condensers for suppressing H.F. oscillations were generally adopted in commercial apparatus. A. G. WARREN.

Bexley Heath.

METAL PANELS AND COMPONENTS.

Sir,—The increasing general use of metal panels for wireless receivers has revealed the necessity, I suggest, for a slight modification to certain types of components. In particular I would refer to potentiometers, such as are commonly used for volume controls, which in so many cases have the slides metallically connected to the spindle and fixing nut. Thus, whenever one of these components is attached to a metal panel it has to be insulated therefrom by a bush or other means—rather tedious and annoying, especially when one is in a hurry!

I have recently made a receiver incorporating Burndept and Igranic potentiometers, and both of these have needed insulation from the panel.

I suggest that manufacturers concerned might, with advantage, modify their components to meet requirements in this connection, or alternatively supply suitable insulating bushes.

Sutton. T. H. BRIDGEWATER.

BALANCE OF PIANO TRANSMISSIONS.

Sir,—I was interested in the paragraphs about piano transmissions on the "Broadcast Brevities" page in your issue of December 31. Your contributor gave an instance of a serious disparity between reception of a pianoforte part in a quintette and subsequent reception (on the same evening, the same set, and wavelength) of piano illustrations to a music talk.

The difficulty of achieving really satisfactory transmission of these pianoforte illustrations is dealt with in the current issue of the B.B.C. Year Book ("Piano Balance," p. 282), where a writer points out that, while it is desirable to have the microphone close to the speaker, it should be eight or ten feet away from the piano for satisfactory reproduction of the musical illustrations.

If the microphone is too close to the piano, "blasting" is liable to occur, while placing it too far away from the lecturer has the effect of making the speech sound distant, and, if a carbon microphone is used, of introducing a background "hiss."

With a view to overcoming these difficulties as far as possible, a microphone of the condenser, or electro-static, type is now used. Even with this type of microphone, however, the reproduction of pianoforte illustrations to music talks is, in my experience, very unsatisfactory on the whole. But, in view of the difficulties mentioned above, it seems improbable that the bad-quality reproduction on the occasion mentioned by your contributor was due to either of the two causes he suggested—namely, a poor microphone in Studio No. 3, or unsuitable acoustic properties of that studio.

In view of the admitted difficulty in obtaining a satisfactory balance of speech and piano music with one microphone, however, it seems rather curious that the B.B.C. engineers apparently do not resort to the seemingly obvious remedy of using two microphones, with appropriate switching or fading arrangements, for these illustrated music talks.

London, S.W. W. WILLIS OLIVER.

SERVICE.

Sir,—There is an aspect of the service question which I have not seen raised. I refer not to what is commonly meant by this term, "after-sales" maintenance, but to "during sales" supply by manufacturers. Every autumn the industry exhibits with much elan their new season's range of components, and the thoughts of those who attend the exhibition (and of those who only scrutinise the advertisements) turn lightly to the possibilities of their new set. By January the fine edge of their enthusiasm has turned to gall and wormwood. Can they obtain the articles required? No, they cannot! And the bigger the manufacturer the worse the prospects. Every year the trade either grossly underestimate the output they will be called upon to supply, or else they would appear deliberately to refrain from even beginning manufacture until the box office has sold out—no gate money, no performance. In some cases one suspects them of selling all their meagre output to set manufacturers; but whatever the cause, the effect is intensely irritating to the constructing public, gives a lot of extra work to one's local dealer in acrimony and correspondence, and is thoroughly bad business. G. M. PART.

Tunbridge Wells.

NEWCASTLE TRANSMISSION.

Sir,—I was very interested to peruse the remarks of "Qualitas" in your last issue with respect to the Newcastle transmission. For some reason or other the quality of the broadcast (from this station, at any rate) seems to vary—one might almost say hourly.

I have given every conceivable type of refinement a trial, but still the trouble persists, and I have finally given up the problem. Push-pull rectification, anode-bend, power grid, leaky grid, etc., together with various forms of inter-valve coupling and matched outputs, do not provide a remedy. My remedy is simply to use a straight two-valver (no reaction incorporated) and leave it at that. It is somewhat amusing to compare the contrasts in reproduction in one evening. Whether it is the particular studio, land-line or broadcaster I cannot say, but it is a remarkable thing that if I switch on my long-distance and quality set I get far more brilliant reproduction from certain foreign stations than I do from the local, which is only a mile or two away. This is not as it should be, but I, like others, have to take things for granted. It seems little use investing in expensive apparatus unless one looks at it from the traders' point of view. DEMONSTRATOR.

Newcastle-on-Tyne.

"WIRELESS WORLD FOUR."

Sir,—I was interested in your further article in December 17th issue dealing with constructional details of the "Wireless World Four," and to note that other readers were desirous of arranging the radio-gramophone switch so that it could be operated from the front of the panel.

The method I have used for this may be of interest. It consists of a three-point Red Diamond switch mounted on a small ebonite bracket and screwed on to the baseboard immediately to the rear of the end bracket of the ganged condenser; an extension is brought through to the front of the set by means of a long insulated rod, which, by the way, is a No. 8 bone knitting needle, finishing with a small knob which is in centre line with the condenser dial, and just below.

The two end supports and the two outside screens are easily drilled, but for the hole in the middle screen (to save dismantling condensers) an extended drill was made of brass tube with a smaller drill inserted so that same could pass through the hole already made in the front screen and a hand-chuck used to drill this hole.

The switch does not need perfect alignment, as it is easily operated as push-pull. Using this method certainly shortens the grid lead when using radio and makes for easier change over.

Hexham. J. W. STAINSBY.

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READERS' PROBLEMS

Replies to Readers' Questions of General Interest.

Technical enquiries addressed to our Information Department are used as the basis of the replies which we publish in these pages, a selection being made from amongst those questions which are of general interest.

For the New D.C. Valves.

With reference to the suggested circuit for the new D.C. indirectly heated valves, which was published in your issue of January 7th, will you please tell me what types of tuning coil would be suitable for this receiver?

Suitable windings for the filter coils and H.F. transformer of this set were described in detail in our issue of September 18th, 1930.

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Causes of L.F. Oscillation.

My five-valve portable set, after working satisfactorily for nearly a year, has developed an L.F. "howl." Suspecting this to be due to the development of H.T. battery resistance, a replacement was made, but the trouble persists.

As far as possible, all circuits and components have been tested, and there is no obvious fault. Can you suggest the most likely cause?

If your receiver embodies a decoupling scheme for its anode feed circuits, it would appear likely that the fault is due to a disconnected by-pass condenser; the disconnection may be either external or internal.

In receivers which include one or more stages of resistance coupling in the L.F. amplifier, troubles of this kind are sometimes traced to the development of an excessively high resistance—almost an "open circuit"—in the grid leak. The detector grid leak might also be suspected.

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Superheterodyne Mains Feed.

It has been stated that the anode current taken by the "Band Pass Superheterodyne" amounts to some 22 milliamps. at 160 volts; if an eliminator with an output of 240 volts at this consumption is used, would it be better to increase suitably the value of each individual feed resistance in the set, rather than to fit a common voltage-absorbing resistance for all the valves? In any case, a separate feed would be provided for the oscillator.

As this receiver is inherently free from interaction troubles, it will be quite safe to use a single external resistance to absorb the surplus eliminator voltage.

All-wave Reception.

Can you tell me if there is any commercially obtainable receiver which is capable of receiving long, medium, and short broadcasting wavelengths?

The Burndept "Universal Screened Five" meets these requirements, as it covers wavelengths from 16 to 2,100 metres, omitting non-broadcasting channels.

This set was reviewed in detail in our issue of June 18th last year.

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Earthed Condenser Spindle.

My new receiver is to have a metal panel, and, if it is possible to do so without sacrificing efficiency, I should like to avoid the use of an insulating bush for the differential reaction condenser spindle. Can this be arranged?

It is not essential that the fixing bush should be insulated from the metal panel, as a differential reaction condenser works quite satisfactorily when its rotor is earthed (*via* the panel) in the manner shown in Fig. 1.

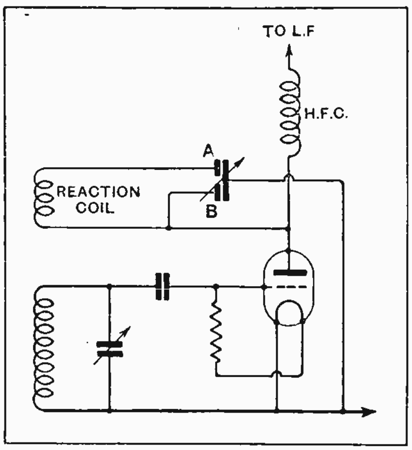

Fig. 1.—Differential reaction condenser with earthed rotor.

The flow of H.F. current through the reaction coil is at maximum when the rotor is fully meshed with stator A, and feed-back is reduced progressively as it is moved into engagement with stator B.

More Magnification.

The anode bend detector of my four-valve receiver—built nearly three years ago—is followed by two L.F. stages, resistance- and transformer-coupled. Now that an eliminator has been added there is a tendency towards motor-boating when full magnification is used. Would matters be improved by altering the first stage to transformer coupling with resistance feed?

We do not recommend this alteration. Any reduction in L.F. reaction will be more than offset by the increased magnification afforded by the transformer.

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Filter Position.

I have been considering the question of modernising my 1-v-2 receiver, and find that it would be much more convenient to fit a filter as part of the H.F. intervalve coupling than in the aerial input circuit. Although the latter position seems to be generally favoured, I should like to know whether there is any serious objection to my proposal.

Unless you are already using some form of two-circuit aerial tuner, we would strongly dissuade you from using a filter in the manner you propose, particularly if a screen-grid valve is used for H.F. amplification.

It is now generally agreed that selectivity devices of this nature should be placed at the aerial input end of a receiver.

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L.T. Accumulator Charging.

Energising current for the field magnet winding of my moving-coil loud speaker is obtained through a low-voltage metal rectifier. Will you please tell me if there is any risk of damaging the rectifying and smoothing equipment if it is used for charging an L.T. accumulator while the set is out of operation?

Provided that reasonable care is taken to avoid short-circuits and overloads, there should be no objection to using the rectifier output for charging purposes. It will be necessary to connect a limiting resistance of suitable value in series with the battery.

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Combined Reaction and Tuning Coil.

Will you please show me how a centre-tapped coil may be used in a choke-fed tuned grid circuit so that the usual extra reaction coil will be unnecessary?

Reaction is to be controlled by a differential condenser.

The circuit you require is given in Fig. 2. We would point out that, in spite of the use of a differential reaction condenser, it will probably be beneficial to connect a small fixed capacity between anode and filament of the detector valve.

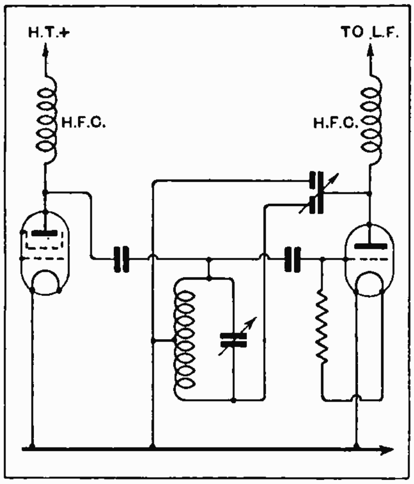

Fig. 2.—Tuned grid H.F. coupling with simple centre-tapped coil and "Hartley" reaction.

Further, an intervalve circuit of this type is unsuitable when ganged tuning is employed.

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Skip Distance.

I have just completed a two-valve detector-L.F. short-wave receiver, and am not at all satisfied that it is working as it should. Although several American stations have been received quite well, signals from the B.B.C. short-wave transmitter 5SW are always so weak as to be barely intelligible. Does this suggest that the set is defective over a part of the wave range that it covers?

We do not think so. In connection with reception of the ultra-short wavelength, there is a well-known phenomenon known as "skip distance," and it is quite normal that a transmission of this sort should not be well received at short range.

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Grid Return Circuits.

Will you please tell me if it is essential that potentiometers should be connected across the L.T. transformer windings of the "Independent Gramophone Amplifier," as described in your issue of December 24th?

As the L.T. secondaries of the transformer used in this amplifier are not fitted with centre trappings, it is essential that potentiometers be used. Otherwise, hum will be produced, due to the fact that the mean grid potential of the valves with respect to the cathode will vary at mains frequency.

Matching Valve and Loud Speaker.

I have recently had an opportunity of comparing my own loud speaker with another of different design, and have been puzzled by the behaviour of the output valve anode milliammeter. When the original instrument is connected heavy fluctuations of the needle are produced long before volume is increased to an excessive extent. On substituting the new loud speaker, which, incidentally, is rather less sensitive to small inputs, it is found that much greater volume can be obtained without obvious distortion, and that the meter needle remains steady unless the output valve is clearly overloaded. Will you explain these effects?

This matter is entirely associated with the question of matching the loud speaker to the output valve. It seems certain that your own instrument is not properly matched, and that some suitably chosen output device is necessary. We advise you to read an article on this subject in our issue of May 28th, 1930.

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Relative Resistance Values.

In the design of high-quality resistance-coupled low-frequency amplifiers it seems usual to employ a considerably lower value of resistance in the detector anode circuit than in the succeeding stage. This rule seems to be observed even when the detector and first L.F. amplifier valves have approximately the same impedances, and consequently where one would expect to find coupling values of the same order. Will you please explain the reason for this?

With regard to the detector valve, it must be remembered that a fairly large by-pass condenser must be connected across its anode circuit in order to prevent excessive damping of the preceding tuned circuit. High-note loss will be produced unless the reactance of this condenser is low in relation to the coupling resistance, which must accordingly be of low value. In the case of the succeeding L.F. amplifier no by-pass condenser is necessary, and sources of high-note loss are confined to stray capacities.

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An Easy Test.

Individual high-frequency circuits of my 2-H.F. set are completely screened, except for the components associated with the detector valve, including an H.F. choke in its anode circuit. In spite of all the usual precautions, it is found that uncontrollable self-oscillation is produced when the set is tuned to wavelengths below about 300 metres: do you think that this might be due to magnetic interaction between the detector grid coil and the choke?

It is most unlikely that self-oscillation is due to this cause, and in any case it should be easy to make a test by temporarily short-circuiting the H.F. choke. There will be no need even to apply this test if reaction is fitted; you should detune all circuits except the detector grid, and, if self-oscillation can be stopped by loosening reaction coupling, it can be assumed that direct interaction is not responsible for your troubles.

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A.C.-Operated Relay.

I have found that my remote control on-off relay may be operated quite satisfactorily from A.C., and have accordingly discarded dry cells as a source of energy in favour of a small step-down transformer, of the type sold for operating electric bells.

It is inconvenient to interrupt the mains circuit, and so my control switch is connected in series with the relay and the transformer secondary. The primary is permanently connected to the mains; can you give me an idea as to how much current it will consume when no load is imposed?

If your step-down transformer is reasonably well designed and constructed, its "no load" consumption should be quite negligible—insufficient to operate the electric supply meter. We would remind you that when electric bells are fed from the same source, the transformer primary is always shunted across the mains.

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Measuring Charging Current.

I have just made a measurement of the current delivered by my A.C. trickle charger, and find that it is nearly 30 per cent. greater than the makers' rating. Is this excessive?

An overload of 30 per cent. would be excessive for many trickle chargers, but we think it is likely that you have been misled by using a moving iron meter, which will often give a reading which is on the high side by about the same percentage when connected in series with a full-wave rectifier.

FOREIGN BROADCAST GUIDE.

GRAZ

(Austria).

Geographical position: 47° 4′ N. 16° 26′ E.

Approximate air line from London: 764 miles.

Wavelength: 352 m. Frequency: 851 kc. Power: 9.5 kW.

Time: Central European (one hour in advance of G.M.T.).

Standard Daily Transmissions.

Relays Vienna throughout the day.

Male announcers.

Opening signal: As Vienna (···— V's *ad. lib.*). Call: *Hier Radio Wien* (phonetic *Veen*).

Interval signal: Metronome (rapid beat) or letter K (—·—).

Closes down as Vienna (*q.v.*).

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As many of the circuits and apparatus described in these pages are covered by patents, readers are advised, before making use of them, to satisfy themselves that they would not be infringing patents.

Competition in Broadcasting Power.

THE technical policy of British broadcasting in relation to its service to the public has been consistent ever since broadcasting in this country first began, but it would seem that this consistency has been maintained without regard to altering circumstances and conditions in Europe, until to-day a position has been reached where, although the B.B.C. policy has not changed, a complete reversal of the receiving conditions which the B.B.C. originally set out to establish has occurred.

By way of explanation of such a statement, it is necessary to trace briefly the history of B.B.C. policy in the matter of broadcasting. Initially, when crystal sets were in the majority, the B.B.C. set themselves the task of providing a broadcasting service which would enable every crystal set user to receive the programmes. It was probably with this object in view that transmitters were located in the centre of the most densely populated areas, and, in addition, a long-wave station at Daventry was put up to serve the country generally. As time went on and the popularity of the crystal set began to wane, the B.B.C. considered that it would be better, especially in connection with the development of the Regional scheme, that the transmitters should be located outside the densely populated areas, and the power increased at the same time in order not to reduce the service area of the stations, and to ensure, as far as possible, that reception conditions would, generally speaking, remain unaltered. The increase in power of the stations presented difficulties where twin Regional transmitters were established, because of the tendency of the less selective sets to receive both transmissions simultaneously.

Modification of receivers, in time, largely eliminated this difficulty, and the B.B.C. were still able to claim that their transmissions were receivable on the simplest of sets over most of the country. But this statement is to-day only true if we ignore the existence of the high-power Continental transmitters. The very fact that the British stations have led the way by increasing their power has resulted in Continental transmitters following suit, until now we have the state of affairs that simple sets are fast becoming obsolete because they are insufficiently selective to separate the B.B.C. transmission from those of Continental stations.

Over very large areas of the country the complaint to-day is, not: "How can I cut out the local British transmitters in order to receive foreign stations?" but, "How can I eliminate the foreign transmissions when I want to hear a British station?" The cause of all this difficulty is, undoubtedly, the rapid extension in power of transmitters, which seems to have been largely brought about by the policy of our own broadcasting organisation, and, as we originally stated, the B.B.C. are fast defeating their own object and making it imperative to use selective and consequently expensive receivers even to receive our own transmissions.

In This Issue

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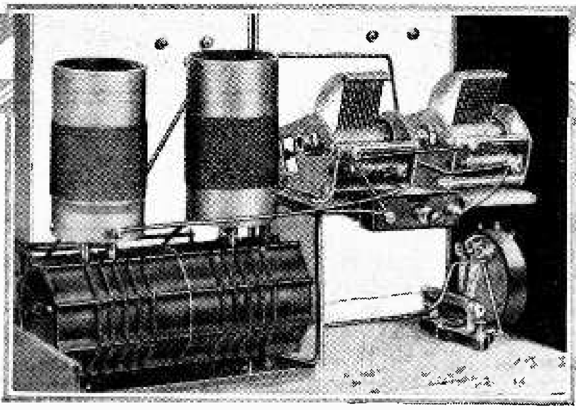
INDUCTIVE BAND PASS FILTERS



Mutual Inductance Coupling and its Advantages.

By
L. E. T. BRANCH,
B.Sc.

As already explained in the pages of *The Wireless World*,[1] the band-pass filter when properly arranged has the great advantage, from a quality point of view, of passing in good proportion all the audio frequencies which are superimposed upon the carrier wave of the station being received. In other words, whereas a single tuned coil "smooths out" the higher audio frequencies, as shown by the curve A in Fig. 1, the band-pass filter gives a curve similar to that shown by B. It is seen that over the region 0 to 5,000 cycles on each side of the carrier frequency the filter gives vastly superior results when compared with the single coil. Further, the selectivity obtained with the filter is much greater.

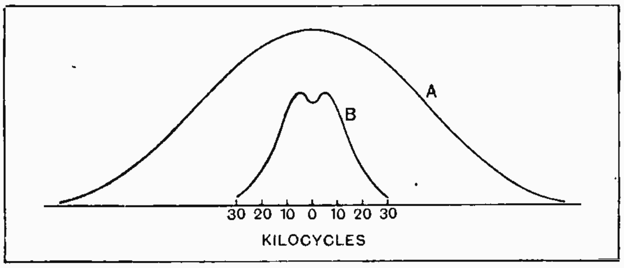


Fig. 1.—Curve A represents the response of a single tuned circuit and curve B that of a well-designed band-pass filter.

Now, a band-pass filter consists essentially of two tuned coils which are coupled together to a very small extent. The amount of this coupling is of the highest importance, and unless this is correct the quality or the selectivity may be most unsatisfactory. In general, if the coupling is too great the selectivity will suffer, while with too small a coupling the quality will be impaired. These effects are shown more clearly in Fig. 2.

The coupling which is referred to can be arranged in a variety of reasonably satisfactory ways, and these fall into two classes known as (a) inductive coupling, (b) capacitative coupling. In any case, the object is to cause the oscillations produced in the one tuned circuit to be slightly injected into the other circuit, and the formula for the band width is $W = \frac{\sqrt{Z^2 - r^2}}{2\pi L}$ where Z is the reactance of the coupling and r is the effective series resistance of each of the coils. A method of attaining the necessary coupling which has been used to a great extent recently is that which belongs to class (b), and which employs a coupling condenser C_m which, when used as shown in Fig. 3 (a), must be of an exceedingly small value, e.g., 0.0001 mfd., or when used as in Fig. 3 (b) has a relatively large value, e.g., 0.01 mfd. In the first case it is doubtful whether the coupling is purely capacitative. In the latter case it will be seen that C_m can be considered as being in series with each of the tuning condensers individually. In other words, C_m is common to both tuned circuits, and consequently the voltage produced across C_m by the first tuned circuit is impressed into the second circuit.

[1] See issues dated Oct. 30th, 1929; Jan. 8th, 1930; Feb. 26th, 1930; April 2nd, 1930; Aug. 27th, 1930; and Sept. 24th, 1930.

Disadvantages of Capacity-coupled Filter.

The disadvantage of the capacity filter is that the peak separation does not remain constant over the waveband; at the lower wavelengths the peaks tend to coalesce, while at the higher wavelengths there may be double tuning due to wide separation.

Comparative results obtained when both forms of coupling are used have been very well set out by A. L. M. Sowerby,[2] who pointed out that with inductive coupling the width of the band remains fairly constant.

[2] *The Wireless World*, February 26th, 1930.

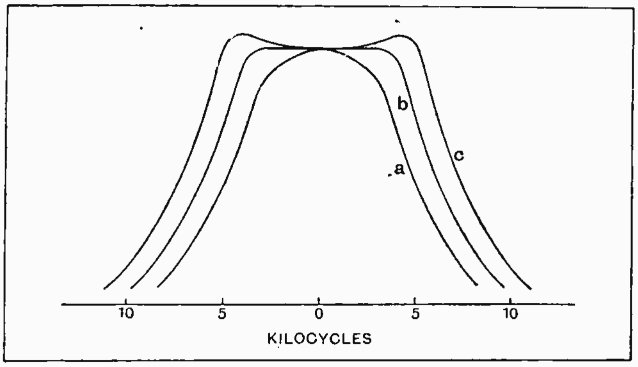


Fig. 2.—When the coupling in a filter is tight the response is given by such a curve as C, and when loose the frequency characteristic may be like curve a.

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The reason for this is explained as follows: The inductive coupling method consists in using a small amount of the field of one tuning coil for exciting the other coil, and while several ways of doing this are possible, the effect in each case is to create a small mutual inductance L between the tuning coils, this inductance having the impedance of $2\pi f L$. This, then, is the value which must be assigned to Z in the formula for the band width. Now, unlike the impedance in the case of the capacitative filter, the value of $2\pi f L$ will increase with increasing frequency. The effective series resistance also increases with the frequency; consequently, Z and r now vary in the same direction, so that W tends to remain constant.

The inductively coupled filter has, therefore, certain advantages, but a set in which it is employed is not

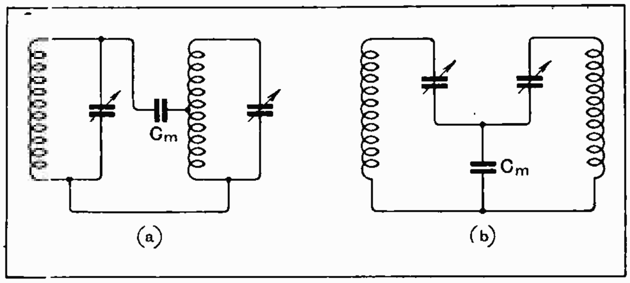

Fig. 3.—Two filters using condensers C_m for the common coupling. In (a) the value of C_m must be about 0.0001 mfd. and in (b) about 0.01 mfd.

likely to be quite so selective at the lower wavelengths, not because of the filter, but simply because any circuit employing a variable tuning condenser must suffer in this way. The quality will, of course, be superior in the inductive filter. One common method of making an inductively coupled filter is to wind a few turns of wire over one of the coils and include these turns in the circuit of the other coil, as shown diagrammatically in Fig. 4 (a). Another way is to wind a small separate coil, and include it in both coil circuits [Fig. 4 (b)]. These methods and similar ones can only be successfully operated if the coils are well screened from one another. This screening must be complete because one or two microhenrys external coupling of the fields is sufficient to spoil the result. The reason for this is that the total coupling usually required is only of the order of two μH.

THE advantages in respect of selectivity and quality conferred by band-pass filters having common capacitative or inductive coupling have been put forward from time to time in this journal. In the accompanying article the case for coupling by the mutual inductance method is made out, and it is shown that the resulting filter lends itself to a simple and inexpensive layout in which unscreened coils are used. Constructional details for a D.C. mains set containing such a filter will be given in next week's issue.

In an article in *The Wireless World* for January 15th, 1930, W. T. Cocking suggested coupled coils for use on the medium waveband which were not screened from one another at all, because he employed as the coupling inductance the mutual inductance between the coil fields. It will be appreciated that, from a mechanical and constructional point of view, this method has great advantages. No screening is required, and, moreover, the coils fit easily into a very small space. However,

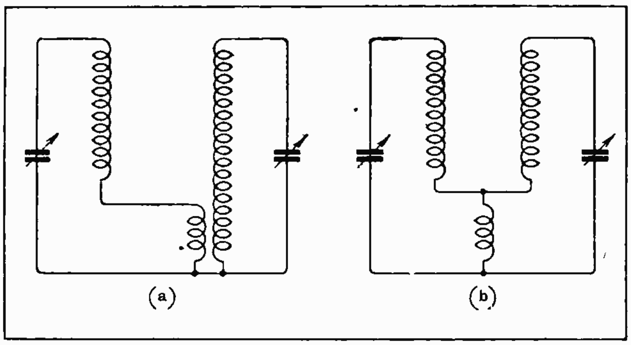

Fig. 4.—Two forms of inductive band-pass filter. In (a) mutual inductance is employed, while in (b) there is a common inductive coupling. In both cases the tuning coils must be totally screened.

it is highly important, in carrying out this method, to be able to find easily the value of the mutual inductance. This can be done without great difficulty in certain circumstances.

Calculating Mutual Inductance.

The first case is that in which the two coils L_1 and L_2 are placed with their axes parallel, as shown in Fig. 5. Let d cms. be the distance apart, of their centres O_1 and O_2. Let S_1 and S_2 be the lengths of the windings. If for convenience we regard L_1 as the coil which is tightly coupled to the aerial, it can be considered as the "exciting coil" producing the magnetic field which acts upon the coil L_2. The mutual inductance H between two such coils is given sufficiently accurately by the formula—

$$H = \frac{A^2N^2}{1000d^3}\ \mu H.$$ A is cross-sectional area and number of turns.

In applying this formula in practice one usually starts with coils of given dimensions, and requires to find d for a certain coupling, in which case we see that $d^3 = \frac{A^2N^2}{1000H}$. Suppose, for example, we are dealing with medium wave coils of 60 turns wound on formers of $2\frac{1}{2}$in. diameter, and we require a coupling of 2.5 microhenrys, we have $A = \pi \times 3.1^2 = 30$ sq. cm.

Hence—

$$d = \sqrt[3]{\frac{30^2 \times 60^2}{1000 \times 2.5}} = 11 \text{ cm.}$$

In the case of long-wave coils, the coupling required is usually in the neighbourhood of 100 microhenrys. The resistance of the tuning coils is relatively small on the long waves, and can be neglected, so that a calculation of the band width at, say, 200 kc. (1,500 metres) gives $Z = 2\pi \times 200 \times 10^3 \times 100 \times 10^{-6} = 125$ ohms, and

$$W = \frac{125}{2\pi \times 2200 \times 10^{-6}} = 9{,}100 \text{ cycles.}$$

The figure of 2,200 is the inductance of an average long-wave coil in microhenrys. Such a coil would consist of approximately 200 turns on a slotted ribbed former

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of 6.5 cm. outside diameter, from which we see that—

$$d = \sqrt[3]{\frac{A^2N^2}{1000H}} = \sqrt[3]{\frac{33^2 \times 200^2}{1000 \times 100}} = 7.6 \text{ cm.}$$

With coils of this diameter this figure places them rather close together. Capacity troubles are likely to be experienced if the coils are too close. Moreover, it is often desired to have the axes of the long-wave coils situated at right angles to the axes of the medium-wave coils. For this purpose it is recommended that the long-wave coils be placed with their axes on the same straight line, as shown in Fig. 6. This method can be adopted, if desired, for the medium-wave band; but, in general, it will be found to be less suitable from a constructional point of view than that described before.

Direction of Winding.

It is found to be exceedingly important, if unwanted capacity effects are to be avoided, that the coils be wound in the proper directions. When the axes are parallel and the low potential ends are at A and B (Fig. 5), the coils must be wound in opposite directions. If it is desired to wind the coils in the same direction, then the low potential ends must be A and C. In the case of Fig. 6 it is usually best to make X and Y the low potential ends, and in these circumstances the coils must be wound in opposite directions. If the coils are wound in the same direction, X and P must be the low potential ends.

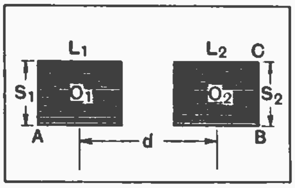

Fig. 5.—Two coils comprising a filter in which the coupling inductance is the mutual inductance between the coil fields.

The formula for the mutual inductance of two coils placed with their axes parallel, as in Fig. 5, is found in the following way.

It is well known that any coil L_1 can be regarded as a magnet of moment M, and of length equal to the length of the coil, and that the intensity of the field of this magnet at O_2 is $\frac{M}{\left(d^2 + \frac{S_1^2}{4}\right)^{3/2}}$ lines per square cm. In the case of the band-pass filter, it is found that, in order to obtain the desired small mutual inductance, the value of S_1 is, in general, less than half d, in which case $\frac{S_1^2}{4}$ is less than one-sixteenth of d^2. For practical purposes, therefore, the term containing S_1 can be neglected, and the error thereby introduced will be a small one. In this case $\frac{M}{\left(d^2 + \frac{S_1^2}{4}\right)^{3/2}}$ approximates to the very simple expression $\frac{M}{d^3}$.

If this formula is ultimately to be of any help, it is obviously necessary to evaluate M in terms of some known quantities. This can be done in the following manner. It is shown in any standard text-book upon Electricity and Magnetism that the magnetic moment of a magnet of length S_1 is $m \times S_1$, where m is the strength of each pole of the magnet. Again, the pole strength m, in the case of a coil, is shown to be simply equal to the product of the cross-sectional area of the coil, the number of turns of wire per centimetre length and the current. In the present case the cross-sectional area is clearly πa_1^2, where a_1 is the radius of the coil. Let n_1 be the number of turns per cm. (these are easily counted), and then we have $m = \pi a_1^2 n_1 C$. Since the definition of mutual inductance, which is what we are seeking, is based upon unit current, we have in these circumstances, $m = \pi a_1^2 n_1$. Having now found m in terms of quantities, which are very easily obtainable from an inspection of the coil construction, we arrive at the convenient result that $M = m \times S_1 = \pi a_1^2 n_1 \times S_1$. Hence the intensity of the field at O_2, which is $\frac{M}{d^3}$, becomes $\frac{\pi a_1^2 n_1 S_1}{d^3}$ lines per square cm.

Clearly, $n_1 \times S_1$ is the total number of turns N_1, hence the mean intensity in the coil is $\frac{\pi a_1^2 N_1}{d^3}$ lines per sq. cm. But it is fairly accurate to assume that each turn of the coil L_2 will embrace these lines of force, and since $\frac{\pi a_1^2 N_1}{d^3}$ is the number of lines of force per square cm. of the cross-section of the coil L_2, the total lines embraced by each turn of L_2 is $\frac{\pi a_1^2 N_1}{d^3} \times \pi a_2^2$. Since the coil L_2 consists of N_2 turns, the total effective lines embraced becomes $\frac{\pi a_1^2 N_1 \times \pi a_2^2 N_2}{d^3}$, and when the coils are identical, being of radius a, and consisting of N turns, this expression simplifies to $\frac{(\pi a^2)^2 N^2}{d^3} = \frac{A^2N^2}{d^3}$, A being the cross-sectional area of each coil. Since every 1,000 effective lines embraced is by definition a mutual inductance of one microhenry, the required inductive coupling between the coils L_1 and L_2 is $H = \frac{A^2N^2}{1000 d^3}$ microhenrys.

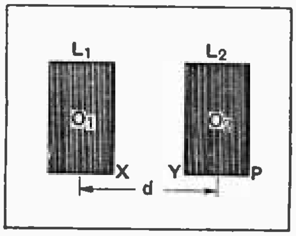

Fig. 6.—The suggested disposition of the coils for the long waveband.

When the coils lie co-axially, the intensity of the field produced by one coil at the centre of the other is practically twice as strong as when their axes are parallel. Actually the intensity of the field of the coil L_1 at O_2 is now $\frac{2Md}{(d^2 - S^2)^2}$, which, in the same way as before, can be approximated to $\frac{2M}{d^3}$, when S is less than one-half of d. Continuing as before, we see that the mutual inductance between the coils when they are wound identically is $\frac{2A^2N^2}{1000d^3}$ microhenrys. If we now use the long-wave coils, mentioned above, we find that $d = \sqrt[3]{\frac{2 \times 33^2 \times 200^2}{1000 \times 100}} =$

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9.6 cm. Since the winding length of such coils is usually no more than about 4 cm., this is a fairly convenient value. Moreover, harmful capacity effects can be reduced to a minimum by connecting the coils so that the low potential ends are those ends nearest one another. Sometimes, when the amount of space which can be allotted to the coils is rather limited, they may be retained in their co-axial relationship and moved nearer together. To counteract the increase of mutual inductance, a single, short-circuited turn of thick wire may be wound round the former at the mid-point of the space between the coils. The mutual inductance is thereby approximately halved, and we now employ in consequence the formula which was used for coils with parallel axes. In the present case the centres of the coils would become 7.6 cm. apart instead of 9.6 cm. for the earlier case.

NEW ULTRA SHORT WAVE OSCILLATOR

The Pierret Circuit

MOST of the recent attempts to get shorter and shorter wavelengths have been made using the circuit of Barkhausen and Kurz or some modification of it. In this circuit the wavelength generated does not depend on the capacity and inductance of the external circuit but on the rapidity of the internal motion of the electrons inside the valve. This is shown by the fact that the wavelength depends on the voltages applied to the tube, the square of the wavelength being inversely proportional to the voltage between the grid and the plate.

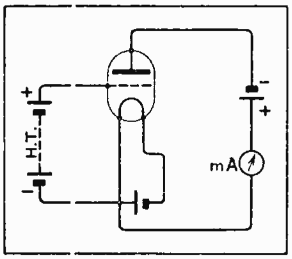

Fig. 1.—A short-wave circuit in which it is possible to generate oscillations of a wavelength less than one meter. The grid of the valve is maintained positive and the anode slightly negative.

The circuit used by Barkhausen and Kurz is shown in Fig. 1, the grid being maintained at a high positive potential and the anode slightly negative. When oscillations are taking place a reading is registered in the plate circuit milliammeter. Using a circuit of this type the record for the shortest wavelength was at one time 0.34 metre, obtained by Schafer and Merzkirch, but later Scheibe managed to get down to 0.24 metre. More recently Professor Okabe, in Japan, using a method originally due to Zacek, ultimately obtained waves of 0.12 metre. Okabe employed a method involving the use of a two-electrode valve and a strong magnetic field applied along the direction of the filament. Although this seems at first a different method from that of Barkhausen and Kurz, theoretical investigations have shown that it is really quite similar, for the to-and-fro motion of the electrons determines the frequency generated. Okabe, in attempting communication with these short waves, found he had to use a somewhat higher wavelength, but he managed to establish communication over a kilometre using 0.41 metre waves.

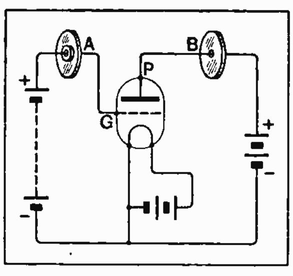

Fig. 2.—By using sliding copper discs in the connecting wires, waves of 0.3 metre have been obtained.

Quite recently M. Pierret, in France, has introduced a new idea into these short-wave circuits. By using sliding copper discs on the connecting wires he has been able to limit the part of the circuit in which oscillating currents flow. One of his circuits is shown in Fig. 2. According to his explanation of the action, standing waves are produced in the wires PB and GA and are reflected to and fro between the copper discs. With this circuit he was able to get waves of 0.30 metre. To get still lower he altered the circuit to that shown in Fig. 3, in which he is of opinion the to-and-fro motion of the electrons is different from that of the Barkhausen and Kurz circuit. With this second circuit using French T.M.C. valves he has got down as low as 0.12 metre.

But perhaps the chief point of interest in connection with the new circuit is that, using this type of oscillator, M. Beauvais, working with waves of 0.17 metre, has established satisfactory communication between Mont Valérien and Saint-Germain, a distance of 9 kilometres. Parabolic reflectors were used in this case.

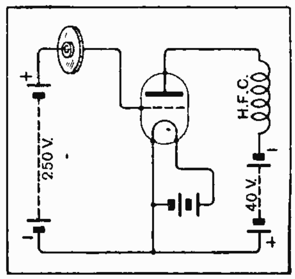

Fig. 3.—Still higher frequencies are possible with this circuit, a wavelength of 0.12 metre being claimed.

BOOKS RECEIVED.

Radioactivity and Radioactive Substances (3rd Edition), by J. Chadwick, M.Sc., Ph.D., with a Foreword by Sir Ernest Rutherford. An introduction to the study of radioactive substances and their radiations, the nature of radioactivity, and the bearing of radioactive transformations on the structure of the atom. Pp. 116+xii, with 33 diagrams. Published by Sir Isaac Pitman and Sons, Ltd., London, price 2s. 6d. net.

The Measurement of Sound Absorption, by V. L. Chrisler and W. F. Synder (Research Paper No. 242). Pp. 16, with 13 diagrams and photographs of oscillograms. Issued by the Bureau of Standards, Washington, D.C., U.S.A., price 10 cents.

Classification of Radio Subjects. An extension of the Dewey decimal system (Circular No. 385). Issued by the Bureau of Standards, Washington, D.C., U.S.A., price 10 cents.

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The R.C.A. Photophone System.

By W. H. O. SWEENY.

AMONG the various systems of sound recording for motion pictures in use in this country, that of recording on film by the variable-area method is the most popular. Out of the nine or so concerns which have adopted this method, at least eight use the apparatus devised and developed by R.C.A. Photophone.

Broadly speaking, the equipment can be divided into three parts, microphone, amplifier, and recording camera. The general principle of operation is as follows:—The sound waves are allowed to impinge on the diaphragm of a condenser microphone, and thus set up electrical vibrations with a wave-form closely approximating to that of the sound waves. These vibrations are magnified by a voltage amplifier, and then converted into power of a useful magnitude by means of a power stage. From this they are split up into two directions—in one to an amplifier which operates a dynamic cone for monitoring purposes, and in the other to the recorder. The recorder is a device for running positive film at a constant speed of 90ft. per minute, on which are photographically registered the electrical vibrations converted into corresponding pulsations of light. Dealing with the apparatus in a more detailed manner, the microphone proper (Fig. 1) is seen to consist of a tightly stretched duralumin diaphragm 1.5/1,000th in. thick, which is electrically insulated from a back plate and spaced a distance of 1.5/1,000th in. from it. A condenser is thus formed by these two plates, on which is impressed a potential of 180 volts through a 27 megohms resistance. The change in capacity caused by the sound waves varying the distance between the plates results in an alternating current being set up in the circuit, corresponding to the sound vibrations. This alternating current produces a varying potential across the ends of the high resistance, which is coupled to the first valve of the microphone amplifier (the circuit diagram of which appears in Fig. 2). In practice the microphone and its amplifier are used as a single unit, battery feeds, etc., being transmitted through a multiple cable. A point of interest is that the output transformer, which is necessarily small, is saved from the risk of saturation by an auxiliary winding wound in opposite sense to the primary, and carrying a portion of the filament current, thus tending to neutralise the field.

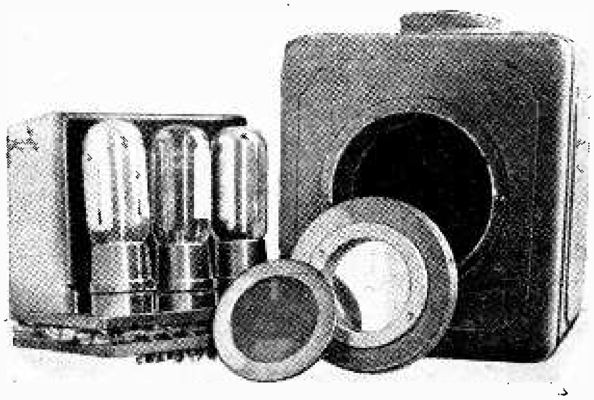

Fig. 1.—Capacity microphone and its associated three-stage resistance-coupled amplifier.

The Amplifiers.

The output of the microphone amplifier is taken to a mixing panel, which can accommodate up to six microphones. This panel feeds a three-stage voltage and power amplifier, the circuit of which is reproduced in Fig. 2. The method of coupling will be seen to be conventional, the valves being coupled by tapped iron-cored inductances, connected as auto-transformers, in conjunction with a filter circuit. For the purpose of giving alternative gain, a switch alters the method of connection to the first coupling choke, thus varying the effective step-up of the auto-transformer. A choke is connected in the filament circuit to smooth out any interference picked up by long battery leads.

The resistance network connected between the output of the three-stage amplifier and the input of the monitor amplifier is a standard "H" connection repeater network, or "T.U. pad" as it is known in the States,

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designed to prevent feed-back and howling. Incidentally, the T.U. or transmission unit, while unfamiliar to many people in this country, is common enough in America. It is a term used by telephone engineers, and is a ratio or measure of amplification. The gain of an amplifier expressed in T.U.s is twenty times the common logarithm of the voltage amplification.

The Recorder and Optical System.

The recorder consists of a sensitive light galvanometer, an optical system, and a light-tight chamber containing the necessary mechanism for drawing the film at a constant speed past the optical system.

in the tension of the wire. The open end of the loop is connected to two terminals. Half-way between the bridges a very small mirror is cemented on to the two limbs of the loop, which are 10/1,000th in. apart. This mirror measures approximately $\frac{5}{64}$ in. $\times \frac{1}{64}$ in. The appearance of the bridges, loop and mirror can be gathered from Fig. 4. It will be seen that when the vibrator is placed between the poles of the magnet, so that the looped wire lies across the plane of the flux, the result is in effect a simple motor, except that the armature, or loop, is fixed at the ends and cannot rotate. If, however, an alternating current is passed through the loop, the part between the bridges will vibrate, the mirror vibrating also.

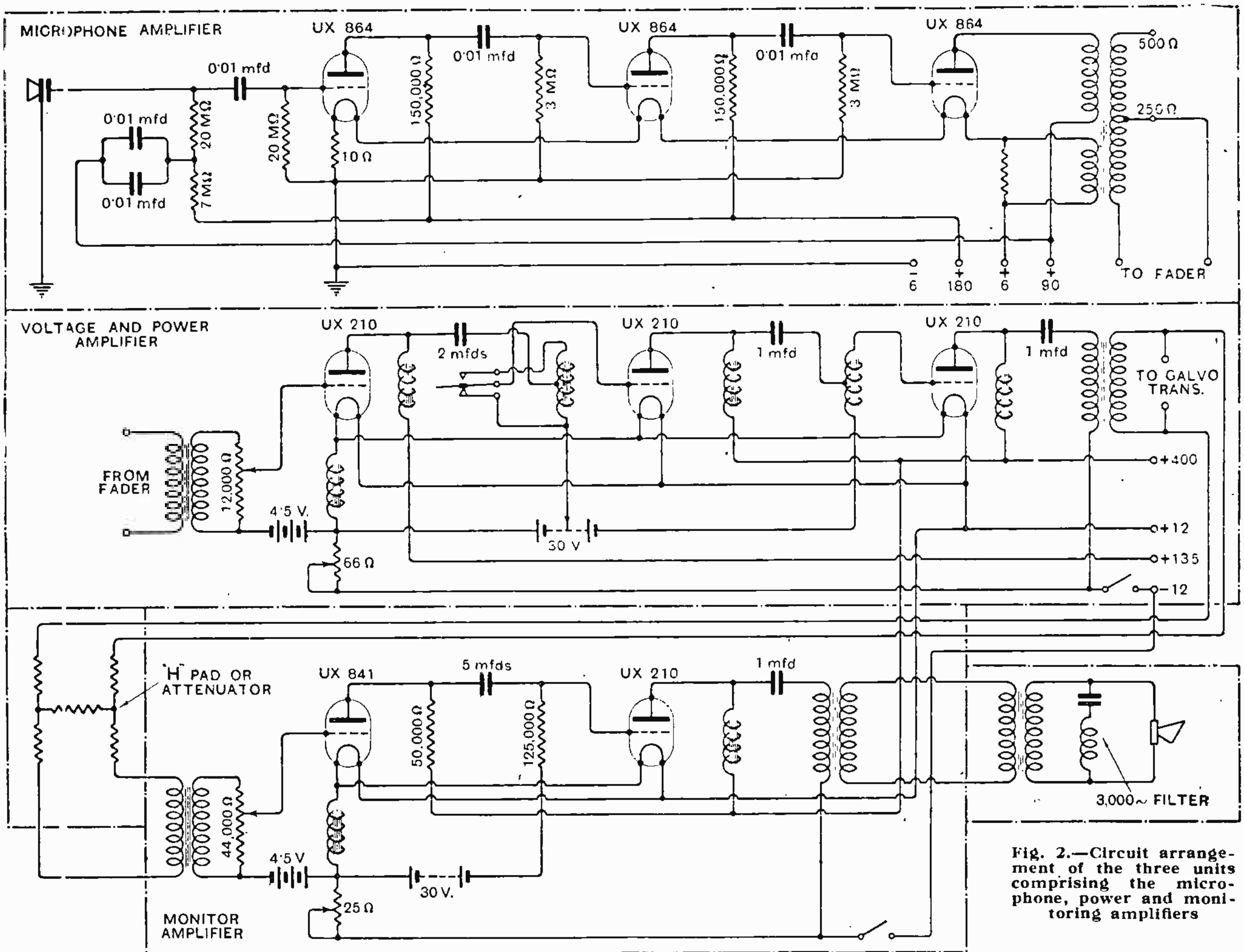

Fig. 2.—Circuit arrangement of the three units comprising the microphone, power and monitoring amplifiers

The galvanometer and optical system are shown diagrammatically in Fig. 3. The galvanometer consists essentially of a powerful magnet, in the field of which is placed a vibrator. This is a flat wire, 0.5/1,000th in. thick, and 5/1,000th in. wide, stretched in the form of a loop over two ivory bridges spaced $\frac{7}{16}$ in. apart, somewhat in the manner of a violin string. The closed end of the loop is taken round an ivory pulley, the position of which is made adjustable, so as to provide for variation

The natural period of the vibrator with the tension correctly adjusted (6 oz.) is 6,000 cycles. The resulting peak in the frequency response is small, and is made negligible by the immersion of the vibrator in a cell filled with a mineral oil. The frequency characteristic of the vibrator alone is given by curve "A" in Fig. 5. Referring to Fig. 3, it will be seen that light from a special exposure lamp (consuming 4 amps. at 5 volts) passes through a double convex condensing lens and

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through a light stop on to the mirror. The lens seen in front of the mirror is a plane lens acting as a window, preventing the damping oil from escaping, and is mounted at an angle, so that light will not be

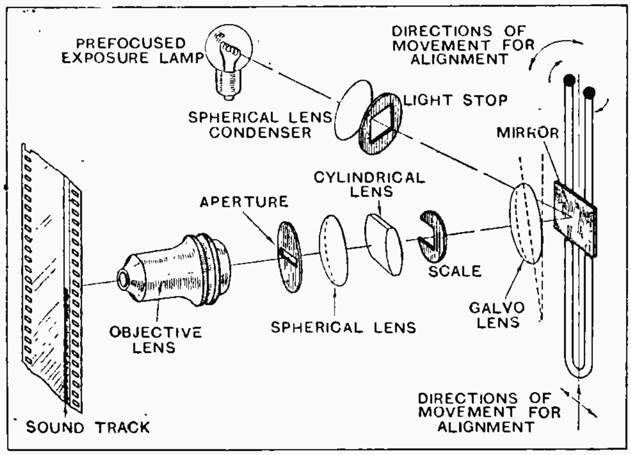

Fig. 3.—Schematic diagram of optical system used for marginal recording.

reflected from its surfaces into the remainder of the system. The light is then reflected from the mirror through a cylindrical lens, which condenses the beam in one direction. It is then condensed still further before it passes through a slit in a disc. This slit is 3/1,000th in. wide, and allows the light to pass through it into a microscope objective lens, with a 4 to 1 reduction. The objective focuses the image of the slit on to the film, resulting in a light image of 0.00075 in. × 0.070 in. In practice half the light beam is intercepted by a celluloid screen on which are inscribed two lines. One line denotes the limit of the beam under conditions of no modulation, in which case half the sound track is exposed (under modulation the beam moves laterally); the second line on the scale denoting the position where the light has reached the full width of the track, and past which it cannot move without "overshooting" and producing consequent distortion. When the track is overshot the tips of the peaks are not registered. When the output of the power stage in the amplifier is applied through a step-down transformer to the two ends of the vibrator loop, the mirror vibrates in sympathy with the impulses. This varies the length of the slit image on the film, and produces a sound track of varying width.

The film is moved past the optical system at a constant speed of 90ft. per minute in synchronism with the film in the mute camera. In order to attain complete synchronism, the motive power for both cameras is obtained from synchronous motors, driven from a common three-phase source. In the sound camera a special gearing drives a supply sprocket, the recording drum, through a special compensating mechanism, and the magazine take-up. The purpose of the compensator is to allow for the shrinkage or expansion existing in different stocks or grades of films. The film is drawn from the magazine by a sprocket at constant speed, from whence it passes over the recording drum into the take-up box. If the film were stretched, a loop would tend to form between the sprocket and the drum. It is essential that the linear speed of the film past the recording drum be constant. The sprocket speed is constant, but in the case of a stretch the linear speed would become slower. Accordingly, use is made of the above-mentioned loop to increase the speed of the drum. This will be understood more readily on reference to Fig. 6.

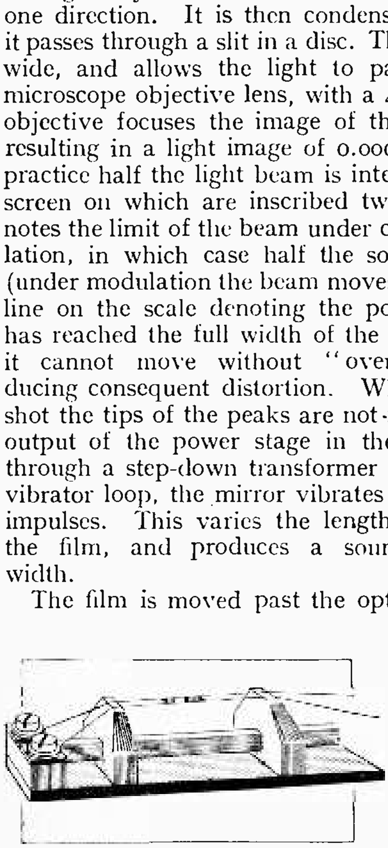

Fig. 4.—The reflecting mirror is carried on a pair of conductors and supported in the field of a powerful magnet.

Driving Mechanism and Film Carrier.

The flywheel F is driven by a synchronous motor through a pinion and gear. On the same shaft as the flywheel is a cone C and sprocket S, which pulls the film from the magazine at constant speed. The shaft floats on a supporting arm. A spring, exerting pressure on this arm, forces the cone C on to an idler A, causing the idler to revolve by friction. Pressure from the cone C is transmitted through the idler to the cylinder B, driving it also by friction, and thus causing the drum D to revolve. It is evident that the speed of the

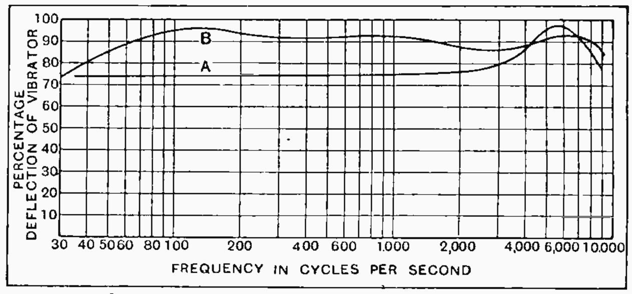

Fig. 5.—Curve A shows the frequency characteristic of the vibrator alone while curve B shows the overall characteristic when the vibrator is combined with microphone and amplifier.

drum is dependent on the position of the idler. If the idler is in position *a* the drum will revolve slower than if it were in position *b*. The position of the idler is changed by a tilting lever which is controlled by a compensating roller. Thus, if the film has been stretched at any part, a loop tends to form between the sprocket and the recording drum. This allows the roller to drop, causing the compensator to move the idler into a position to increase the speed of the recording drum, and take up the slack film. With shrinkage in the film the reverse takes place. The position of the compensator is indicated by a pointer on the door of the recorder. The complete machine is carried on a table on which are mounted switches controlling the power supply, signal lamps, etc. Fig. 7 shows the recorder, the control switches and the meters on the table.

In practice, the amplifier rack, an illustration of which

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is reproduced (see Fig. 8), is mounted together with the monitoring loud speaker and communication phones in a portable booth on the studio floor. From here the

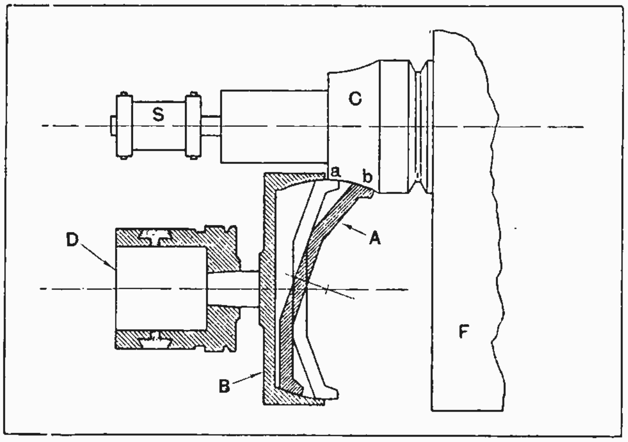


Fig. 6.—Compensator mechanism for allowing for variation in the stretch of the film.

recordist can follow the action on the set. The recorder table is either housed in a compartment adjacent to the amplifier, or in a room near to the studio floor. In the first case, the recordist watches the light on the celluloid scale through a window. Sometimes the portion of the light normally intercepted by the scale is passed through a prism and projected on to a ground glass screen as an image an inch or so in width, thus being easier to see from the recordist's chair.

In the second case, use is made of either a modulation meter or of a second optical system installed in the booth, and calibrated with that on the recorder. A volume indicator, or modulation meter, is fitted as standard on the panel. This is really a valve voltmeter with a meter showing the rectified output. The method of using a second optical system is by far the best, as a meter needle with its inertia will not respond to transients and high-frequency peaks. The primary windings of the two step-down transformers, which are associated with the galvanometer, are series connected.

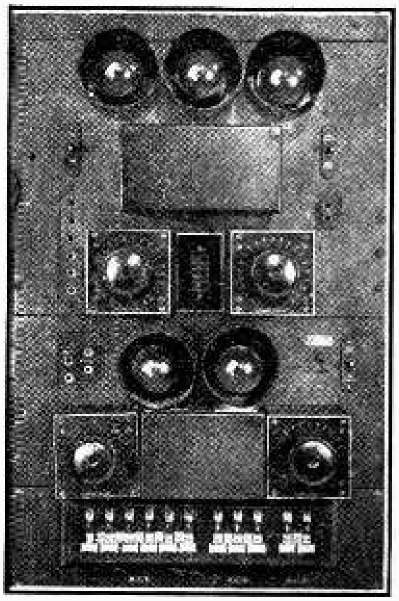
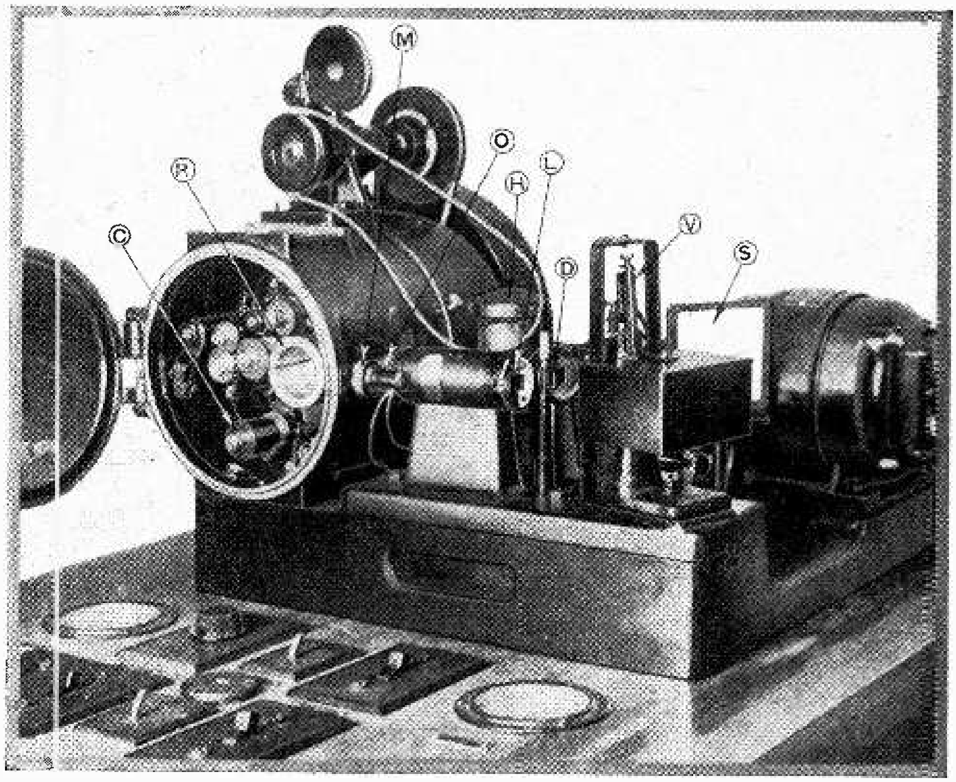


Fig. 8.—Recorder three-stage amplifier, monitoring amplifier and fuse panel.



(*Courtesy R.C.A. Photophone and the British Lion Film Corp.*).

Fig. 7.—R.C.A. photophone recorder showing the complete mechanism and control switches. C is a compensator roller; R, recording drum; M, marker lamp; O, objective lens; H, lamp housing; L, cylindrical lens; D, deflecting prism; S, light screen and V, vibrator.

In order to ensure accurate synchronising during printing, when the sound-track and picture are combined, a system of marker lamps is used. The edge of each film is exposed for a few seconds at intervals by lamps, connected in series. These are controlled from the recorder table.

The light from the exposure lamp may be checked at intervals by means of a calibrated photometer, which can be plugged into the recording drum. The sound track is always exposed and developed to a density of 1.4. It is not considered safe to adopt a higher figure than this, owing to the danger of fog or halation filling up the valleys in between the high-frequency stations. The valves used in the three-stage amplifier and in the first position of the monitor have constants similar to those of the Marconi or Osram LS5 and LS5B valves respectively.

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RECORD MAKING OUTFIT

The Kingston Home Recorder, Tested and Described.

A NEW development is now taking place in the form of home recording, so that the radio-gramophone not only serves as a source of entertainment from broadcast or record, but provides a means for making records of items from the broadcast programme. The process of recording being well known, one might think that the making of a home record making outfit would be a simple matter. This is not the case, however, as there are many practical problems to solve. The first popular home record making equipment has now made its appearance on the market and, known as the "Kingston Home Recorder," is being supplied by The Kingstophone Co., Ltd., 91, Tottenham Court Road, London, W.1. In spite of the fact that it is a first model there is much evidence that the design has been carefully developed before setting about production.

The entire assembly is made up from castings, pressings and small turned parts, is generously designed, and exceedingly well finished. It is obvious from the design that it is the intention of the manufacturers to go ahead with the production of a large number of home recorders. Primarily, the outfit in its simplest form is intended for making records from speech delivered into a mouthpiece arranged as a horn. The sound is conveyed on to a light aluminium diaphragm, suitably stiffened and adjusted by several annular corrugations. At the centre of the diaphragm a lever is attached which, mounted between adjustable centres, carries a cutting needle at its opposite end. Thus, the sound waves actuate the diaphragm, giving a movement to the lever, which, in turn, vibrates the cutting stylus. The recorder is carried on a pivoted arm free to swing across the record and arranged for lifting clear of the surface. There is a heavy adjustable counterweight which allows of critical adjustment of the pressure of the cutting point on the record. In addition, a second needle point is provided, this being used as a guide in order that the recorder may traverse the record.

The "acoustic" recording outfit with mouthpiece fitted to a portable gramophone.

In this respect a very simple and effective method is adopted for giving both a traverse to the recorder and a drive for the record with avoidance of slip. The arrangement consists of a 10in. record carrying a plain spiral, in which the guide point travels. Locked on to the centre of the record by the simple process of engaging on to three studs is the blank aluminium disc upon which the record is to be made. A positive drive is thus obtained under the cutting load of the stylus, while the spiral imparts a cross-movement to the recorder. The spiral on the record plate gives a cross-traverse in respect of some 200 revolutions of the turntable, so that at normal running speed the playing duration is just over two minutes.

Used with a Clockwork Motor.

It is well known that the process of record making normally demands a gramophone motor of generous power in order to avoid a severe slowing up of the turntable when cutting the groove. With the Kingston recorder the aim has been to produce an outfit suitable for use with the ordinary gramophone fitted, possibly, with but a meagre type of gramophone motor. That this has been achieved is revealed by the public demonstrations which are being given at 245, Tottenham Court Road, London, W.1, where the recording is carried out on a small portable gramophone. In order to accomplish home recording on a gramophone fitted with a small clockwork motor critical adjustment of the balance weight fitted to the arm is necessary, and the various tests made with the recorder were carried out using an electrically driven turntable.

The process of recording had no appreciable retarding effect, and, in fact, when one came to the recording of broadcast transmissions with an electrical recorder an additional weight was attached to increase the pressure on the record, in spite of the fact that the electrical recorder, with its permanent magnet, is much heavier than the direct sound recorder with its trumpet. Much of the weight is, however, taken by the guide point resting in the spiral, and an increase of pressure is not entirely added to the recorder.

A very interesting evening can be spent making

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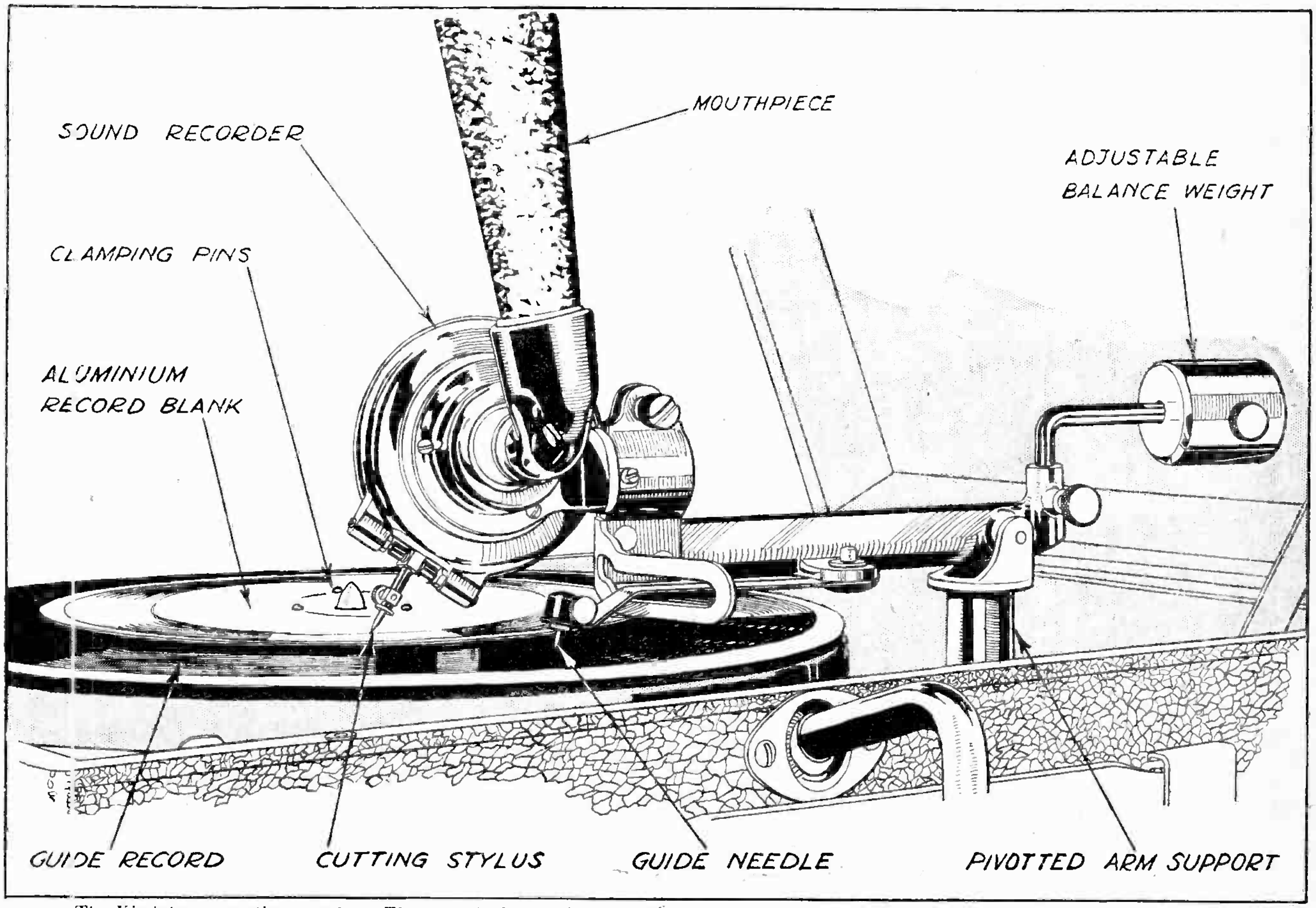
Record Making Outfit.—
records by speaking or singing into the small trumpet. One must not expect to obtain results comparable with the ordinary record, but nevertheless, speech and music are clear and sufficiently loud, and from a novelty standpoint the result is quite entertaining. Special needles are provided both for tracking and cutting, whilst a fibre needle must be used for playing, and it is important to keep a good point on the fibre needle in order that it may follow the groove. Detailed instructions are given for recording and playing dealing with the little difficulties which one encounters when starting off.

It is thought, however, that the principal application of home recording is that of using the electrical recorder connected to the output terminals of the wireless set for making recordings of broadcast transmissions. Really good results can be obtained by following the instructions and carefully regulating the pressure on the cutting point at the time of recording. Some experience is necessary in order to get just the right depth of cut in relation to the strength of signal applied to the recorder. Too loud a signal will prevent the playing back of the record, as the needle cannot follow the spiral and successive grooves will overlap. Insufficient pressure will make too light a groove for the fibre needle to follow. It is surprising what good results can be obtained from broadcast transmissions when playing back with a sharp fibre needle. Blank records are supplied suitably etched at the centre for making various entries of the item recorded. The outfit is reasonable in price and costs 45s. for the acoustic model or £3 16s. 6d. for the electrical recording equipment. The electrical recorder may be used as a pick-up.

Among the practical hints that might be offered to one starting off to use the Kingston Home Recorder in conjunction with the broadcast receiver is that of bringing down the signal strength to a lower value than is customarily applied to the loud speaker. The recording needle must be sharp, and should it have become accidentally damaged the substitution of a new and sharply pointed needle is essential. Additional weight on the pick-up is also probably an advantage. Should the guide groove become accidentally damaged the guide plate should be discarded, as every record made will bear evidence of the broken spiral. The gramophone on which the records are replayed must be level excepting, perhaps, when the tone arm is incorrectly mounted, when a slight tilt will assist the point of the needle in following the groove. Of the packet of twelve blank records supplied with the outfit the last six used represent quite good recordings of broadcast items, each giving results when replayed like normal gramophone records, though not quite so loud, while care is necessary in playing them.



The Kingston acoustic recorder. The electrical recorder is similar in appearance and construction to a gramophone pick-up.

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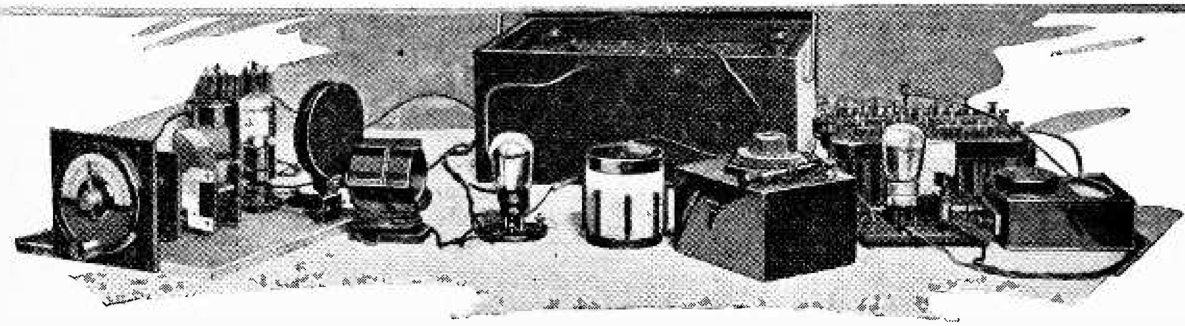
Theory of the H.F. Transformer



Self and Mutual Induction in A.C. Circuits.

By S. O. PEARSON, B.Sc., A.M.I.E.E.

BEFORE it is possible to obtain a clear and intelligent understanding of tuned high-frequency transformer coupling between two consecutive valves in a radio receiver, it is essential to have a knowledge of the fundamental laws of mutual induction between two inductive circuits magnetically coupled together. This applies in particular to the behaviour of such circuits when carrying alternating currents, the general laws being the same for currents of all frequencies. In the explanations to follow it will be assumed throughout that all the alternating quantities involved, namely, currents, electromotive forces and magnetic fluxes, vary with time according to the simple sine-wave law at a frequency of f cycles per second. It must be borne in mind that in dealing with alternating current circuits it is necessary to know the inter-relationships between the various currents and voltages not only as regards their magnitudes, but also as regards their relative phase differences.

Self Induction.

The laws of mutual induction are very closely related to those of self induction, and we can, therefore, use our knowledge of the latter as a stepping stone towards acquiring a clear conception of what actually occurs in two circuits magnetically coupled together when each is carrying an alternating current. Let us first of all refresh our memories regarding self induction. When a current of electricity is passed through a coil of wire it causes a magnetic field to be established, the "lines of force" being "linked" with the turns of the coil in the manner shown in Fig. 1. The magnetic field is said to be "linked" with the turns of the circuit because each line of force is a completely closed loop threaded through the turns of the coil.

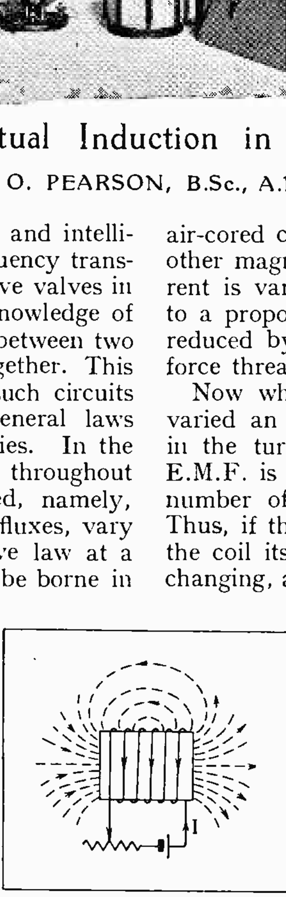


Fig. 1.—A current in the coil produces a magnetic field linked with the turns. If the current is varied the changing magnetic field induces an E.M.F. in the winding and this phenomenon is called self induction.

The strength of the field produced, or the number of lines of force passing through the coil, is exactly proportional to the current in the turns in the case of an air-cored coil, that is to say, one which has no iron or other magnetic material at its centre. Thus, if the current is varied, the strength of the field will also vary, to a proportional extent; for instance, if the current is reduced by one half, the number of lines of magnetic force threading through the coil will also be halved.

Now when the magnetic field linked with a coil is varied an electromotive force is generated or *induced* in the turns of the coil, and the magnitude of this E.M.F. is exactly proportional to the rate at which the number of lines of force is increasing or decreasing. Thus, if the magnetic field is produced by a current in the coil itself, it follows that, whenever this current is changing, an E.M.F., proportional to the rate of change, will be generated in the coil. It is this property of a circuit which is called "self induction." The word "self" is used because the coil carrying the varying current has the induced E.M.F. produced in its own turns.

It must be borne in mind that the actual value of the current at any instant has nothing whatever to do with the induced E.M.F. It is only the rate at which the current is changing that determines the magnitude of the induced voltage. An unvarying current in an inductive coil is not accompanied by an induced E.M.F. because the magnetic field is not changing. A circuit is said to have a self inductance (or coefficient of self induction) of one henry if one volt is induced in it when the current is changing at the rate of one ampere per second. In a circuit with an inductance value of L henrys the self-induced E.M.F. is given at any instant by multiplying the inductance L by the rate at which the current is changing at that instant.

It is a matter of great importance to know the direction in which the induced E.M.F. acts in relation to the direction in which the current is *changing* (not flowing). Lenz's law states that the induced E.M.F. of self induc-

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tion always acts in such a direction that it tends to prevent the changing of the current. This means that if the current in an inductive circuit is increasing, the induced E.M.F. will be opposed to the applied voltage actually producing the current, or when the current is falling in value, the self-induced E.M.F. is reversed, and tends to maintain the current. In the same way a heavy body resists the taking up of motion due to its inertia, and when once the body has been set in motion it tends to continue moving when the driving force has been removed. A frictional or other retarding force is necessary to bring it to rest. Owing to the similarity of the laws of self induction and inertia, the self inductance of a circuit is sometimes referred to as "electrical inertia."

Alternating Current in an Inductive Coil.

An alternating current is one which is changing at all times except during the instant when it passes through its maximum value every half cycle. Thus, if

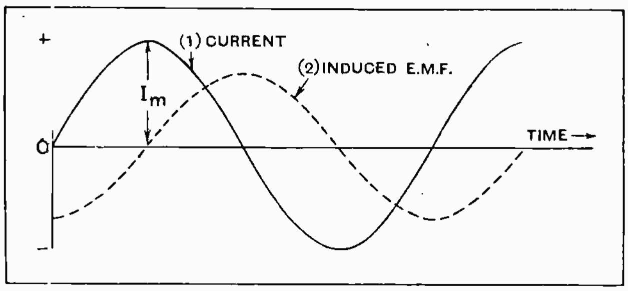

Fig. 2.—When a sine wave of current is passed through an inductive coil the induced E.M.F. is out of step by a quarter of a cycle, lagging behind the current.

a sine wave of current is passed through a coil of inductance L henrys, there will be an induced E.M.F. in the coil at all times except during the minute fraction of a second every half cycle when the current ceases to increase and begins to fall again. The sine wave of current is represented by curve (1) in Fig. 2 where I_m denotes the maximum or peak value, the "root mean square" (R.M.S.)[1] or effective value being, therefore, $I = 0.707 I_m$.

At any point on the curve the slope or steepness gives the rate at which the current is changing at the instant concerned. Now, obviously, the curve is steepest at the points where it crosses the zero line, and this means that the rate of change of current is greatest just as it passes through its zero values. Hence the induced E.M.F., being proportional to the rate of change of current, will be greatest when the current is zero, and zero when the current passes through its maximum values, so that the induced E.M.F. curve, which is also a sine wave, will be exactly a quarter of a cycle out of step with respect to the current wave, the phase difference being just 90 degrees. As the current is building up from zero in the positive direction the induced E.M.F. will, according to Lenz's law, be opposing its growth, and will, therefore, be negative during this quarter cycle. Similarly, during the time that the current is receding towards the negative maximum value, the induced E.M.F. will be positive. Consequently, the sine wave of induced E.M.F. will be in the position shown by curve (2) in Fig. 2, that is to say, *lagging by a quarter of a cycle behind the current wave*, because it reaches its positive maximum value a quarter of a cycle later than the current.

Reactance.

If the frequency of the current is f cycles per second it can be shown by measurement, or mathematically, that the maximum rate of change of current (as it passes through zero) is equal to $2\pi f I_m$ amperes per second, where I_m is the peak value of the current (this was proved by a simple method on page 491, of October 30th, 1929, issue of *The Wireless World*). Consequently, if the inductance of the coil is L henrys, the maximum value of the self-induced E.M.F. will be $E_m = 2\pi f L \times I_m$ volts. This equation gives the relationship between the maximum values of current and induced E.M.F. in terms of inductance and frequency. If we multiply each side of the equation by 0.707, it will be converted to one involving R.M.S. values instead of maximum values, so that $E = 2\pi f L \times I$ volts, where E and I are effective values.

The reactance of a coil is the opposition to the passage of an alternating current, arising as a result of the back E.M.F. of self induction. Its numerical value in ohms is the ratio of the generated E.M.F. to the current, being, therefore, $\frac{E}{I} = 2\pi f L$ ohms, where E and I are 90° out of phase. The quantity $2\pi f$ recurs so frequently that it will be an advantage to use the Greek letter ω to represent it. Thus, for the reactance of a coil we have:

$X = \omega L$ ohms .. .. (1)

Incidentally, it will be seen that when the current is one ampere the induced E.M.F. will be numerically equal to ωL volts, lagging behind the current by a quarter of a cycle; in other words, when the current is one ampere the R.M.S. value of the induced voltage is numerically equal to the reactance.

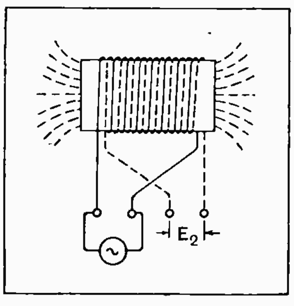

Fig. 3.—Double-wound coil referred to in the text. Each winding has the same self inductance and embraces the same magnetic flux.

Mutual Induction.

Now let us see what happens when a second coil is brought within the influence of the alternating magnetic field caused by the passage of an alternating current through a coil, in the manner already described. It will be at once obvious that the portion of the alternating field which is linked with the turns of the second coil will generate an alternating E.M.F. in the latter. Under such conditions mutual induction is said to exist between the two coils. The degree of mutual induction present, like self inductance, is expressed in henrys. The mutual inductance, or coefficient of mutual induction, between the two

[1] See "Wireless Theory Simplified," *The Wireless World*, 16th October, 1929.

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circuits is one henry if a current in one circuit, changing at the rate of one ampere per second, causes an E.M.F. of one volt to be generated in the other. If M is the mutual inductance in henrys, the induced E.M.F. in one circuit due to a varying current in the *other* is given by the product of M and the rate of change of current in amperes per second.

Consideration of a special double-wound coil will assist us to obtain a clear understanding of the mechanism of mutual induction. Suppose that in winding a cylindrical coil in the ordinary way two insulated wires of equal diameter are wound on side by side, instead of one. Such an arrangement is shown in Fig. 3, but the windings need not be confined to a single layer. We then have, in effect, two identical coils occupying the same space. Each will, therefore, have the same value of self inductance L henrys. Let the mutual inductance between them be M henrys.

Now, suppose that an alternating current whose effective value is I_1 amperes at a frequency of f cycles per second is passed through one of the windings. This current will set up an alternating magnetic field which, in turn, will generate electromotive forces *in both windings*, and, since these two windings are identical in form and the turns are side by side throughout, *the same value of voltage will be generated in each coil.* From this, and in view of the similarity of the definitions of one henry of self induction and one henry of mutual induction, it follows, for this arrangement, that the mutual inductance M between the windings must be numerically equal to the self inductance L of each winding. Now, it has already been explained that the reactance of the coil carrying the current (called the primary coil) is equal to ωL ohms, where $\omega = 2\pi \times$ frequency. The induced voltage in the primary coil is, therefore, $E_1 = \omega LI_1$ volts. But the generated E.M.F. in the secondary winding has an equal value, so that $E_2 = E_1 = \omega LI_1$ volts in this case; and, since $M = L$, we arrive at the very important formula

$$E_2 = \omega MI_1 \text{ volts} \quad \ldots \quad (2)$$

where $\omega = 2\pi \times$ frequency.

The quantity ωM or $2\pi fM$ is the ratio of the generated E.M.F. in the secondary coil to the current in the primary when there is no current in the secondary. Since it is a ratio of volts to amps., it is expressed in ohms, and may be called the "mutual reactance." It is a reactance which is common to both circuits. It must be remembered always that *the primary current and the resulting secondary voltage are a quarter of a cycle out of phase.*

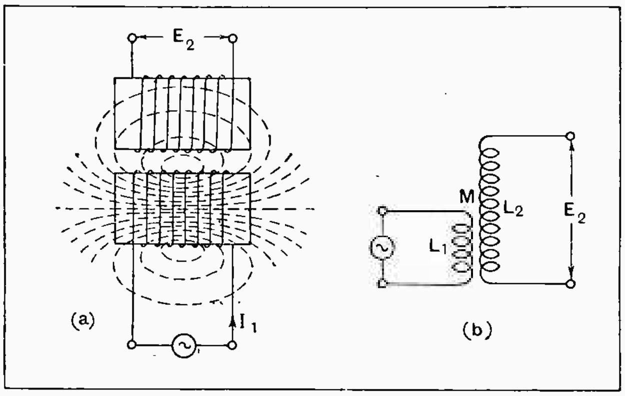

Fig. 4.—(a) The two coils each have the same dimensions and turns as those of Fig. 3, their self inductances being equal. (b) Two unequal coils magnetically coupled. The coupling coefficient is $K = \frac{M}{\sqrt{L_1 L_2}}$.

Degree of Coupling.

For the double-wound coil depicted in Fig. 3, the magnetic field is equally linked with both circuits, and under these conditions the mutual inductance has the greatest value it is possible to obtain with these particular coils, M being equal to the self-inductance L of either coil, so that $\frac{M}{L} = 1$. In these circumstances the circuits are said to be fully coupled, or to have a "coefficient of coupling" equal to unity.

Now let us consider two coils, wound on separate formers, each having the same dimensions and number of turns as the individual windings of Fig. 3, so that the inductance of each is L henrys as before. Suppose that the coils are placed relatively to each other in such a way that only part of the field produced by a current in one of them is linked with the turns of the other as shown by Fig. 4 (*a*). For a given value of alternating current passed through one coil, the E.M.F. produced in the other will now obviously be less than the self-induced or back E.M.F. in the first—that is to say, ωMI_1 is now less than ωLI_1, and therefore M is less than L, the inductance of each coil. The coefficient of coupling is now less than unity, its value being $k = \frac{M}{L}$. This expression for coupling coefficient only applies when the individual coils have equal self inductances.

Coils with Unequal Inductances.

In practice it is usual for two coils magnetically coupled together to have different values of self inductance, and so, although the foregoing serves to illustrate the principles involved, it is necessary to be able to calculate the degree of coupling when the two coils have different self inductances L_1 and L_2 henrys respectively as shown in Fig. 4(b). In terms of alternating current theory the coefficient of coupling between two circuits is defined as *the ratio of the common or mutual reactance to the square root of the product of the individual reactances.* Thus, for the coils shown in Fig. 4(b), where the mutual inductance is M henrys, the coefficient of coupling will be

$$k = \frac{\omega M}{\sqrt{\omega L_1 \times \omega L_2}} = \frac{M}{\sqrt{L_1 L_2}} \quad \ldots \quad (3)$$

For the coupling coefficient k to be unity the whole of the magnetic field would have to be linked with all the turns of each coil, a condition which cannot be fully realised in practice. In high-frequency work relating to tuned circuits it is very often an advantage to have a loose coupling.

(To be continued.)

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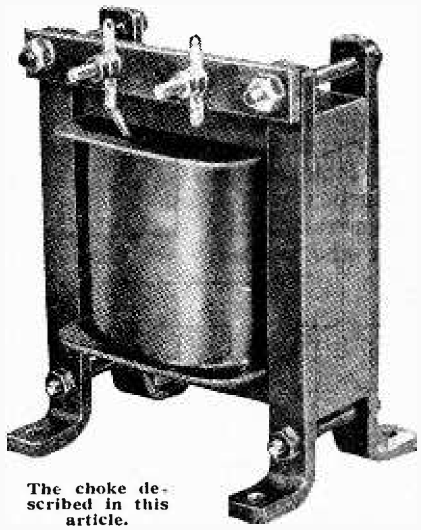
MAKING A 30 Henry Choke

Constructional Details of an L.F. Choke to Carry 50 mA. of D.C.

By H. B. DENT.

AN L.F. choke of some 30 henrys inductance is a convenient size for most H.T. smoothing circuits, and in many cases will serve as an output choke, provided its D.C. resistance is comparatively low. In designing the choke to be described these facts have been borne in mind, the object being to produce a component that will have the widest application. Therefore the inductance should remain fairly constant over a wide range of D.C. polarising currents. The curve reproduced here shows that this condition has been achieved; with no D.C. flowing through the choke, but with approximately 1 mA. of A.C. the measured inductance was 30.2 henrys, this value being maintained until the D.C. exceeds some 25 mA. With increase in the polarising current the inductance curve drops, but even with 50 mA. flowing a value of 27 henrys is available.

To obtain a curve of this nature the air gap in the core must be slightly larger than the optimum, and as a consequence more turns of wire are required to obtain a given inductance. This adds slightly to the cost, but it is amply compensated for by the knowledge that within the limits mentioned above the available inductance will not change to any appreciable extent.

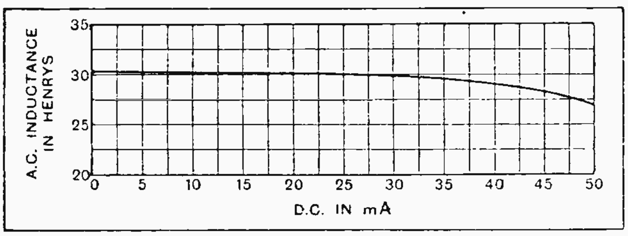


The choke described in this article.

With a view to keeping the D.C. resistance reasonably low without rendering the component too bulky, it was decided to use No. 30 S.W.G. enamelled wire, the 6,000 turns that are required can be accommodated on a stock size bobbin and give a resistance of 198 ohms, so that when the choke is passing some 50 mA. of D.C. less than 10 volts will be dropped across the winding.

For the construction of the choke the following material will be required:

Sixty pairs of transformer stampings, size No. 4; one bobbin, size 4F.S. (obtainable from Savage's, 292, Bishopsgate, London, E.C.2); $1\frac{1}{2}$ lb. of No. 30 S.W.G. enamelled wire; a quantity of 2B.A. screwed rod with nuts to fit; and about 2ft. of $\frac{1}{2}$in. × $\frac{3}{16}$in. iron strip to form the clamps. In addition there will be required a piece of $\frac{1}{32}$in. thick paxolin measuring 4in. × 4in., also a piece 4in. long × $\frac{1}{2}$in. wide × $\frac{3}{16}$in. thick for the terminal strip, and a length of Empire cloth, or other suitable material, as a protective covering for the coil.



From this curve it can be seen that the inductance is almost constant with loads up to 35 mA.

The process of winding will be greatly facilitated if a lathe is available, but an excellent substitute can be readily made up in the form of a simple coil winder as illustrated in this journal some time back.[1] The winding consists of 6,000 turns of the wire specified, this should be run on evenly but not necessarily in layer form with consecutive turns touching. Occasional layers of paper insulation are not advisable, as the winding space available is only just sufficient to accommodate the required number of turns.

The assembly of the core stampings calls for a little explanation, as it is not quite so straightforward as in the case of the 20-henry model described in these pages on October 29th last. It was found that the rather long tongues of the "T"-shaped pieces had a tendency to go out of alignment with the centre of the companion "U" pieces, the effect being to render the air gap a variable quantity. Thus two chokes made up to the same specification did not show the same characteristics. On examination it was found possible to displace slightly the tongues of the "T" pieces where they aligned with the inside of the "U's."

To overcome this undesirable effect a "T" and a "U" piece cut out of thin paxolin, and to the same shape as the stampings, were introduced in the centre of the core, but inserted from the opposite sides from their respectively shaped iron stampings. The small sketch should make this quite

[1] *The Wireless World*, Jan. 22nd, 1930.

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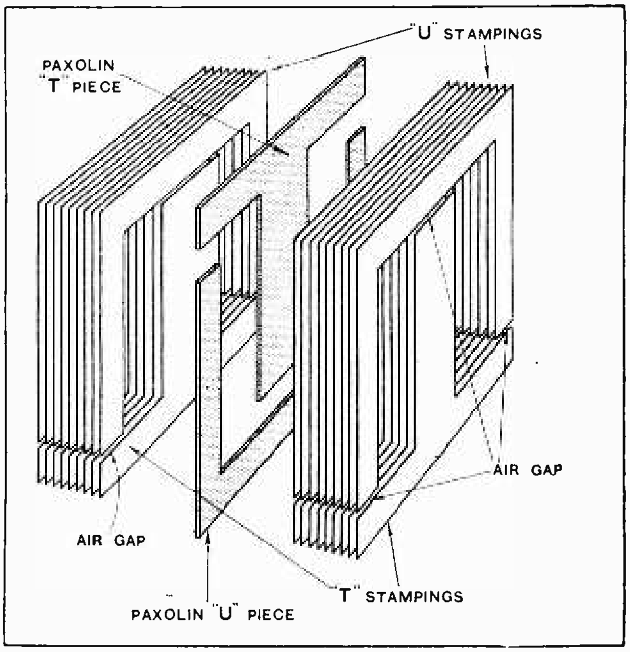
Making a 30 Henry Choke.—
clear. Having assembled the core the clamps can be placed in position with strips of Empire cloth to insulate them from the stampings. The reason for this is to prevent partial short-circuit of the air gap.

Before tightening the nuts, spacing pieces must be inserted into the two gaps where the arms of the "U" pieces butt against the top of the T's. Since these gaps are divided down their centres by the paxolin inset, two spacers must be introduced into each. Any insulating material can be used, paxolin, mica, Empire cloth built up to the required thickness being suitable, to mention a few only. These pieces must be 0.021in. thick. For the benefit of those not possessing a micrometer, this is equivalent to No. 25 S.W.G. A little Seccotine smeared on each piece will fix them in position. The joints must now be closed up so that the stampings bed down on to the air gap retaining pieces and the nuts tightened up. The exposed edges of the stampings, also the iron clamps, will quickly rust unless these parts are coated with a protecting agent. A quick-drying black enamel is recommended.

Since considering the various possible applications of the choke, it has occurred to the writer that it would be an advantage to provide tappings so that it could be used as an output choke in conjunction with a pentode valve. If this appeals to the constructor, the winding can be tapped at the 2,000th and 4,000th turns, thereby enabling stepdown ratios of 3 : 1 and 3 : 2 to be available.



Showing stamping assembly and position of air gap.

CURRENT TOPICS

Events of the Week in Brief Review.

GERMANY'S "BROADCASTING HOUSE."

The new "Funkhaus" in Berlin was officially opened on Thursday last, January 22nd, with a symphony concert and a performance of "Hamlet."

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LOUD SPEAKER IN A VACUUM.

At the meeting of the Wireless Section of the Institution of Electrical Engineers on Wednesday next, February 4th, Mr. P. K. Turner will deliver a lecture entitled, "Some Measurements on a Loud Speaker in Vacuo."

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PIRATE ROUND-UP IN LONDON.

Portsdown Road, Maida Vale, London, was the scene a few days ago of a "raid" conducted by the Post Office to round up unlicensed listeners. The sequel was the appearance in Marylebone Police Court of eight persons, each of whom was fined ten shillings for contravening the Wireless Act.

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STILL RISING.

On January 1st 3,411,910 British receiving licences were current, this total including 19,460 issued free to the blind.

During last year there was an increase of 455,174, compared with an increase in the previous 12 months of 326,448 and during 1928 of 230,598. In December the total rose by 85,012.

IT'S AN ILL WIND . . .

The Italian Press has been discussing the influence of the world's trade crisis on wireless in Europe. According to the general opinion trade depression and its attendant unemployment have assisted rather than hindered the radio industry. Although the shortage of money has undoubtedly reacted unfavourably on the sale of the more expensive apparatus, the sale in Italy of parts for home construction during the last six months has exceeded all records, due to the enforced leisure of so many people.

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FORTHCOMING EVENTS.

WEDNESDAY, JANUARY 28th.

Muswell Hill and District Radio Society.—At 8 p.m. At Tollington School, Tetherdown, London, N.10. Lecture and Demonstration: "The Designing and Operation of Mains Receivers and Moving-coil Speakers," by Mr. Garside (of Messrs. Ferranti, Ltd.).

North Middlesex Radio Society.—Lecture (Part II): "H.T. Eliminators," by Mr. E. H. Laister.

THURSDAY, JANUARY 29th.

Slade Radio (Birmingham).—At 8 p.m. At the Parochial Hall, Broomfield Road, Erdington. Lecture and demonstration by Messrs. Garnett, Whiteley and Co., Ltd.

FRIDAY, JANUARY 30th.

Radio Society of Great Britain.—At 6.15 p.m. (tea at 5.30). At the Institution of Electrical Engineers, Savoy Place, W.C.2. Presidential address by Mr. H. Bevan-Swift: "An Historical Survey of Amateur Radio."

Bristol and District Radio Society.—At 7.15 p.m. In the Geographical Lecture Theatre, Bristol University. Lecture: "Power Speaker Amplifiers," by Mr. Adamson (of Messrs. Philips Lamps, Ltd.).

Golders Green and Hendon Radio Society.—At 8 p.m. In the Club Ballroom, Willifield Way, N.W.11. Second club dance.

WIRELESS AND BODY-TEMPERATURE.

M. Jean Antenie, a Paris radio enthusiast, writes to the *Intransigeant* to say that, while he was listening on a sick-bed to three lady singers broadcasting from Radio P.T.T., his temperature rose by one degree Centigrade.

We suggest an investigation of this phenomenon by the Radio Research Board.

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WIRELESS OPPORTUNITIES IN R.A.F.

Positions in the Royal Air Force as wireless operator-mechanics and electricians will be open to five hundred boys between the ages of 15 and 17 who are successful in Open and Limited Competitions for entry into the Schools of Technical Training at Halton, Bucks, and Cranwell, near Sleaford, Lincs. Full information is obtainable from the Secretary, Air Ministry (Aircraft Apprentices' Dept.), Gwydyr House, Whitehall, London, S.W.1.

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THREE AND A HALF MILLIONS.

German registered listeners numbered 3,509,509 on January 1st.

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HONOUR FOR FRENCH ENGINEER.

M. Emile Girardeau, President of the French Radio Industry Syndicate, and prominent in commercial wireless circles, has been elevated to the rank of Commander of the Legion of Honour.

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THE EDISON MEDAL.

Mr. Frank Conrad, assistant chief engineer of the Westinghouse Electric and Manufacturing Company, has been awarded the Edison medal of the American Institute of Electrical Engineers for his researches into short-wave transmission.

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THE HEADMASTER'S MICROPHONE.

A new school at Königgratz (Czechoslovakia) has been equipped with a modern amplifying plant which enables the headmaster to give lectures from his private room. Each classroom is equipped with loud speakers.

More illuminating results might be achieved if the classrooms contained microphones and the headmaster contented himself with a loud speaker and a switch to each classroom.

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A YOUTHFUL ENTHUSIAST.

France's youngest wireless amateur is Mlle. Francine Pecqueur, aged seven months.

Her admission to the sacred ranks is explained by the fact that the "Radiophonie du Nord" Association, which controls the Lille station, discovered that it had 9,999 members. To complete the ten thousand by the end of the year the father of Mlle. Pecqueur hurridly enrolled his daughter.

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GUARDIAN ANGELS FOR INDIAN LISTENERS.

The Radio Association of India has just been formed to relieve Indian listeners of all troubles connected with the technical side of their pastime. The Association aims at recruiting a large number of trained mechanics who will be ready to attend to a member's set at any time of the day between 9 a.m. and 8.30 p.m. The service will also include free loan of "Crystal, Valve or Super Set, Portable or Main" during any period when the member's set is under repair. The headquarters of the Association are at 52-1-1, College Street, Calcutta.

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AMERICA'S 800 STATIONS.

On January 1st there were 615 broadcasting stations licensed to operate in the United States. These and Canada's 70-odd stations, Cuba's 60, Mexico's 35, and a few in Central America and the West Indies bring North America's total to about 800—fully double the number of stations in all other countries of the world combined (writes our Washington correspondent). South America, according to the latest Department of Commerce compilation, has 106 stations, including 43 in Argentina, 26 in Uruguay, 23 in Brazil, and 6 in Chile.

INCORPORATED RADIO SOCIETY OF GREAT BRITAIN.

"An Historical Survey of Amateur Radio" is the title of the Presidential address which Mr. H. Bevan Swift will deliver before the Incorporated Radio Society of Great Britain at a meeting on Friday next at 6.15 p.m. at the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

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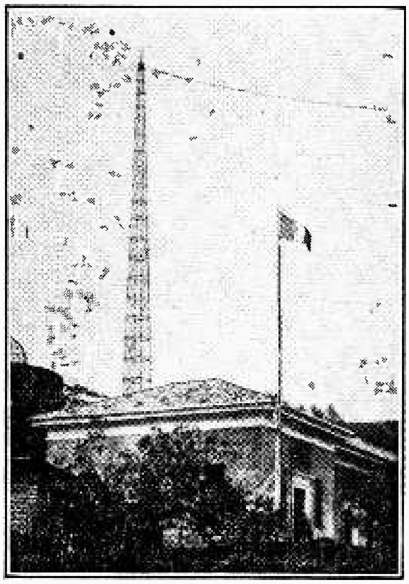
'PHONE v. MORSE.

American amateurs have just concluded a unique contest arising out of a challenge issued by operators of 'phone stations declaring that code men are wrong in assuming that radiotelephony is less useful and accurate than radiotelegraphy.

Early on Sunday mornings in January ten stations on both coasts of the United States went "on the air," half using 'phone and half using code, with an official test message prepared by the American Radio Relay League.

The results of the struggle are not yet announced.



VATICAN CALLING. A near view of the new Papal broadcasting station which, according to unconfirmed reports, will open on February 6th, the anniversary of the Pope's accession. It is understood that wavelengths of 50.26 and 19.84 metres will be used, with a power of 12 kW.

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INDEX AND BINDING CASES.

The index for Volume XXVII of *The Wireless World* is now ready, and copies are obtainable, price 3d. (post free 4d.) from the publishers, Dorset House, Tudor Street, London, E.C.4. Binding cases for the volume can also be supplied, together with the index, price 3s. 1d., post free.

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NEW CONDENSERS FOR OLD.

To popularise Polar "Ideal" condensers, the manufacturers, Messrs. Wingrove and Rogers, Ltd., have initiated an interesting New Year Part-Exchange Scheme. Under the scheme the sum of 2s is allowed on any variable condenser irrespective of age, make, or country of origin, if it is accompanied by an order for one of the Polar "Ideal" condensers or "Ideal" drum control type, capacity .0005 or .0003. To take advantage of the scheme, which extends to the end of February, the purchaser must take one or more old condensers to his local retailer, ordering "Ideal" condensers to the same number as those returned.

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ACCESSORY MAKERS COMBINE.

A new departure in the French radio industry is the formation of a union comprising the makers of wireless components and accessories as distinct from the manufacturers of sets. Our Paris correspondent states that the primary object of the new body is to protect the interests of its members in the domain of patents.

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RADIO LOVING CUP.

A loving cup has been presented by Count Felix von Luckner to Mr. R. Parmenter (W1MK) as the radio amateur who proved the most helpful in maintaining contact between land and the Count's yacht "Mopelia" during his cruise with fifty boys between New York and Trinidad last summer.

Catalogues Received.

Gambrell Radio, Ltd., Buckingham House, Buckingham Street, Strand, London, W.C.2.—Illustrated folders dealing with radio-gramophones and all-electric A.C. and D.C. receivers.

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Lectro-Linx, Ltd., 254, Vauxhall Bridge Road, London, S.W.1.—Descriptive folders dealing with Clix valve holder, new model "All-in" terminal, plugs, sockets, and connectors.

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Bloomsbury Wireless, 9, Old North Street, Theobald's Road, London, W.C.1. —Particulars of accumulator charging service.

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London Electric Wire Co., and Smiths, Ltd., Church Road, Leyton, London, E.10.—Illustrated catalogue of components and accessories with diagrams showing the various uses of each component.

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Edison Bell, Ltd., Edison Bell Works, Glengall Road, London, S.E.15.—Twenty-four-page catalogue illustrating and describing the range of receivers, accessories, and components made by this firm.

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The Ever Ready Co. (Great Britain), Ltd., Hercules Place, Holloway, London, N.7.—Illustrated catalogue of dry-cell H.T. batteries, L.T. accumulators for stationary and portable use.

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Ferranti, Ltd., Hollinwood, Lancashire. —Publication W522 dealing with the construction of H.T. eliminators and combined supply units for A.C. and D.C. mains. Also literature dealing with mains transformers and Ferranti receivers.

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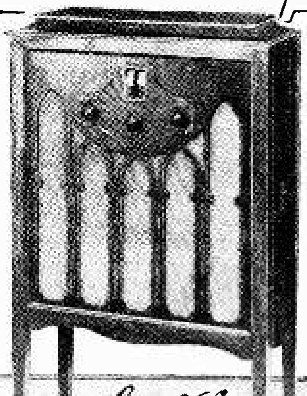
Burndept A.C. Receiver

Self-contained Console Cabinet with Internal Loud Speaker.

Indirectly Heated A.C. Valves. Power Pentode Output.



De Luxe Model 1850

THE 1931 range of Burndept broadcast receivers and radio gramophones is centred round a three-valve chassis designed for operation from A.C. mains and incorporating one stage of H.F. amplification, a grid rectification detector and a single power pentode L.F. amplifier. At Olympia this chassis attracted considerable attention on account of its clean design, the accessibility of valves and the mechanical strength of the sheet-steel framework.

The circuit is designed to work in conjunction with an external aerial—either indoor or outdoor. The maximum permissible length of 100 ft. is advised in situations remote from broadcasting stations, but for use in the vicinity of a regional station a short indoor aerial is preferable on the score of selectivity. The input to the tuned-grid circuit of the H.F. valve is controlled by a differential condenser which enables a wide range of volume control to be obtained without upsetting the tuning once the dials have been set for a given station. The input volume control also serves as a means of minimising cross-modulation in the screen-grid valve.

The tuned grid coils are of efficient design, and their diameter is greater than is usually found in commercial designs at the present time. The short-wave coil is a single-layer winding, and the long-wave coil is section-wound in deep slots in a built-up paxolin former. A few turns of each coil are included in the aerial circuit, but the arrangement of the long-wave coupling is unconventional. Actually, the coupling turns are not included in the tuned-grid circuit, but form an external subsidiary circuit which is shunted by a fixed condenser of about 0.0003mfd. It was found with the conventional type of coupling that at certain settings of the differential aerial condenser the coupling turns were tuned to powerful medium-wave stations which seriously interfered with reception on long waves. The arrangement finally adopted raises the resonance of the subsidiary coupling circuit to a wavelength between the long- and medium-wave bands, and the interference, if not entirely eliminated, is considerably reduced.

SPECIFICATION.

CIRCUIT: *Three-valve. One H.F. (tuned auto transformer), grid detector (with reaction), power pentode with dual ratio output transformer. Full-wave valve rectifier. Indirectly heated valves throughout.*
CONTROLS: (1) *Semi-ganged tuning controls (side-by-side drum dials).* (2) *Volume control (differential aerial condenser).* (3) *Reaction.* (4) *Wave-range and pick-up switch.* (5) *Double-pole mains switch.*
GENERAL: *Self-contained console cabinet (depth 10 inches). Terminals for gramophone pick-up and alternative high- or low-impedance external loud speakers. Power consumption 33 watts.*
PRICE: *26 guineas in oak or mahogany.*
MAKERS: *Burndept Wireless (1928) Ltd., Blackheath, London. S.E.3.*

The tuned-anode circuit of the H.F. valve is centre-tapped, and only half the inductance is included in the valve circuit. Thus the circuit functions as an auto-transformer with a 2 : 1 ratio, and both signal strength and selectivity are increased. The long-wave coil is placed between the two halves of the medium-wave winding to preserve symmetry in the circuit. Reaction is obtained without the necessity of a separate winding by coupling the anodes of the H.F. and detector valves through the medium of a small variable condenser. In practice this scheme works extraordinarily well, and the reaction control is smooth and free from backlash and remains practically constant over the tuning scale on both wave ranges.

The condensers tuning the grid and anode circuits of the H.F. valve are not ganged mechanically, but the edgewise drum dials are mounted side by side so that they can be rotated simultaneously. The condensers remain in step over the greater part of the scale, and one has the satisfaction of knowing that the last ounce of selectivity and range is being extracted when the final close adjustment of each condenser is made independently. The right-hand dial, which controls the tuned-anode circuit, is calibrated in wavelengths.

Wave Range Switching.

The dials are illuminated by a 3.5-volt flash lamp deriving current from the 4-volt filament circuit through a 10-ohm resistance. The lampholder is mounted on a cranked arm which can be swivelled to facilitate replacement of the bulb.

The change from medium to long waves is effected by two switches of new type, which are exceptionally well designed from the mechanical point of view and capable of standing up to prolonged use without developing noisy contacts. They are coupled by a link motion to an operating knob disposed centrally on the control panel at the front of the cabinet. Contacts are included on both switches for changing over to a gramophone pick-up, those on the first switch being arranged to short-circuit the aerial input and so prevent the intrusion of radio signals.

The detector is coupled to the power pentode output valve through a Ferranti AF4 transformer. A fixed condenser connected across the secondary prevents the transfer of stray H.F. currents to the output circuit and also restricts the higher audio frequencies which

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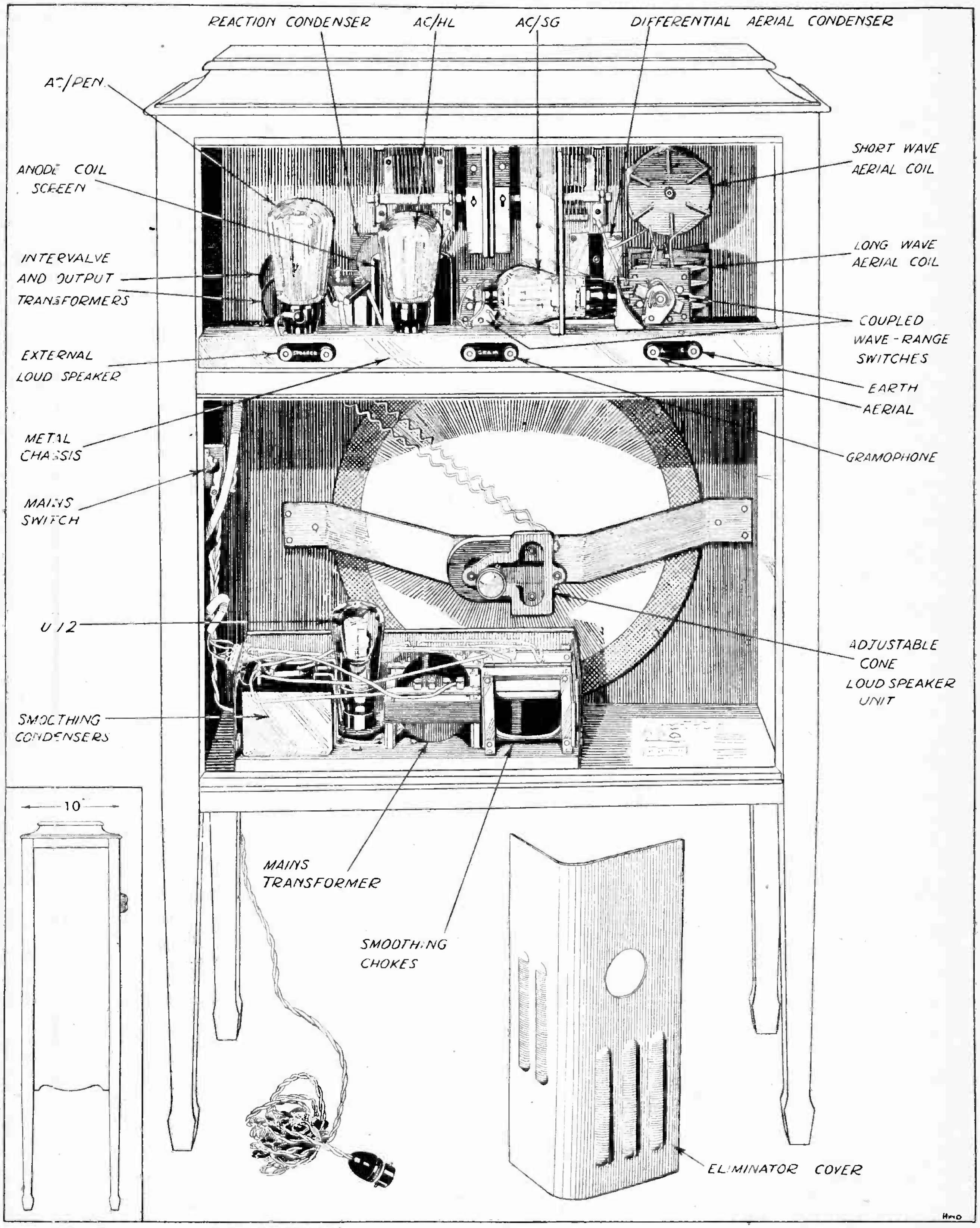

Layout of components in the receiver chassis and power unit of the Burndept A.C. Receiver de Luxe. The back-to-front depth of the cabinet is only 10 inches.

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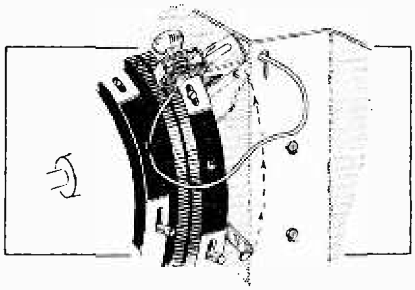
Burndept A.C. Receiver.—

would otherwise be over-emphasised by the pentode in conjunction with the moving-iron loud speaker movement. For a similar reason a resistance is connected across the secondary of the output transformer. This resistance also maintains a constant load across the anode circuit and prevents the development of excessive A.C. voltages which might cause a breakdown in the insulation of the transformer windings.

The H.T. supply to the pentode is 28 milliamps. at 230 volts, with a screen voltage of 200, and under these conditions the valve is capable of delivering an undistorted A.C. output of at least 1,000 milliwatts.

In the model reviewed separate terminals were provided for an external loud speaker of average impedance 2,500 ohms, the step-down ratio being 2 : 1; but we understand that in present models an additional tapping is included which gives a ratio of 25 : 1 for moving-coil loud speakers of low impedance.



Pilot light mounting showing cranked lever to facilitate replacement of the bulb.

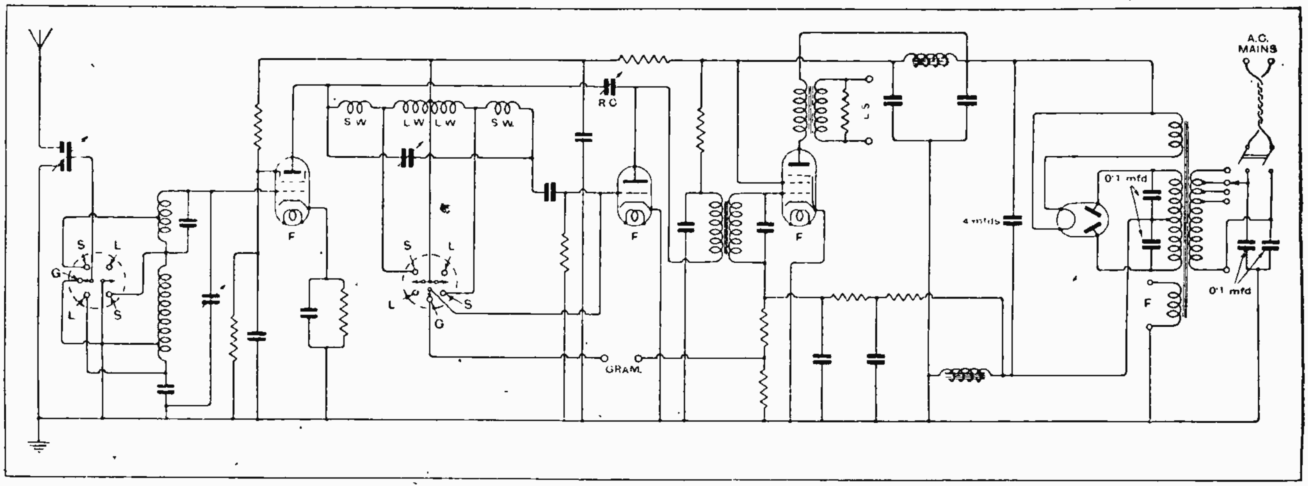
The components associated with the power supply are assembled in a separate unit. High tension is derived from a type UU2 full-wave rectifier, and the output, after smoothing by chokes in both negative and positive leads, is supplied to the receiver chassis at two voltages—230 volts for the anode of the pentode and 200 volts for the H.F. and detector valves and the auxiliary grid of the pentode. The high-tension circuits are liberally decoupled throughout, the by-pass condensers being constructed as a single bank. It is interesting to note that the anodes of the rectifier are by-passed by two 0.1 mfd. to prevent the development of parasitic H.F. oscillations which might carry 50- or 100-cycle hum into the H.F. circuits of the receiver. Condensers of similar capacity are connected across the mains leads and the mid-point earthed to prevent the ingress of H.F. interference along the supply mains.

The receiver was tested at a distance of five miles from Brookmans Park on a 50ft. outdoor aerial, and 17 foreign stations were received on the medium waveband. The Regional and National transmitters were easily separated at this distance, and Göteborg (322 metres) was received between the two stations without serious interference from either. There was also some free space between the National transmitter and the bottom of the dial, and Nürnberg (239 metres) was successfully tuned-in in this region. In Central London, on a short indoor aerial, either local transmitter could be confined to within 2 degrees of its normal setting.

The range on long waves is good, and eight stations in addition to Daventry were received at programme strength. Radio Paris and Daventry were easily separated, and Königswusterhausen could be received clear of Radio Paris but with some background from 5XX.

In spite of the special precautions which have been taken in the aerial circuit to prevent local medium-wave stations from breaking through into the long waveband some trouble was experienced from the National transmitter (261 metres) when using the 50ft. aerial at a distance of five miles from Brookmans Park. This is a somewhat severe test, however, and in Central London the trouble disappeared entirely.

The cone loud speaker gives pleasing quality and ample volume for a large living room. The control of high-note output from the pentode has been skilfully adjusted, and the balance between high- and low-frequency response in the reproduction of music is just right.



Complete circuit diagram of the Burndept Model 1850 chassis and power supply unit.

Freedom from mains hum is a notable feature of the performance. One has to listen carefully, even during intervals in the transmission, for any evidence of 50-cycle hum.

At the revised price of 26 guineas the A.C. Receiver de Luxe is extraordinarily good value for money. The cabinet is available in either oak or mahogany at the same price. A table model in walnut, without loud speaker, is now being made, the price being 20 guineas.

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BROADCAST BREVITIES

By Our Special Correspondent.

Mystery Signals Explained?

Stories concerning the mystery signals reported to have been heard from Moorside Edge may be partially explained by the B.B.C. admission that radiation tests have been carried out in the locality with an improvised transmitter of low power during the past few weeks. But the carrier-wave has been unmodulated, so those aspirants to fame who can boast of having heard recognisable signals deserve our congratulations!

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First Transmission from Northern Regional.

The twin transmitters are now nearly completed, but I understand that the first announced test need not be expected before the middle of February. The wavelength will be 479.2 metres.

Considering that Northern Regional will have a larger service area than any other of the regional stations, listeners in the south may expect to get quite good signals, possibly comparable with those from the medium-wave Daventry.

oooo

Pamphleteering by Stealth.

There are dangers, no doubt, attaching to the practice of stealing round to the house of one's neighbour and stuffing into his letter box an anti-oscillation pamphlet; but the custom is now an ancient one, sanctified by long usage, and I cannot altogether sympathise with the B.B.C.'s attitude in the matter.

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The B.B.C.'s Advice.

For the B.B.C. is suggesting that its pamphlets are prepared for the individual listener who applies for them, not for propaganda work by self-appointed missionaries among the listening public.

"What does one do," I asked a B.B.C. official, "if one's neighbour is known to be oscillating?"

"Write to the B.B.C. about it," was the reply. "A few days afterwards the offender will probably be visited by a Post Office official."

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A Preference.

Now some of us have an innate objection to "telling tales out of school." If and when I know which neighbour is oscillating I shall much prefer to employ the letter-box method, ignoring the enamelled threats on his gate, and trusting to regain the King's Highway before the dog is let loose.

oooo

"By Request."

Jack Payne and his band are constantly replaying dance tunes "By Request." Who is this fellow, that he should receive so much attention? The answer to this query, which appeared a few days ago in the daily Press, is that the requests come from listeners who write to Savoy Hill expressing a preference for a particular tune. Sometimes a single mail will bring twenty or more letters each asking for a repetition of the same number. It is then repeated "by request."

Here To-day and Gone To-morrow.

Two days before Maria Basilides takes part in the concert to be relayed to Britain from Budapest on February 11th, she will be appearing in person in a Savoy Hill studio for a broadcast from London National.

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Another Royal Broadcast.

The Duke of Gloucester's speech at the British Industries Fair banquet will be relayed from the Guildhall to London Regional listeners on February 16th.

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Descriptive.

In a letter to the B.B.C. last week a correspondent referred incidentally to the new interval signal. He wrote: "Since you let loose this death watch beetle . . ."

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President Hoover and the Microphone.

If President Hoover's claims to popularity were based solely on his radio reputation he might expect a "walk over" in the next election, for, according to Mr. Frank Russell, vice-president of the National Broadcasting Co., the President is "radio's ideal speaker."

"He is never late," says Mr. Russell. "His addresses run the specified time almost to the minute. His voice never varies. While most of his speeches are made on platforms before large audiences, he never forgets the microphone. He faces it at all times, never turning to one side or the other as most speakers do. President Hoover's voice, from the standpoint of radio engineers, is easier to handle than the voices of most speakers."

oooo

Steel Rhythms for your Loud Speaker.

Listeners have heard, now and then, the sounds of machines as they form themselves in the minds of composers. All the sounds of factory life in the great Robot play, "R.U.R.," were made by musical instruments. Schonberg, on the other hand, used massive chains in his "Gurrelieder."

On February 25th, listeners to the B.B.C. Symphony Concert are to hear another version of the machine theme in the form of a symphonic episode entitled "The Factory," an overture which depicts the activity of a steel factory in full swing. The composer is Alexandre Mossolov, one of the youngest Russian composers—he was born at Kiev in 1900. "The Factory" is described as a movement "hammered out on a rhythm of steel."

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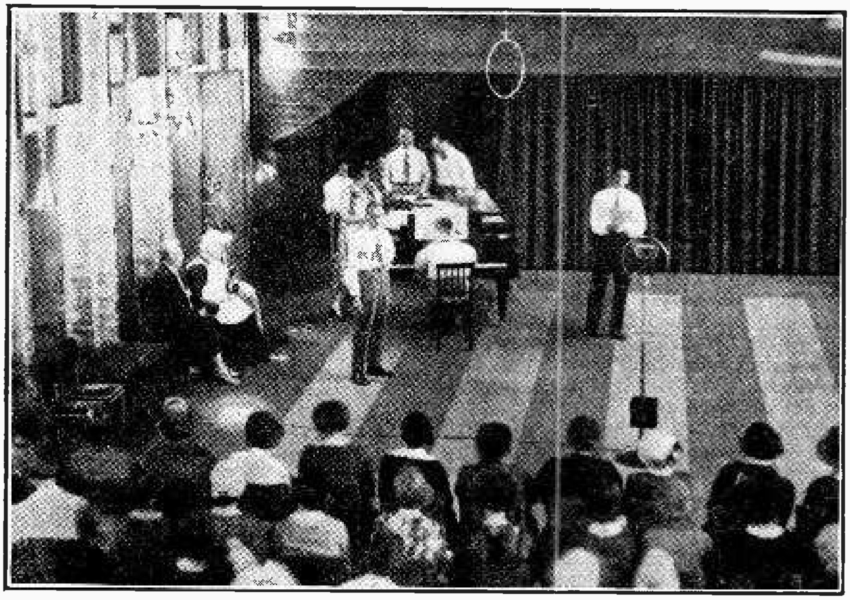
Long Live the Studio Audience.

A campaign is still afoot to abolish the studio audience, but I am glad that in this matter the B.B.C. shows no sign of accepting the advice which is so generously showered upon it.

The hand-clappers in the studio are sometimes a trifle exasperating, but perhaps it is not always realised that they are ordinary listeners like ourselves, gathered from the highways and by-ways. In a sense they are our representatives, and it will be a bad day for the Man in the Street when he is forbidden *free* access to the B.B.C. studios.



THE STUDIO AUDIENCE IN GERMANY. A recent photograph taken in the Munich studio during an actual broadcast, showing an audience composed of ordinary listeners. Far from discouraging the studio audience, the B.B.C. will provide at least 1,000 seats for the public at "Broadcasting House."

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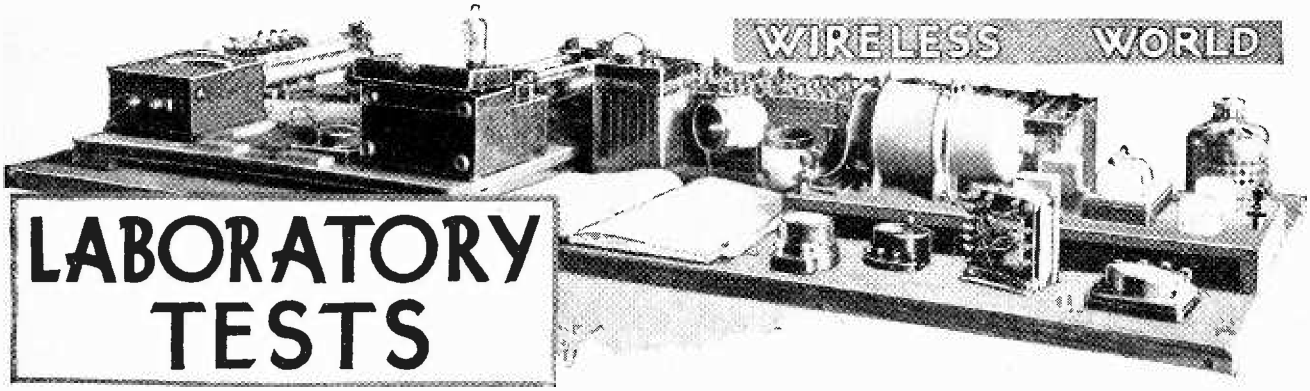


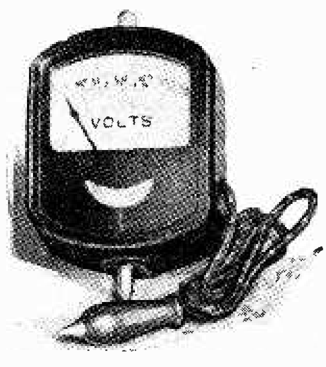
LABORATORY TESTS

A Review of Manufacturers' Recent Products.

RIPAULT'S DUAL-RANGE VOLTMETER.

The inexpensive type of dual-range voltmeter generally has much in common with others of its class, but occasionally one appears which exhibits a number of exclusive features. Such a one is the Ripault's instrument. It is of the moving-iron type, falls within the watch-pattern class, and has two ranges, viz., 0-6 and 0-120 volts respectively. The pointer rests on the zero in whatever position the meter is held, and shows only a very small error over both ranges, being of the order of the thickness of the pointer only.

In addition it incorporates a unique range-change switch which is operated by a small press button located on the top of the moulded case. Normally the 120-volt range is available, the change being effected by holding down the switch plunger. On pressing the plunger the 0-120 engraved scale disappears, and is replaced by one marked 0-6. There can be, therefore, no confusion as to which range is in use, as might arise in cases where both sets of engravings are at all times visible.



Ripault's dual-range voltmeter, the engraved scale of which is changed when the switch is depressed.

The resistance of the instrument is given as 4,600 ohms. On measurement it was found to be 4,450 ohms, and 27 mA. were required to give a full-scale deflection. The above refers to the 0-120-volt range. Consequently, a little care must be exercised in measuring the voltage of small-size dry-cell batteries, only "snap" readings being advised, and with the battery off load.

Large-capacity batteries need not be treated so carefully, since this order of current should be within their capacity. Nevertheless, no other load should be imposed on the battery at the same time.

Supplies are obtainable from Ripault's, Ltd., King's Road, London, N.W.1, and the price is 12s. 6d.

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TWO NEW REGENTONE ELIMINATORS.

The two mains units dealt with in this review have only recently been introduced, and are officially known as model W5A and model D.C. Combined No. 2. The W5A is for use on A.C. mains, and the other is its D.C. counterpart. Both these units resemble in some respects existing models, but the new versions have been evolved with the main object of producing a satisfactory power unit at a lower price than hitherto.

The overall size of the W5A is 9in.$\times$ 5in.$\times$3½in.; thus it can be included in the portable set class, since it will occupy the space usually allocated to the dry-cell battery in portable sets in addition to fulfilling the same rôle in the case of ordinary cabinet-type receivers.

New Regentone combined H.T. eliminators and trickle chargers for A.C. and D.C. mains. The D.C. model can be identified by the special adaptor on the end of the flex lead.

The W5A provides three fixed output voltages: one is derived from a potentiometer, and is obviously intended to supply screen potential to S.G. valves. The other intermediate tapping derives its voltage *via* a series of resistance, and will normally be used to feed the detector stage, while the remaining supply is for the L.F. and power valves and gives the maximum output.

Tested on a 240-volt 50-cycle supply, the first tapping gave 80 volts, the second 90 volts at 3 mA. when the power output was delivering 150 volts at 10 mA.

A Westinghouse full-wave rectifier is employed, and the usual smoothing choke and condensers are included.

When not employed as an H.T. eliminator the unit can be utilised to charge the L.T. accumulator. Provision is made to charge 2- and 6-volt cells, the measured charging rate being 0.22 amp. and 0.21 amp. respectively. When the switch on the unit is in the "charge" position the valves must be switched off.

The D.C. Combined No. 2 gives similar output voltages. There is no transformer or rectifier, of course, and the charging current is obtained by inserting an ordinary electric lamp in a special holder provided on the adaptor end of the flex cord.

The price of model W5A is £4 15s., and the D.C. Combined No. 2 is listed at £2 12s. 6d. These eliminators are products of Regentone, Ltd., Regentone House, Bartlett's Buildings, Holborn Circus, London, E.C.4.

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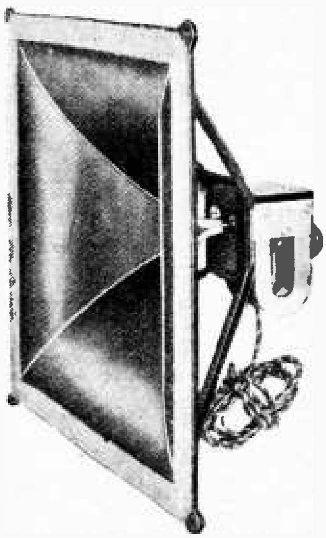
"GRAWOR" LOUD SPEAKER UNITS.

The Grawor programme for 1931 includes an interesting 8-pole balanced armature movement designed for inputs up to 5 watts. The twin permanent magnets are exceptionally large, and more than usual care has been taken to ensure rigidity and freedom from backlash in the adjusting mechanism. The unit was tested in conjunction with the "Sector" cone chassis, which consists of a square paxolin diaphragm mounted in a cast aluminium frame 13in. square. The four segments of the diaphragm open out exponentially, and the joints between the segments are made with a flexible material resembling medical adhesive tape, which is unlikely to develop any trace of "buzz" after prolonged use.

The sensitivity, even with the diaphragm adjusted centrally for maximum power input, is decidedly above the average, and the quality of reproduction is excellent. The output rises rapidly from



"Grawor" 8-pole balanced armature unit mounted on the "Sector" cone chassis.

practically zero at 50 cycles to its maximum at 100 cycles, and maintains this high level up to 3,000 with a small depression of no great importance between 2,000 and 2,250 cycles. Between 3,000 and 4,000 cycles the output falls off slightly, but continues at the new level from 4,000 to 6,000 cycles. The high-frequency response is amply sufficient to give brilliance to the general effect, while the absence of resonances in the lower middle register results in good reproduction of speech.

Measurements of impedance at octave intervals gave the following results :—

Frequency (cycles).	Impedance (ohms).
50	832
100	1,570
200	2.530
400	3,480
800	5,730
1,600	9,450
3,200	16,700
6,400	20,900

The price of the "Sector" chassis, with 8-pole adjustable movement as tested is 68s. A non-adjustable model is available at 65s.

"Goliath" cone chassis and unit.

The second model tested was the "Goliath" chassis and unit. The diaphragm is a 9in. cone of the type used in the Grawor moving-coil loud speakers, and the adjustable unit is fitted with a single permanent magnet of the type used in the 8-pole unit. The band of frequencies effectively covered is not so wide as in the "Sector" model, and for practical purposes the cut-off at high and low frequencies may be placed at 3,500 and 200 cycles respectively. There is a marked increase of output between 400 and 550 cycles, which tends to make speech deep-toned, and an additional small resonance occurs at 2,500 cycles. The impedance measurements show a falling off at the upper frequencies which would seem to indicate a shunt condenser across the windings. This probably accounts for the reduced output above 3,500 cycles.

Frequency (cycles).	Impedance (ohms).
50	497
100	892
200	2,010
400	3,600
800	6,200
1.600	18,000
3.200	8,440
6,400	3,710

The price of the complete chassis is 35s., and of the "Goliath" unit alone 21s. "Grawor" products are handled in this country by Messrs. Henry Joseph, 11, Red Lion Square, High Holborn, London, W.C.1.

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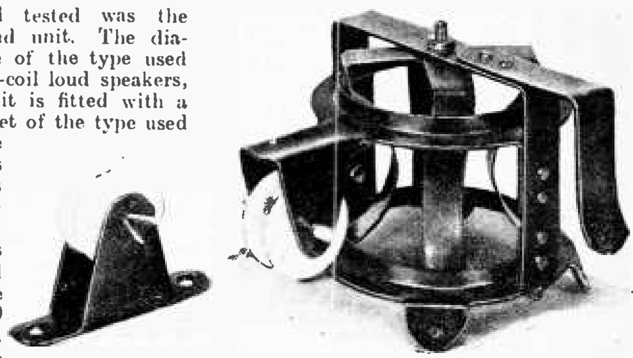
BROOKES WIRELESS ACCESSORIES.

At some time or other many readers must have experienced the misfortune of a broken aerial halyard, or been brought face to face with the problem of replacing a pulley that has come adrift from the top of the aerial mast. To dismantle the mast is difficult enough, even if it is supported by guy wires alone, but where the mast has been buried in concrete, repairing the damage might well prove both costly and laborious.

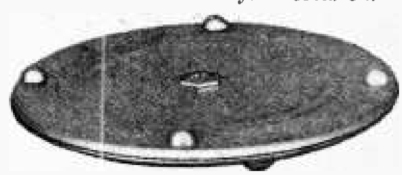
It is to meet such cases that the Brookes Aerial Mast Combination No. 11 has been evolved. This device consists of two metal hoops, 3in. inside diameter, spaced 2in. apart and provided with four bow-shaped springs which will accommodate themselves to any thickness of pole from 1½in. to 3in. in diameter. The top ring carries a porcelain pulley and an extension arm, while the lower one has provision for the attachment of four guy wires.

To erect the device, first fix the four guy wires and halyard, then lash a light pole to the extension arm and raise the combination by means of the pole and drop the cap over the top of the pole. The guy wires can be used to bed it down firmly, after which they can be used as supports for the mast.



Brookes Aerial Mast Combination No. 11 and halyard pulley.

The price of this useful accessory is 2s. 6d., and a special porcelain pulley for the lower end of the halyard costs 9d.



Double-sided turntable finished in gilt, made by Brookes.

Another interesting accessory by the same firm is a double-sided ball-bearing turntable for portable sets. This measures 7in. in diameter, is finished in gilt, and costs 5s. The makers are the Brookes Manufacturing Co., Ltd., 222-224, Lichfield Road, Aston, Birmingham.

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CABINET FOR BLUE SPOT "SPECIAL" CHASSIS.

Readers contemplating the construction of a loud speaker embodying the new Blue Spot "Special" chassis may be interested to learn that the Camco Melodee Cabinet, No. 1 size, will nicely accommodate this chassis and its unit.

The makers are the Carrington Manufacturing Co., Ltd., Camco Works, Sanderstead Road, South Croydon, and the price is 22s., finished in oak or mahogany.

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Modern Views on the Moving Coil Speaker

Factors Which Adversely Affect Frequency Response.

By N. W. McLACHLAN, D.Sc., M.I.E.E., F.Inst.P.

(*Concluded from page 54 of previous issue.*)

IN general, the average coil-driven diaphragm breaks up below 250 cycles, and resonances or diaphragm modes occur progressively as the frequency is increased. In addition to the radial modes of vibration already discussed—the lowest being characterised by 4 nodes, as shown in Fig. 7—there are also so-called symmetrical or concentric modes where the centre of the diaphragm moves in an opposite direction from the edge.[6] This is illustrated diagrammatically in Fig. 5a, which shows one nodal circle. Also, at certain frequencies the diaphragm moves whilst the coil is substantially at rest, as shown in Fig. 5b. These latter are the *centre fixed* modes, but they are not powerful. Prominent resonance in between 2,000 and 3,500 cycles is due to a centre free mode (Fig. 5a). In certain types of speaker, mainly those with small diaphragms of crisp paper, there are powerful resonances at higher frequencies which make the letter "s" whistle. To illustrate resonance effects in the upper register, Fig 6 has been reproduced. It is one of a large number of curves taken under different mechanical conditions pertaining to diaphragms. It portrays a decided peak in the motional resistance (added resistance due to sound radiated and diaphragm loss) of the coil driving the diaphragm at 3,000 cycles, and indicates a reduction in output from 1,000 to 2,000 cycles, also above 4,000 cycles. In other words, with a moving coil loud speaker part of the frequency register is uneven.

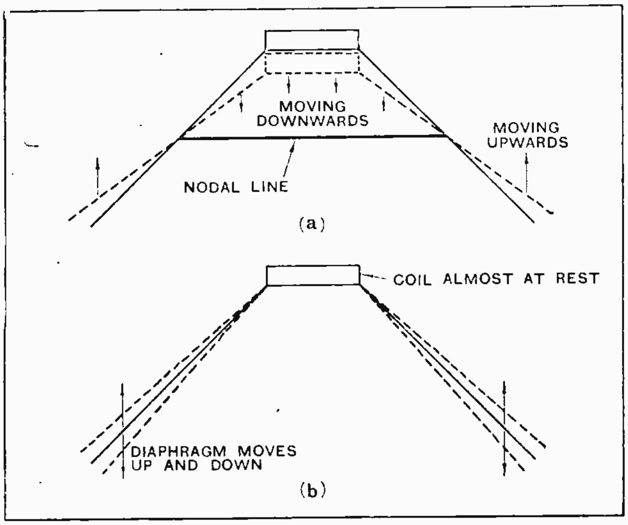

Fig. 5.—(a) Resonance of coil and diaphragm when the centre (i.e., coil) moves. The diaphragm moves in opposite directions on either side of the nodal line. (b) Diagram illustrating resonance of diaphragm when the coil remains substantially at rest.

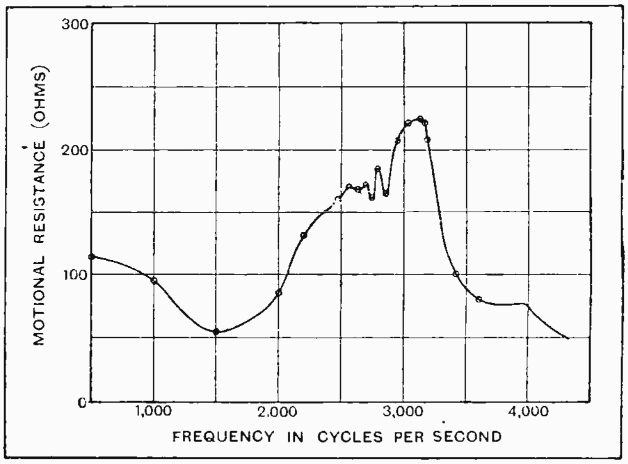

Fig. 6.—Diagram showing "Motional Resistance" of a high-resistance coil on a conical diaphragm of the form illustrated in Fig. 8. The motional resistance is the sound radiation resistance + resistance due to frictional loss in diaphragm.

Reference to an experiment which I performed during a lecture to the Institution of Electrical Engineers at the Liverpool University in November, 1929, may not be amiss. Does the reader realise that he can draw music from his coil without the aid of a receiver? Remove the diaphragm from the speaker and place it mouth downwards on the table. Take a well-resined violin bow and draw it skilfully over the edge of the coil. The latter will give forth a variety of notes according to the method of bowing. Some skill is required to obtain

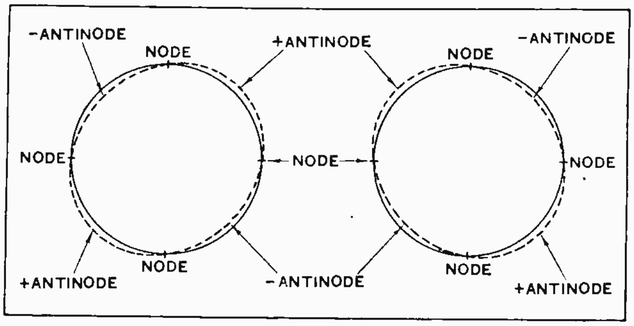

Fig. 7.—Diagrams illustrating the first mode of flexural vibration of a thin circular ring (moving coil). There are four nodes. On the left the positive half-cycle is shown and on the right the negative half-cycle.

[6] These modes do not manifest themselves readily under the neon lamp treatment, but they can be traced with a fairly flat cone provided the frequency at which they occur is low enough to ensure a reasonable amplitude. The asymmetry due to the seam in the cone introduces irregularities and the motion resembles a heavy sea.

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Modern Views on the Moving Coil Speaker.—

single notes. The bow causes the coil to execute its natural oscillations of the form illustrated in Fig. 7. It should be observed that the first mode of vibration is characterised by *four nodes.*[7] Data are given in Table I relating to the natural frequencies of an impregnated and baked high-resistance coil of 1,000 turns No. 47 enamelled wire, as obtained by a violin bow and checked against an oscillator and loud speaker for beats.

The dimensions of the coil and diaphragm are shown in Fig. 8. Oscillograph records of the acoustic output from a low-resistance coil and diaphragm when bowing

TABLE I.

Showing Natural Frequencies of 1,000-turn Baked Coil when Stroked with Violin Bow.

Natural Frequency of Coil. Cycles per Second.	Remarks.
690	
1,900	This frequency most readily excited by bow.
4,000	
Greater than 4,000	Pitch difficult to ascertain by beats, since note impure.

the former are shown in Fig. 9. Here again the frequencies check closely with those found by beats. These resonances are, of course, imparted by the coil to the diaphragm during the reproduction of speech and music, and are in part responsible for resonances above 2,000 cycles or more. The more flexible the coil the more powerful is the upper register, and vice versa.

Having shown that the upper register of the speaker is due to resonances, we proceed to an examination of the register below 300 cycles. Take a diaphragm as shown in Fig. 8, but with the edge free and not bent over, and suspend it by means of a centring device so that the natural frequency of the combination is well below audibility. When used on broadcasting with a baffle, the bass is weak in comparison with the upper register. Measurement of the acoustic radiation resistance indicates sharp peaks—which only last a few cycles—where the radial modes occur, the first starting about 50 cycles. These resonances get weaker as the frequency rises, and from 150 to 300 cycles they are unimportant. At the same time the output between these frequencies is small but fairly uniform.

[7] This also applies to chime bells, and to conical diaphragms With the latter, however, I have obtained two nodes, but this was probably due to asymmetry caused by the seam and by suspension from three threads.

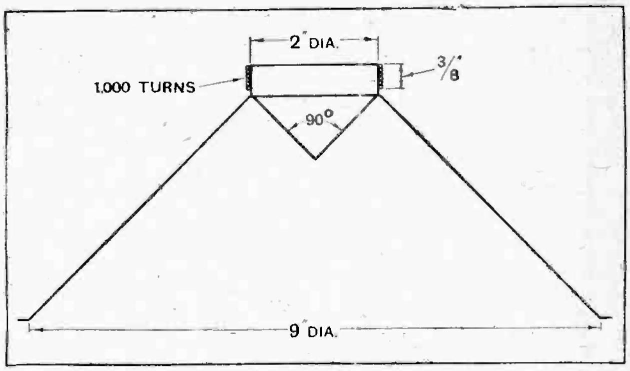

Fig. 8.—Dimensions of coil on which experiments were conducted. The base of coil was glued to the diaphragm.

If the edge is folded over horizontally, as shown in Fig. 8, and a cardboard ring, say, 12 mils thick and ¼in. wide, is glued on, it is quite stiff and will not bend readily. Moreover, radial modes disappear at the lower frequencies, although the diaphragm has a tendency to break up *between* the edge and the apex at frequencies of about 200 cycles. In fact, by aid of a neon tube it appears to heave on either side of the seam like a ship on an angry sea. Measurement shows that the output below 300 cycles is even less than with a free edge, although by ear on broadcasting there may not appear to be a great deal of difference.

Next remove the cardboard ring and mount the diaphragm on, say, a thin rubber support giving an overall diameter of 11 inches. Measurement shows that the register below 300 cycles is now as powerful or slightly more so than the upper register.

The inclusion of the bass register—in this particular case—*is not due to the resonance of the diaphragm on its surround,* since that occurs at 18.5 cycles; it is due to the surround acting as an auxiliary resonant diaphragm whose area is about one-third that of the

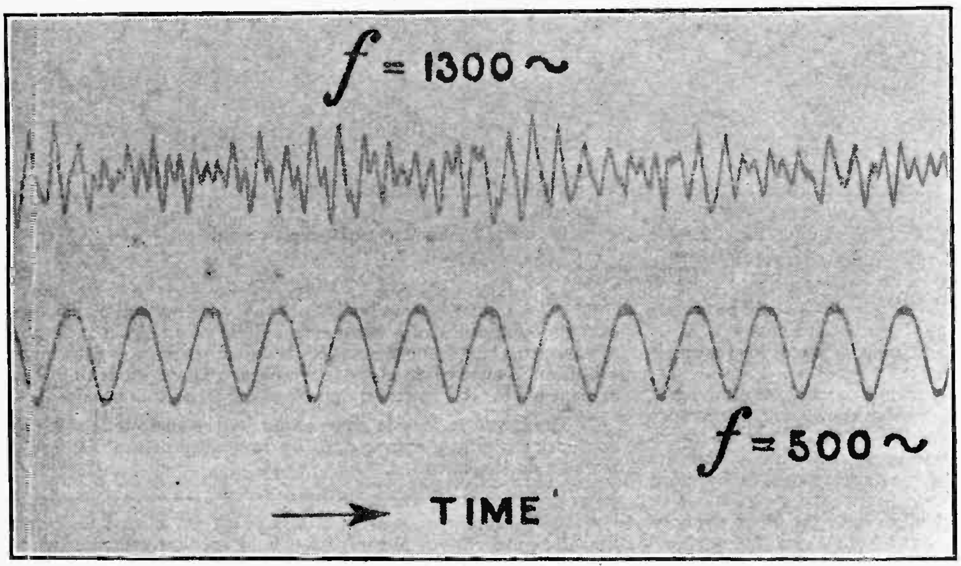

Fig. 9.—(a) Record showing acoustic output when bowing low-resistance coil mounted on diaphragm of form shown in Fig. 8.

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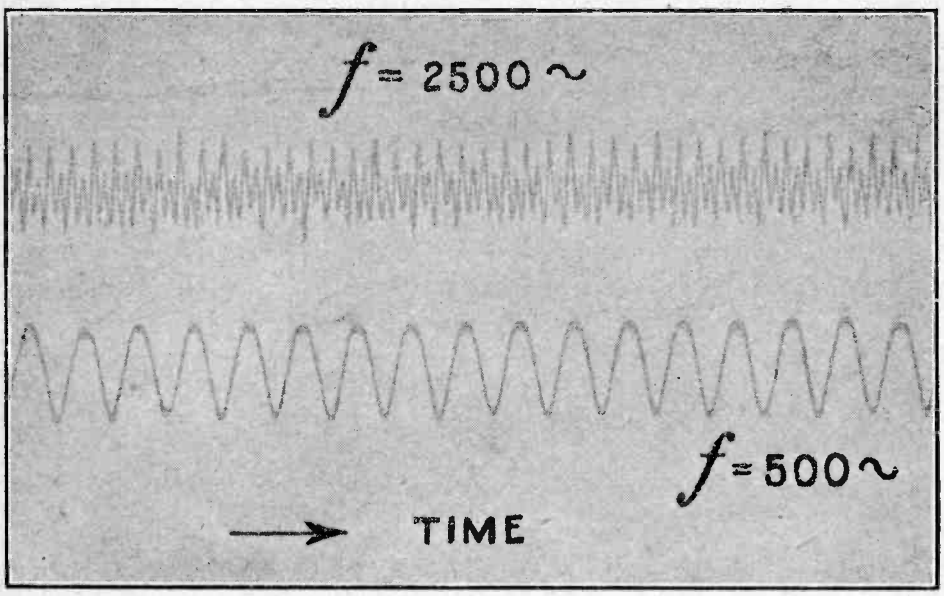

Fig. 9.—(c) Record showing 2,500-cycle resonance.

from 50 to 4,000 cycles can be made quite pleasing to the ear, although there may be at times a tendency for the bass to preponderate if the tension of the rubber is wrong.

In most commercial speakers the surround is fairly tight, and gives a resonance of the *diaphragm as a whole* thereon, which varies from 40 to 100 cycles, according to the design. Under such conditions the bass is given by this resonance and does not cover the wide range of that cited above, i.e., it is confined to a much narrower frequency band. Also the radiation resistance of the diaphragm on its support is many times that of the support itself.

cone. The resonance of the *surround itself* occurs at 129.5 cycles, but it varies with temperature and humidity. If the diaphragm is imagined to be fixed, it is easy to see that the surround can move between the diaphragm and the frame. By taking an impulse record (see *The Wireless World*, April 3rd and 10th, 1929) the 129.5-cycle surround resonance can be shown quite clearly. This resonance disappears when the rubber is removed. Also, by varying the radial tension of the surround the bass register and the surround resonance can be varied accordingly. By carefully adjusting matters the register

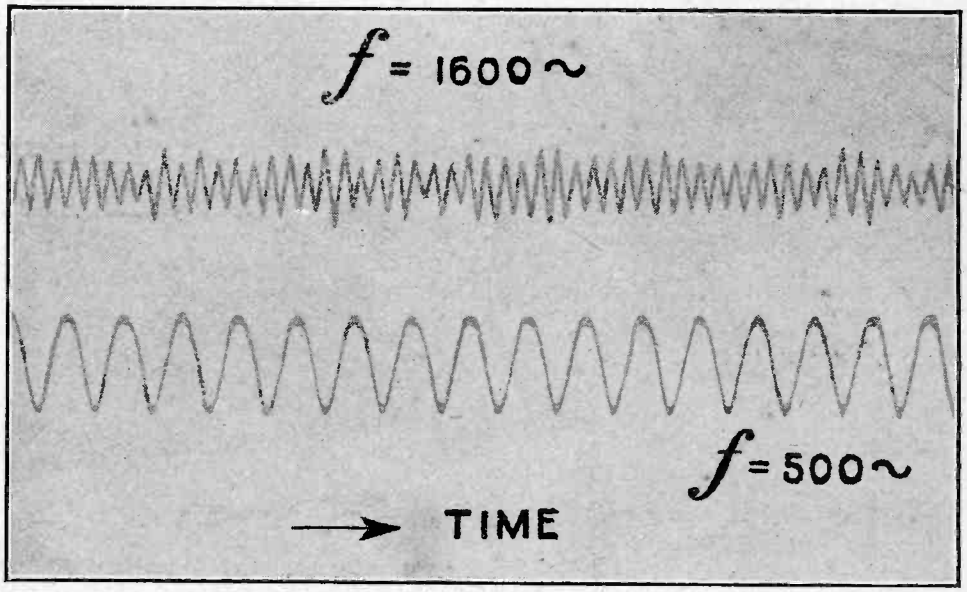

Fig. 9.—(b) Acoustic output showing 1,600-cycle resonance.

SUMMARY.

1. A coil-driven rigid disc—complete with baffle—would be useless as a loud speaker for the reproduction of speech and music.

2. A coil-driven diaphragm depends upon resonances for its upper and its lower registers.

3. No practical form of diaphragm moves as a whole at all musical frequencies, i.e., it exhibits the phenomenon known as "break-up."

4. The "break-up" phenomenon can be demonstrated by means of dust figures or by aid of neon tubes driven at nearly half the frequency of the current supplied to the moving coil, or by other suitable stroboscopic means.

5. There are two salient modes of vibration: (a) where the edge bends and the "nodes" are a series of radii, (b) where the "nodes" are circles. In practical cones, due to asymmetry and non-uniformity in mechanical properties, the nodal figures are often very irregular, i.e., it is difficult to get a good approximation to a circle.

6. The flexural "modes"[8] of the moving coil itself can be excited by the aid of a well-resined violin bow. As in the case of a symmetrical and homogeneous conical diaphragm, the first mode of vibration is characterised by four nodes. These modes are largely responsible for the powerful upper register in certain speakers.

7. The lower register is given either by the surround acting as an auxiliary resonant diaphragm, or by resonance of the diaphragm as a whole on the surround.

[8] There are numerous other modes which we have not discussed, and there are various phases of the loud speaker question which it has been impossible, through space limitations, to incorporate herein. A more complete account of the problem will be found in the *Philosophical Magazine*, pp. 1-54, January, 1931.

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READERS' PROBLEMS

Replies to Readers' Questions of General Interest.

Technical enquiries addressed to our Information Department are used as the basis of the replies which we publish in these pages, a selection being made from amongst those questions which are of general interest.

A Faulty Switch.

I have found that the measured voltage across the filament terminals of my receiver rises from 1.6 to 2 volts when the on-off switch is short-circuited. Do you consider that this is due to a fault, or to the fact that I am passing more current—0.8 amp.—than the switch is intended to carry?

An on-off switch should be capable of carrying a current of this magnitude without introducing an appreciable voltage drop, and we think that your component must be considered as being defective either in design or construction.

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Current for Nothing.

I wish to make up the simplest possible two-valve set to operate entirely on 240-volt D.C. mains, and am thinking of wiring the filaments in series, and also in series with a 60-watt lamp, which will serve as a voltage-reducing resistance while fulfilling its normal function for lighting. It seems that some form of special adaptor will be necessary, and I am uncertain as to how the connection for the H.T. feed should be picked up; will you please give me a simple sketch showing this point?

A combined adaptor and lamp holder should be wired up as shown in Fig. 1. As an alternative to the use of 0.25 amp. valves in series, you might use a 0.1 amp. detector in parallel with a 0.15 amp. output valve.

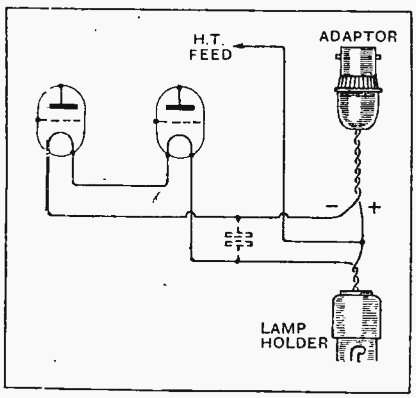

Fig. 1.—A lamp as a filament resistance; connections of a plug-in adaptor.

There may be difficulty in smoothing the filament circuit supply, as it will be impossible to use a choke without introducing an appreciable voltage drop. A large condenser connected as shown in dotted lines should help matters, although its reactance at very low frequencies may not be sufficiently low in comparison with the resistance of the lamp. A good deal depends on the "roughness" of your mains supply and the overall magnification of the set.

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Receiver Reviews.

As a new reader, I was greatly interested in your review of a commercial three-valve receiver in your issue of January 7th, and should now like to learn more about my own set, which is a Murphy Portable. Has this receiver ever been treated in a similar way?

Your set was reviewed in *The Wireless World* for August 6th, 1930, but at that time circuit diagrams were not included in these descriptive articles.

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H.T. Voltage Changes Tuning.

Is it possible that the tuning of a "ganged" receiver will be upset if the anode voltage applied to one of the valves be changed to any great extent?

Yes; by altering H.T. voltage, the magnification, and consequently the input capacity, becomes changed. The value of the change is, however, insignificant and is of no practical importance.

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Another Automatic Volume Control.

In the receiver review published in your issue of December 31st, 1930, it is stated that the detector valve acts as one limb of the screening-grid feed potentiometer. It occurs to me that in the case of a receiver using an anode bend detector, an arrangement of this sort might be made to serve as a form of automatic volume control, but I am not quite clear as to whether change of screening-grid voltage under the influence of a strong signal would be in the right direction. Do you think that there is anything in this idea?

Up to a point, results could be obtained from this form of connection, but we do not think that control would be sufficiently great to maintain the receiver output at anything approaching a constant level. Taking a practical case where normal values are used, calculations show that the change in screening-grid voltage between "no signal" and "maximum permissible signal" will not be very great.

The essentials of the circuits are shown in Fig (2) (a), where R is a combined detector and screening-grid feed resistance, and Z is the anode circuit coupling impedance, which need hardly enter into our calculations. The equivalent circuit is given in Fig 2 (b), where the two valves in question are shown as plain resistances. When a strong signal is applied to the detector, its mean effective resistance will decrease, and the voltage distribution across R and R_1 will be changed; a larger proportion of the total will be developed across R, and a smaller proportion across R_1 (which represents the detector). Consequently, the voltage across R_2 (representing the screening-grid circuit) will be correspondingly reduced.

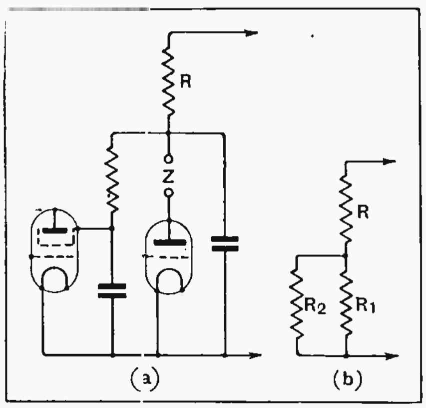

Fig. 2.—(a) Anode bend detector as one limb of a potentiometer. The equivalent circuit is shown in diagram (b), from which the screening-grid decoupling resistance is omitted.

A decoupling resistance in the screen grid feed lead would probably be necessary; this is shown in Fig. 2 (a).

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Reaction Control Fails.

The reaction control of my three-valve H.F.-det.-L.F. receiver has suddenly failed, and the effect of increasing the capacity of the feed-back condenser is merely to decrease signal strength. Careful tests have been made, and the reaction winding and condenser seem to be perfect; can you suggest where the fault is likely to lie?

This sounds like a faulty grid leak, and we think you will find that this component has developed an open circuit.

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H.F. Valve Operating Conditions.

I have just noticed that the anode current passed by my H.F. valve varies in sympathy with the adjustment of the input volume control, which is in the form of an H.F. potentiometer connected across the grid coil, in series with a stopping condenser. So far as I can see, grid voltage should not be altered by this adjustment, and I am afraid that something must be wrong with the valve. Changes of current take place whether a signal is being received or not. Will you please let me have your comments?

It would appear that current is flowing in the grid circuit of your H.F. valve, and that the voltage drop across the grid resistance is being changed sufficiently to influence anode current. It may be that the valve is being operated incorrectly as regards its normal bias voltage, or that it is defective.

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Where Dielectric Losses Count.

I am more than satisfied with the performance of my receiver on the long waveband, and also on the medium band, so far as wavelengths over about 350 metres are concerned. Unfortunately, on very low wavelengths, there is a well-marked falling-off both in sensitivity and selectivity. Although the constants of the circuits are fairly conventional, I am inclined to attribute this trouble to an unsuitable choice of inductance and capacity values. Do you agree?

We think it more likely that your trouble is due to excessive dielectric losses. The presence of material having poor dielectric properties is much more likely to make itself felt when dealing with the short wavelengths.

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Rated H.T. Voltage.

Is it desirable that an output valve should be operated at the maximum H.T. voltage as specified by its manufacturers?

Best results are obtainable when a valve is worked at full pressure and when figures with regard to power output are given, it is always assumed that the maximum permissible anode voltage will be applied. However, this is not essential, and some designers of commercal receivers find it convenient to operate valves at a considerably lower voltage.

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Differential Reaction.

I have recently modified my detector-L.F. receiver (Hartley circuit) by fitting a differential reaction condenser, and now find it difficult to prevent self-oscillation under about 300 metres unless detector anode voltage is reduced. As I am using a combined tuning and reaction coil, it is not possible to take off turns. What would you advise me to do?

If your coils are wound as single-layer solenoids, it might be convenient to move the earth connection farther away from the "grid" end of the windings. If not, we suggest that you should connect a fixed condenser of 0.0001 or 0.0002 mfd. between plate and negative filament terminals of the detector valve.

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Ultra-short-wave By-pass Condensers.

Is it worth while to use condensers of normally high capacity in the H.F. decoupling circuits of a short-wave receiver? I ask this question because I happen to have a number of spare mica condensers of 0.01 mfd. Would they be suitable?

The reactance of these condensers over the ultra-short waveband is quite negligible, and so they could certainly be used. Capacities of conventional values are still necessary where both H.F. and L.F. currents are dealt with, as, for instance, in the detector anode circuit.

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Reception Conditions Abroad.

Have you any information as to reception conditions in the British West Indies? Is it possible to receive British stations?

According to our correspondence, North American broadcasting stations are well received after dark, when atmospherics are not too heavy; unfortunately, this form of interference is prevalent. Except as a "freak," you could not depend on hearing British stations, except that the short-wave transmission from 5SW seems to provide very satisfactory and fairly consistent signals. Good reception of many other short-wave stations is to be expected.

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A Question of Range.

Will you give me an idea as to the range obtainable (for loud-speaker reception) from a detector-L.F. two-valve set operating on a frame aerial?

A good deal depends on the size of the frame, the "goodness" of the valves, and on the design of the set, as well as on your local receiving conditions; one can hardly expect good signals, even from high-power stations, at a greater distance than 10 to 15 miles.

FOREIGN BROADCAST GUIDE.

PTT STRASBOURG

(France).

Geographical position: 48° 35′ N., 7° 45′ E.

Approximate air line from London: 415 miles.

Wavelength: 345.2 m. Frequency: 869 kc. Power: 15 kW.

Time: *Greenwich Mean Time.
**France adopts B.S.T.*

Standard Daily Transmissions.

11.00 G.M.T., gramophone records; news (German); 13.50, news (French); 16.45, tea-time music; 17.45, talks; 18.15, concert; 20.30, relays of outside broadcasts (Café de la Paix, Odéon, Caveau de l'Aubette); concert, gramophone records, or dance music.

Opening and interval signal: deep booming gong lasting 5 seconds with interval of 5 seconds.

Man and woman announcers. Call: *Allo! Allo! Ici radio Strasbourg PTT (du reseau de l'Etat Français).*

All announcements are made in both French and German.

Closes down with usual French and German good-night greetings, followed by La Marseillaise.

THE WIRELESS WORLD FOUR.

THE interest which the publication of the design of THE WIRELESS WORLD FOUR has created amongst our readers has resulted in an overwhelming volume of correspondence on this receiver. In the course of replying to questions an analysis was made of readers' requirements and the article "Hints on Building THE WIRELESS WORLD FOUR" which appeared in the issue of December 10th, 1930, was prepared to meet readers' needs and difficulties, practically all of which are covered by this article, with the exception of requests for modifications to the original design.

We take this opportunity of pointing out that we are not prepared to give suggestions for the modification of all-mains receivers, since often quite small departures from the original plan necessitate a complete revision of the design.

Readers who are now building the Battery Model WIRELESS WORLD FOUR are reminded that additional information on construction is contained in the article which appeared in the issue of December 10th, and they should also refer to the original articles on the all-mains operated set which appeared in the issues of October 15th and 22nd, 1930.

However willing we may be to assist our readers by replying individually to their enquiries, we now find that the enormous volume of correspondence makes it no longer possible even to contemplate sending replies through the post. We wish to point out, also, to those readers who are contemplating the construction of the set, that our experience is that difficulties met with have invariably been traced to modifications in the design or the substitution of different valves or components. We have overwhelming evidence from our correspondence to show that those who have followed precisely the instructions given have had the utmost satisfaction from the receiver.

Whilst being obliged to decline to reply individually through the post to enquiries we may receive, we shall do our utmost to give general assistance to constructors through the pages of this Journal.

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